Fisheries Department
6 Redheughs Rigg
South Gyle
Edinburgh, EH12 9DQ

T: 0131 335 6662
E: fisheries@acoura.com

INTERTEK FISHERIES CERTIFICATION*

November 2015

Ref: 82044 v4

Ross Sea Toothfish Longline Fishery

Final Report

Authors: A Hough, P Medley, J Akroyd, J Pierre

Client name(s) and address

Ross Sea Antarctic Toothfish Client Group
c/o P Thomson
Argos Georgia Ltd
Clarendon House
PO Box HM 1022
HM DX Hamilton
Bermuda

*Dear stakeholder. This fishery commenced full assessment with Intertek Fisheries Certification (IFC). During the assessment the client transferred to Acoura Marine Ltd. This report, and subsequent certification product, is from Acoura Marine. Any reference in this report to Intertek or IFC should be read as Acoura Marine Ltd. Any communication related to this fishery assessment should be directed to Acoura Marine: fisheries@acoura.com or 0131 335 6662

Contents

1. EXECUTIVE SUMMARY

This assessment was carried out by a team under Intertek Fisheries Certification, comprising Andrew Hough (team leader and Principle 2 expert), Paul Medley (Principle 1) and Jo Akroyd, assisted by Johanna Pierre (Principle 3). Peer reviewers were Geir Honniland and Indrani Lutchman.

This is the first re-assessment of this fishery; the Ross Sea Toothfish Longline Fishery was previously certified by Moody Marine (now Intertek Fishery Certification) on 16 November 2010 (expiry 15 November 2015[1]). There are no other fisheries certified or undergoing assessment which require harmonisation with this assessment. There were eight conditions of certification following the original assessment in 2010; all were closed during the original period of certification. This assessment was carried out in accordance with CR v1.3 (January 2013) and uses the MSC Full Assessment Reporting Template v1.3. The default assessment tree (Annex CB) was used without adjustment. The RBF was not used.

It should be noted that in 2005, the WG FSA recommended that Subareas 88.1 and 88.2 be split into two areas for purposes of *D. mawsoni* stock assessment: Subarea 88.1 and Small-Scale Research Units (SSRUs) 88.2A–B referred to as the Ross Sea Region stock (RSR), and SSRU 88.2C-H referred to as the Amundsen Sea Region (ASR) Subarea 88.2 stock. This split was confirmed by a recent review of the available information (WG-SAM-14/26). Catches from both areas come within this certification, but are treated as separate units of assessment although this only affects scoring for Principle 1.

As the client group consists of members in New Zealand, Australia and UK, Norway and Spain (with New Zealand providing the focus of Client Group, scientific and management activity), site visits were held by members of the assessment team in UK and New Zealand. Meetings were held in September 2014 in London, UK with client group representatives and in November 2014 with representatives of the client group, Ministry of Foreign Affairs and Trade (NZ), Department of Conservation (NZ), Environmental Non-Government Organisations (WWF-NZ, WWF-Antarctic and Southern Ocean Initiative and ECO), Ministry for Primary Industries (NZ) and NIWA.

The management system framing the fishery is developed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Members of this Commission are responsible for the implementation of the Commission's requirements in their own fisheries. In addition to CCAMLR requirements, domestic management measures may also be applied by each state. Therefore, the companies comprising the client group must operate their vessels, flagged to five countries (Australia, New Zealand, Norway, Spain, UK), in accordance with both CCAMLR and flag-state requirements.

Key strengths of the management approach applied to the fishery include:

- a natural alignment of the CAMLR Convention's objective ("the conservation of Antarctic marine living resources"[2]) with MSC Principles 1 and 2,
- comprehensive utilisation of scientific and technical information as a foundation for management,
- frequent and ongoing review of fishery performance within the management system,
- ongoing collection of detailed scientific and technical information to support management,
- a multi-faceted monitoring, control and surveillance system,
- frequent and regular opportunities to refine and update the management system,

[1] Extended by variation till 14th January 2016, granted by MSC November 2015

[2] See Article 2 of the CAMLR Convention, available at: www.ccamlr.org/en/organisation/camlr-convention-text

- extensive, detailed and publicly available documentation of management decisions and discussions supporting decision-making,
- a very conservative approach to fisheries decision rules, the CCAMLR decision rules are that the median estimated spawning stock size remaining greater or equal to 50% of the average pre-exploitation spawning biomass after a further 35 years of fishing (that is 35 years from each assessment); and that a no time will there be more than a 10% probability that the spawning stock biomass would reduce below 20% of the pre-exploitation level.

The main weakness of the fishery derives principally from its relatively small size and location in Antarctic waters, making information gathering on the stock and ecosystem and determination of effects of the fishery difficult. Many of the conditions of certification following the original assessment of this fishery related to the lack of information. Nevertheless, significant data collection has, and continues to, take place and development of the fishery takes place in a precautionary manner.

Final Principle Scores of this reassessment were
Principle 1 – Target species RSR 93.1
Principle 1 – Target Species ASR 88.8
Principle 2 – Ecosystem (both areas) 89.7
Principle 3 – Management System (both areas) 90.1
and so the fishery is recommended to be recertified.

One condition of certification was raised with regard to PI 1.2.4 for the ASR only. Currently the relevant CCAMLR committees do not have a consensus that the current model and data are appropriate. To meet SG80 requirements within the term of this certification, the assessment should be made appropriate for the stock and for the harvest control rule.

Two recommendations were made:
Recommendation 1 (PI 2.2.1 SIa). While it is not highly likely that grenadiers or skates are outside of biologically based limits, this is not so well demonstrated for skates as for grenadiers. A risk assessment for bycatch species, as reported in the initial MSC assessment did not consider skates at risk: recommendations have been made for an updated risk assessment and those recommendations are supported by the assessment team.

Recommendation 2 (PI 2.3.1 SIc). It is recommended that possible effects of changing toothfish distribution on foraging success of Weddell seal and type c killer whale, at critical life stages, be considered a suitable focus for research.

2. AUTHORS AND PEER REVIEWERS

Team Members:

Andrew Hough: Hough Associates Ltd. Lead Auditor and Principle 2. Dr Hough has a PhD in marine ecology from the University of Wales, Bangor on marine ecology. He has been involved in marine and coastal environmental management since 1991, including management of fishery impacts on ecosystems and marine conservation biology. He has been manager of Moody Marine operations within Moody International Certification from 1999 to 2011 with particular responsibility for the implementation of MSC Certification procedures and development of MSC methodologies. Dr. Hough has acted as lead assessor on the majority of Moody Marine MSC pre assessments and main assessments during this time, including Principle 2 assessments of several fisheries, including Falkland Islands Toothfish. Andrew Hough is trained in the use of the Risk Based Framework,

although this was not used in this assessment.

Paul Medley. Principle 1. Paul is an independent fisheries consultant, based in the UK. His expertise includes mathematical modelling of fisheries and ecological systems, techniques for multispecies stock assessment and external review of stock assessment methodologies. He has been an invited expert for a number of stock assessment working group meetings. He has a wide practical experience in marine biology, including design and implementation of surveys and fisheries experiments. This includes addressing wider environmental issues of ecological management, including maintenance of marine biodiversity. He has also taken part in the MSC assessment of the South Georgia and Falkland Island Patagonian Toothfish fishery and has worked with MSC on new methodology developments.

Jo Akroyd. Principle 3. Jo is Director and Principal Consultant of Jo Akroyd Ltd, an International consultancy company specialising in marine fisheries policy and marine ecosystem and community based management. She has also provide services in quality system implementation and training in project management and negotiation skills. Prior to a career in consultancy, she was manager of International Projects at the Auckland University of Technology and Director of Quality and Strategic Management and Assistant Director of Marine Research at the Ministry of Agriculture & Fisheries, Wellington, NZ. Her specific experience includes acting as a lead auditor and team member on several MSC assessments, including Ross Sea Toothfish and NZ hoki fishery, providing specialist inputs on Principle 3 (Fisheries management).

Johanna Pierre. Principle 3. Johanna assisted Jo Akroyd in completing Principle 3, in particular assisting with logistics and recording during site visits in New Zealand. Johanna is a consultant based in New Zealand, who specialises in sustainable fisheries management.

Peer Reviewers

Geir Hønneland is Research Director of the Fridtjof Nansen Institute and adjunct professor at the University of Tromsø, Norway. He holds a PhD in political science from the University of Oslo. Among his books are Implementing International Environmental Agreements in Russia (Manchester University Press, 2003) (including fisheries agreements), Russian Fisheries Management: The Precautionary Approach in Theory and Practice (Martinus Nijhoff , 2004), and Making Fishery Agreements Work: Post-Agreement Bargaining in the Barents Sea (Edward Elgar, forthcoming 2012). He has also published a number of articles about Russian fisheries management, and the Barents Sea fisheries management more widely, in peer reviewed journals. Geir also has wide range of evaluation experience, e.g. for the FAO relating to the FAO Code of Conduct for Responsible Fisheries. Further, he has produced a country study of Russian fisheries management for the OECD and several consultancies about Russian fisheries management. He was member of the team that performed the first MSC assessment of a Russian Barents Sea fishery in 2010 and the Aker BioMarine Krill fishery reassessment in 2015. Geir is based near Oslo in Norway. A more comprehensive presentation can be found at the FNi´s website: http://www.fni.no/cv/cv-geh.html

Indrani Lutchman. Indrani is an independent marine policy specialist based in London with over 20 years of experience in designing at a national, regional and international level. Her expertise covers diverse aspects of fisheries and marine governance and management. She has either led or contributed to a number of research projects focused on the implementation of the ecosystem –based approach to fisheries management In Europe and Antarctic; developing indicators to evaluate the performance of fisheries policy including the EU Data Collection Framework, the EU discard and control policies and the CCAMLR scheme to deter illegal unreported and unregulated (IUU) fishing. She is an expert in impact

assessment of EU fisheries and marine policies including recent projects on the EU Marine Strategy Framework Directive (MSFD) and the European Fisheries Fund (EFF). Her international experience includes monitoring and research in support of effective management of marine resources in Small Island Developing States (SIDs), the UK Overseas Territories, the Southern and Antarctic Oceans and the design of systems to ensure compliance with management measures.

3. DESCRIPTION OF THE FISHERY

3.1 Unit(s) of Certification and scope of certification sought

The Unit of Certification is:

Species: Antarctic toothfish (*Dissostichus mawsoni*)
Geographical Area: Ross Sea (CCAMLR Subareas 88.1 and 88.2)
Method of Capture: Bottom set longline
Stock: Within CCAMLR Subareas 88.1 (RSR) and 88.2 (ASR)
Management: Management advice by CCAMLR, enacted by relevant Flag States
Client Group: Argos Georgia Ltd, Sanford Ltd, Ervik Havfiske AS, Pesquerias Georgias SL,Talley's Longline (TLL), Australian Longline Pty Ltd,

It should be noted that Subareas 88.1 and 88.2 are considered as separate stocks in *D. mawsoni* stock assessment: (i) Subarea 88.1 and SSRUs 88.2A–B referred to as the Ross Sea Region stock (RSR), and (ii) SSRU 88.2C-H referred to as the Subarea 88.2 or Amundsen Sea Region stock (ASR). Catches from both areas come within this certification, but are treated as separate units of assessment for Principle 1.

For the 2014/15 season Client Group vessels were:

Vessel name	State	Registration number	Gross Tonnage	Length	Fishing method
Argos Froyanes	UK	708451	1352.00t	52.55m	Bottom autoline
Argos Georgia	UK	708449	897.00t	46.58m	Bottom autoline
San Aspiring	NZ	900522	1508.00t	51.20m	Bottom autoline
San Aotea II	NZ	63631	1079.00t	46.50m	Bottom autoline
Seljevaer	Norway	SF-35-S	1155.00t	54.58m	Bottom autoline
Tronio	Spain	736929	1058.00t	55.00m	Spanish longline
Janas	NZ	63634	1079.00t	46.50m	Bottom autoline
Antarctic Chieftain	Australia	859032	1136.00t	62.80m	Bottom autoline

The fishery is not conducted under a controversial unilateral exemption; nor does the fishery use poisons or explosives (notified destructive fishing practices). The fishery is entirely within the scope of the MSC Principles and Criteria.

Any further licensed fishing companies/vessels which agree to the Client Group rules may be admitted to the client group.

3.2 Scope of Assessment in Relation to Enhanced Fisheries

No enhancement activities take place within this fishery.

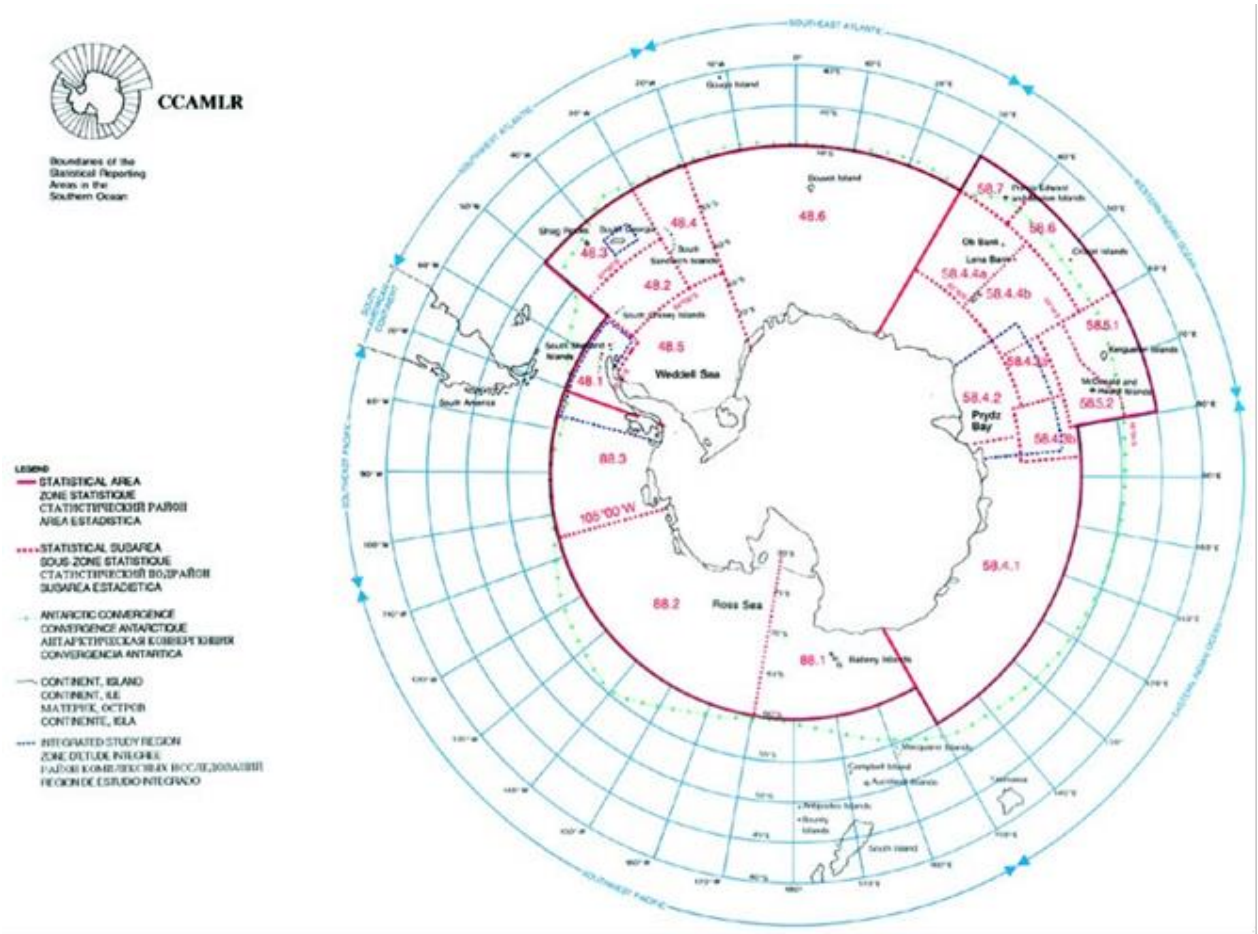
3.3 Scope of Assessment in Relation to Introduced Species Based Fisheries (ISBF)

The fishery takes place on native species only.

3.4 Overview of the fishery

The fishery operates as a CCAMLR exploratory fishery under a catch-allocation set annually based on a biennial stock assessment. Access is restricted to licensed vessels from CCAMLR Member states deemed appropriate by CCAMLR member countries at the Scientific Committee and Commission annual meetings in October each year.

The fishery is based on bottom-set longlines targeting Antarctic toothfish. The fishery operates in two CCAMLR Subareas; 88.1 and 88.2. The fishery continues to be managed as an 'Exploratory Fishery'. This categorisation is seen as a means of ensuring sufficient biological and other information is provided by fishing vessels to underpin fishery management while maintaining a precautionary TAC. The fishing season extends between 1 December and 31 August (2014). This fishery closes annually when the catch (or by-catch) levels are reached. No fishing takes place during the austral winter due to ice conditions.



Conservation of Antarctic Marine Living Resources (CCAMLR). Member states acceding to this Convention are required to comply with all regulations and requirements set by CCAMLR (including approving specified vessels to fish within the Convention Area) and subsequently licence their own flagged vessels. They may impose additional requirements or controls in addition to CCAMLR requirements. Finally there is the individual level of management and control by the operating fishing companies to ensure compliance and

operation consistent with the regulations and principles of CCAMLR and flag state requirements.

A summary of management responsibilities is as follows:

1. The Commission agrees Conservation Measures after receiving advice from its subsidiary bodies.
2. Member states submit specific vessel applications to CCAMLR for approval to fish within Exploratory Fisheries.
3. Once approved to fish within specific CCAMLR exploratory fisheries Member states licence their flagged vessels / operators consistent with all CCAMLR measures.
4. The CCAMLR Secretariat monitors fishing activities via the system of observation (CCAMLR accredited observers) and VMS – satellite based position reporting.
5. Member states may require additional flag state observers to be present on their own vessels in addition to the CCAMLR observers – note that CCAMLR Conservation Measures 41-09 and 41-10 require at least two observers in the target fishery evaluated here.
6. Member states report annually to CCAMLR Secretariat and provide scientific and technical input to the commission's subsidiary bodies.
7. Fishing companies ensure that adequate training and information is available to vessels and ensure compliance with all CCAMLR and flag state requirements.

Fishing in Subarea 88.1 began in 1996/97 at a low level of catch with the fishery beginning in earnest in the 1999/2000 season. The fishery in 88.2 began in 2001/02, although catch limits here have also been set since 1996/97. Initial catch limits were as for 88.1, but were later reduced as the fishable area was found to be much smaller.

In Subarea 88.1, the fishing zone is divided into a number of Small Scale Research Units (SSRU's) A – M, with individual catch limits in each. Of these SSRU's a number are closed to exploratory fishing (A, D, E, F and M). In Subarea 88.2 the fishing zone is divided into a number of Small Scale Research Units (SSRU's) A – I, with individual catch limits in each. Of these SSRU's a number are closed to exploratory fishing (A, B and I).

Gear use is regulated and only bottom set longlines are permitted. Bait used is Humboldt squid, caught in Central and South America. All fishing methods and gear types employed in the fishery are known. In-situ observations are made by observers (with two observers per vessel coverage). Comprehensive information is maintained on the size and composition of the fleets during each season.

4. Principle One: Target Species Background

4.1 Biology of the Target Species

Toothfish are large Nototheniids endemic to Antarctic and sub-Antarctic waters. There are two species of toothfish: Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*). Their distribution is circumpolar. *D. mawsoni* have a more southern distribution than *D. eleginoides* and are generally found in latitudes south of the Antarctic Convergence. *D. mawsoni* dominates catches in Subareas 88.1 and 88.2.

Toothfish are high trophic level predators, with fish the most important prey category, in particular icefish and Whitson's rattail, and squid, bait and prawns following in importance in the diet (Fenaughty *et al*. 2003). Growth, estimated from tagging and age estimates based on otoliths, for this species is relatively fast considering the cold environment and toothfish life history (Horn 2002).

Considerable uncertainty remains over spawning dynamics and early life history of *D. mawsoni*. The present hypothesis is that *D. mawsoni* in Subareas 88.1 and 88.2 spawn to the north of the Antarctic continental slope, mainly on the ridges and banks of the Pacific-Antarctic Ridge (Hanchet *et al*. 2008). From the more southern areas, it is proposed that fish gradually move northwards as they mature, feeding in the slope region in depths of 1000–1500 m, where they gain weight before moving north onto the Pacific-Antarctic ridge to start the cycle again. Spawning fish may remain in the northern area for up to two or three years. They then move southwards back onto the shelf and slope where food is more plentiful and where they regain condition before spawning again.

Antarctic toothfish in spawning condition have been found on isolated geographic features north of the main Antarctic shelf areas, north of 70°S. Surveys are being used to monitor and map stock structure with the Ross Sea, and could lead to a better understanding of the distribution and dynamics of this species in this area. The spawning appears to take place during winter and spring, and may extend over a period of several months. Depending on the exact location of spawning, eggs and larvae become entrained by the Ross Sea gyres, and may either move west settling out around the Balleny Islands and adjacent Antarctic continental shelf, south onto the Ross Sea shelf, or eastwards with the eastern Ross Sea gyre settling out along the continental slope and shelf to the east of the Ross Sea in Subarea 88.2. As the juveniles grow in size, they move west back towards the Ross Sea shelf and then move out into deeper water (>600 m).

At the depths where the fishable biomass of toothfish is found, environmental conditions are relatively stable. New recruits comprise only a small proportion of the fishable biomass and the stock has a generally low productivity. Productivity may be affected by changes in environment and climate most likely through adjustments in recruitment, but recruitment appears relatively stable (WG-FSA-13/51).

Genetic analysis may be difficult to use to identify clear stocks. *D. mawsoni* from areas around the Antarctic including the Ross Sea have found weak genetic variation (Smith *et al*. 2004; Kuhn and Gaffney 2008). This differentiation is supported by some physical oceanography (oceanic gyres may retain juveniles), and by the limited movement of adult tagged fish. However, recently Mugue *et al*. (2014) found no significant genetic differences among locations across the Antarctic from samples taken 2011-13, in contrast to other studies, suggesting some genetic mixing among populations.

In 2005, the WG FSA recommended that Subareas 88.1 and 88.2 be split into two areas for purposes of *D. mawsoni* stock assessment: (i) Subarea 88.1 and SSRUs 88.2A–B referred to as the Ross Sea stock (RSR), and (ii) SSRU 88.2C-H referred to as the Subarea 88.2 stock (ASR), confirmed by a recent review of the available information (WG-SAM-14/26). Catches from both areas come within this certification, but are treated as separate units of assessment.

D. eleginoides is excluded from certification. It is unlikely that the two species of toothfish which are caught will be confused as vessel crew are specifically trained to recognise the two species and all of the Client Group vessels also work in fisheries where Patagonian toothfish predominate the catch, there are two scientific observers on board each vessel, and landings inspections. *D. eleginoides* is at the edge of its habitat range, and managing the harvest with primary reference to the *D. mawsoni* populations is appropriate. *D. eleginoides* are included in the tagging programme.

4.2 Monitoring of Stock Status

Toothfish tagged and subsequently recaptured so far generally show very limited movement of fish between the RSR and the ASR stocks (WG-FSA-13/49): a single tagged toothfish released at McMurdo Sound has been recaptured in the ASR, one fish tagged by the fishery having moved from the RSR to the ASR, and two from the ASR to the RSR. Furthermore, the hypothetical life history of Antarctic toothfish in the RSR (Hanchet *et al.*, 2008) and its

known circulation and hydrography (Rickard *et al.*, 2010) suggest that for management purposes the RSR fishery, including SSRUs 882A and B (190°W to 210°W), should be treated separately from the ASR.

The information on life history, in particular reproduction and recruitment, is limited and the understanding of the impacts of oceanography on the population are hypothetical (Hanchet *et al* 2008). There is no evidence for strong variation in year class strength in the fishery (Fishery Report 2013), suggesting short-term environmental impacts on recruitment may not be great. Likewise, impacts of krill and other species population fluctuations are uncertain, but being investigated (WG-EMM-13/28; Koch *et al*. 2012).

The catch, catch age and length composition, catch rates and tagging information are all monitored with both high-frequency and a high degree of accuracy. In particular, the main indicators are monitored with sufficient frequency to support the harvest control rule (HCR). Particularly important information for the HCR is derived from the tagging programme. Under CM 41-01, each longline vessel fishing in exploratory fisheries for *Dissostichus* spp. has been required to tag and release at the rate of one toothfish per tonne of green weight caught throughout the season since 2004, with an upper limit of 500 fish tagged per vessel applied until the end of 2007. Tagging also needs to meet a minimum tag-overlap statistic if more than 10 tonnes is caught, which ensures that there is sufficient overlap between the length distributions of tagged and retained fish. All vessels fishing in Subareas 88.1 and 88.2 have consistently exceeded the required tagging rate of one fish per tonne, with one exception in 2011 (0.9 fish per tonne) and all vessels have exceeded the minimum tag-overlap requirements with one exception in 2013.

In total, 30 548 *D. mawsoni* have been tagged and released and 1447 have been recaptured in Subarea 88.1. In Subarea 88.2, 4 539 have been tagged and 430 have been recaptured. A relative index of vessel-specific tag detection performance for the Ross Sea fishery using a case-control methodology was developed in WG-SAM-13/34. The method controls for the interannual spatial and temporal variability of commercial fishing operations from which tags are released and recaptured. Selection criteria to determine a subset of vessels for which there was confidence in their tag-recapture data were developed and then applied, resulting in the tagging dataset used for the assessment models (WG-FSA-13/50; WG-FSA-13/51). The tagging data are not without problems. For example, although one vessel had released a total of 1792 tags in Subareas 48.5, 88.1 and 88.2, none of these tags have ever been recaptured. There is a reliance in the stock assessments on the New Zealand vessels' tagging data, which are thought to be most reliable.

Standardised CPUE analyses of *D. mawsoni* in the Ross Sea were updated for 2013 (WG-FSA-13/48) for the first time since 2006. In 2006 it was concluded that the CPUE indices did not appear to be monitoring abundance of toothfish in the Ross Sea fishery (SC-CAMLR-XXV, Annex 5, paragraph 5.58). The updated CPUE indices were quite variable between years and the overall trends had very wide confidence bounds and varied widely between the north, slope and shelf fisheries, probably reflecting the effect of ice conditions on catch rates. Therefore, the only index of abundance remains the tagging data.

The legal catches are well documented and reliable. The species catch has not been confused with the nearest relative, *D. eleginoides*. The total catch is recorded and verified at landing and monitored through the catch documentation scheme. On board observers provide good information on catch composition (length, sex and maturity of individual fish), as well as a description and check on fishing operations (outlined in observer reports). Each vessel participating in the fishery has at least two scientific observers, one of whom is appointed in accordance with the CCAMLR Scheme of International Scientific Observation, who remains on board throughout all fishing activities within the fishing period.

The size and age structure of the catches is estimated from catch samples. The strata for estimating selectivity from the *D. mawsoni* length- and age-frequency data were determined using a tree regression post-stratification method (WG-FSA-SAM-05/8; WG-FSA-13/48). On average, about 800 *D. mawsoni* otoliths collected by observers have been selected for

ageing for each year 1999-2012, and used to construct sex and area specific age–length key (ALK) for the RSR stock. The age–length key is applied to the scaled length-frequency distributions for each year to produce catch-at-age (WG-FSA-13/48). These approaches seem appropriate and adequate to determine the catch composition.

In Subarea 88.2, aged otoliths were only available from the New Zealand fleet, and not available for every year. Most aged otoliths are taken from SSRU 882H and numbers are not sufficient to generate reliable ALKs for those years where otoliths are available (WG-FSA-13/48). A recent re-examination of the age–length data showed that there had been a decreasing trend in mean age at length over time and that the use of a single ALK across all years was not valid. Therefore, several models were run in the 2013 assessment to evaluate the sensitivity of the model results to the age data.

Although the length-frequency distribution of the toothfish catch in the north of the Ross Sea fishery has been reasonably stable over time, there has been a change in the mean age of males and females in the catch with a slight increase in the early years followed by a decline since 2005. There has also been a substantial increase in the proportion of males in the catch in the north over time. Although the length-frequency distribution of the toothfish catch in SSRU 882H continues to be very stable, there has been a decline in the mean age of males and females in the catch since 2005, similar to that seen in the north of the Ross Sea fishery.

Three research longline surveys of sub-adult (70–110 cm) toothfish were carried out in the southern Ross Sea with results reported to CCAMLR (WG-FSA-14/51). A forth survey was carried out during the 2014/15 season. Catches and size structure were very similar between the three surveys analysed to date and some indication of year class progression was apparent in the age distributions. Incorporating the survey age structure into the assessment had the effect of stabilising the index of year-class strength, and continuing the surveys has been recommended.

Other data are also collected, but may not be used yet in the harvest strategy. Perhaps most importantly, information on sea ice conditions is being explored in relation to vessel activity (WG-FSA-14/55), particularly important in light of the Intergovernmental Panel on Climate Change (IPCC) findings of changing sea-ice conditions in the Ross Sea.

4.3 Stock Assessment and Current Stock Status

The stock assessments and results are described briefly in the 2013 fishery report for the exploratory fishery for *Dissostichus* spp. in Subareas 88.1 and 88.2 (Fishery Report 2013). An integrated stock assessment was first completed for the Subarea 88.1 in 2006 and the Subarea 88.2 stock in 2011, both being updated for 2013. Catch limits prior to this were based on proxies based on CPUE data from other toothfish fisheries and the fishable area.

The catch limits set by CCAMLR for 2012 and 2013 in Subarea 88.2 (ASR) were determined from yield estimates from an integrated stock assessment model of Antarctic toothfish in SSRUs 88.2C– H with data up to the end of the 2011 season (Mormede et al. 2011a). This was the first time SSRUs 88.2C–H had been assessed together using a formal stock model. The 2011 model was based on age and length data assuming two fisheries; SSRU 88.2H consisting of seamounts in the north and SSRUs 88.2C–G on the southern continental slope and shelf; and included total catch data (C2 data); catch-at-age frequencies reported by Hanchet et al. (2013); and tag-release and recapture data in 88.2H through the 2011 season (Mormede et al. 2011b).

The stock assessments for both RSR and ASR stocks are based on a statistical catch-at-age model implemented in well-developed and well tested software (CASAL; see Bull et al., 2012). The CASAL assessment model is designed to use the catch, age, compositions, and tag-recapture data. It is particularly suited to model this sort of fishery, and can account for some detail in the life characteristics of toothfish, such as growth and mortality rates. The stock assessment models were sex- and age-structured.

The models assume a single area population, but account for differences among areas by treating areas as separate fisheries with their own selectivity. For the RSR three areas are defined - shelf, slope, northern hills.

For the ASR catch limits set by CCAMLR for 2012 and 2013 were determined from yield estimates from an integrated stock assessment model of Antarctic toothfish in SSRUs 88.2C– H with data up to the end of the 2011 season (Mormede et al. 2011a). This was the first time SSRUs 88.2C–H had been assessed together using a formal stock model. The 2011 model was based on age and length data assuming two fisheries; SSRU 88.2H consisting of seamounts in the north and SSRUs 88.2C–G on the southern continental slope and shelf; and included total catch data (C2 data); catch-at-age frequencies reported by Hanchet et al. (2013); and tag-release and recapture data in 88.2H through the 2011 season (Mormede et al. 2011b).

Differences in selectivity are allowed for between males and females, and for the ASR model, between differences in the average depth fished.

Working Groups (WG-SAM and WG-FSA) and Scientific Committee (SC) indicate consensus that the RSR model is appropriate for the stock and the harvest control rule. Furthermore, the model is able to take account of the available data and what is known about the biology of the species and nature of the fishery in this region, meeting SG100.

For the ASR model, these groups do not have a consensus that the current model and data are appropriate. Specifically, most tagging occurs in SSRU H and tagging recaptures in the remaining SSRUs C-G are very low. This creates a problem fitting the model to the tag data. Effectively, SSRUs C-G are not considered to have been adequately assessed yet. The Scientific Committee has endorsed a two-year research plan the first year of which has been carried out to provide information in order to address this issue.

Two-area models of the ASR have been developed to account the spatial structure better and will be tested further once the two-year research plan has provided further data.

While this additional data collection takes place the ASR assessment is considered precautionary. The tag-based estimate gives an index of the current biomass and WG-SAM have provided advice (SC-CAMLR-XXXII/05, paragraph 2.7) that when catch limits are confined within research blocks as is the case in the ASR research that catch limits are set to provide a suitable level of tag recaptures to achieve a credible stock assessment within a 3 to 5 year time period while providing reasonable certainty that exploitation rates at the scale of the stock or SSRU will not exceed appropriate levels as estimated in ASDs with assessed fisheries (e.g. 3–4%) (Welsford, 2011; WG-SAM-13/37). Following the first year of tagging in the southern ASR tag recoveries should assist in the assessment of that region.

In the absence of an agreed stock assessment for the ASR a Management Strategy Evaluation could provide a method of assessing risk and potentially an interim or alternative management strategy.

Because there are no observations at low stock abundance, there are inadequate data to fit a stock recruitment relationship. The current mean level of recruitment and SSB is estimated within the stock assessment, and a Beverton and Holt stock recruitment relationship was assumed for the simulations with a steepness of 0.75 (a reasonable default precautionary value).

The objective for the stock assessment was to provide a “base case” assessment that is, in the opinion of the assessment scientists and working group, the closest to the true population dynamics. The understanding of the stock dynamics is limited by the available time series of data, which is relatively short, and issues over stock structure and tag mixing. Investigation of the impact of the mixing assumption for tag data, using spatially explicit models, have begun using the Spatial Population Model, and again show that the single area stock assessment model is likely to under-estimate true abundance (Mormede & Dunn 2013a). The models are regularly reviewed and there have been efforts made to improve

them, while exploring shortcomings. Furthermore, there is evidence that choices made in providing management advice err on the precautionary side. The available information indicates that both stocks are still well above the target level of 50%B_0 with the 2013 stock assessment indicated a level of 74.8% of B_0 for the RSR and 65%. B_0 for the ASR using the conservative model run as a precautionary value due to conflicting information between the age and tagging data increasing uncertainty (Moremede et al 2013).

The model parameters were estimated using a Bayesian analysis, first by maximising an objective function (MPD), which is the combination of the likelihoods from the data, prior expectations of the values of those parameters and penalties that constrain the parameterisations; and second, by estimating the Bayesian posterior distributions using Monte Carlo Markov Chains (MCMCs). Diagnostics suggest the MCMC simulations converged for both models. The Secretariat undertook the validation of the CASAL parameter files, MPD estimates, and yield calculations for the RSR and ASR. The model explicitly takes account of known observation and process errors, and applies a Bayesian approach to fitting which is useful for the probabilistic decision rule.

As well as observation and process errors estimated using MCMC in the base case models, structural errors in the models have been explored for the RSR and ASR assessments (Mormede *et al.* 2014; WG-FSA-14/56; WG-FSA-14/57; Fishery Report 2013). These mostly take the form of sensitivities which test how final results and management advice are affected by different assumptions, such as unrecorded fishing mortality. For the RSR model, sensitivity included dropping or including particular data to test their influence on final results, altering weights among data sources, testing alternative selectivity functions and exploration of the use of sub-adult survey results. For the ASR model, sensitivities that have been examined include unaccounted mortality due to lost gear, catch and tag data from the southern fishery (SSRUs C-G), and tag data from all trips rather than those considered most reliable. The inclusion of the unaccounted mortality from lost gear had little impact on estimates of biomass. The inclusion of tag data from the south fishery led to a 10% increase of biomass, due to the low numbers of tags there, whilst including tag data from all vessels led to a 20% increase in biomass.

For the RSR model, various structural assumptions have also been tested using data simulated from alternative models of stock structure. Mormede *et al.* (2014) found that, assuming the underlying spatial distribution of the population and movement functions for toothfish were as described by their operating models, then the assessment model was a conservative estimator of the true state, especially when estimating biomass over the entire Ross Sea region.

For the ASR model, alternative assessment models have been used to investigate declines in tagged fish recaptures (WG-FSA-14/56; WG-FSA-14/57), which have not been explained in the current model. Spatial stock structure may well explain observations (WG-SAM-14/26). Alternative scenarios have included different emigration, immigration and rates of exploitation, but so far a single area model has not been able to explain the observed tag-recapture patterns. However, results suggest that a multiple area model may be able to (WG-FSA-14/57), with the resulting exploitation rate higher than the objective for this type of fishery (20% vs 4%). However, WG-FSA requested more tagging data to confirm or reject this alternative model. In addition, any migration may also be confounded with other factors that could be occurring in SSRU 882H, such as IUU fishing and predation. Simpler biomass estimates were also determined based just on tagging data, which have indicated generally larger biomass levels than currently assumed, but were also consistent with immigration to the fished population (WG-FSA-14/58). Minimising the immigration bias by using only tag returns after up to one year of release, the advised catch limit from the target exploitation rate (4%) resulted in a catch limit of 200t for SSRU 88.2H. An alternative assessment based on the same approach (WG-FSA-14/14) suggested higher biomass, but made no correction for possible migration effects, so it may effectively apply to a larger area. Although further

research was anticipated (WG-FSA-14/59), this did not delay setting precautionary management advice and the existing management approach, as recommended by WG-SAM, is being continued by the Scientific Committee. The latest assessments (Fishery Report 2013) were reviewed by the Fish Stock Assessment Working Group (WG-FSA-13; WG-FSA-14). The review supported the RSR assessment, its conclusions and advice. However, this review did not reach consensus over the ASR model, but the current precautionary management advice was agreed by the Scientific Committee. The WG-FSA had agreed that the catch limit for SSRUs 882C–G be retained in 2014/15 from 2013/14 (124t) in SSRUs 88.2C–G, but could not reach consensus in recommending a catch limit for SSRU 88.2H due to differences in opinion. Two options were put forward to the Scientific Committee as catch limits taken in SSRU 88.2H of 200t or 619t based on different interpretations of the data, as well as a proposal for a two-year research programme to resolve this issue. Among the other things, the Scientific Committee agreed that the catch limit for SSRU 88.2H would be 200t and the combined catch limit for SSRUs 88.2C–G will be 419 tonnes, with no more than 200 tonnes to be taken from specified fishing areas, that toothfish will be tagged at the higher rate of 3 fish per tonne in SSRUs 882C–G and normal rate of 1 fish per tonne in SSRU 88.2H and finally that tag-overlap statistics will be calculated separately for each of SSRU 88.2H and SSRUs 88.2C–G. This should, it was hoped, enable a better understanding of the stock structure so that a stock assessment model can be successfully fitted to all the data since tag returns are expected from the SSRUs 88.2C–G. The Commission endorsed this research plan for the next two years.

4.4 Fishery Management

An outline of the strategy and other aspects of the CCAMLR management regime are available from the CCAMLR website (http://www.ccamlr.org/). The full range of conservation measures are described in Conservation Measure 41-09 for limits on the exploratory fishery for *Dissostichus* spp. in statistical subarea 88.1 and Conservation Measure 41-10 for limits on statistical subarea 88.2.

The harvest strategy is essentially the same between the two stocks, RSR and ASR, albeit some temporary adjustments have been made to the ASR due to the lack of an accepted stock assessment. Although management is applied to areas 88.1 and 88.2, effectively no fishing is currently applied in SSRUs 88.2 A and B which belong to the Subarea 88.1 RSR stock, so this does not present a problem for the current harvest strategy. The boundaries between areas have been subject to ongoing revision based on the available scientific evidence.

The harvest strategy consists of a biennial process of data collection, stock assessment, scientific advice, management decisions and implementation. Data are provided by vessel reporting and scientific observers on board vessels. Stock assessments update stock status and provide management advice through, among other things, the harvest control rule in the form of catch limits sub-divided among SSRUs. The stock assessments also provide an evaluation of past management performance in relation to its objectives.

Fishing is limited to notified vessels using demersal longlines, with an overall catch limit each season split between SSRUs. Some SSRUs have a 0 catch limit (88.1 A, D, E, F, M and 88.2 A, B, I are all closed to fishing). The fishing season is limited from 1st December to 31st August each year.

Fishing operations are carried out in accordance with CM 41-01 and by-catch is regulated (CMs 33-03, 41-09 and 41-10). Measures are required to minimise seabird bycatch (CM 25-02 and CM 24-02). Monitoring is carried out through VMS (CM 10-04) and a scientific observer programme. There is also a catch documentation scheme (CM 10-05), which is used to discourage any IUU fishery. Toothfish are required to be tagged at a rate of at least one fish per tonne green weight caught. Daily catch and effort are required to be reported (CM 23-07) so the management system can respond rapidly when catch limits are approached. Haul-by-haul catch and effort data are reported monthly (CM 23-04). Other

gear and depth regulations exist (CMs 22-06, 22-07, 22-08 and 22-09); environmental protection is governed by CM 26-0; and fishing within 10 nautical miles of Balleny Islands is prohibited.

Catch limits are fixed for two years unless new information or circumstances indicate a major change in the assessed area and calculated from projections (the harvest control rule). In 2014/15, the catch limit for *Dissostichus* spp. In the RSR was 3044t including 68t set aside within the SSRUs 881J, L catch limit for the sub-adult survey and included a research catch limit of 200 tonnes set aside for a multi-Member research survey in the north of 88.2 in SSRUs A and B. In the ASR, the precautionary catch limit for *Dissostichus* spp. was set at 200t in SSRU 882H and 419 tonnes in SSRUs 881C–G to be taken only within defined research blocks and with no more than 200 tonnes taken from any research block for 2014. Fishing has been conducted by an average of about 15 licenced vessels over the past decade using longlines.

When a catch limit is reached within an SSRU or SSRU block, it is closed. For example, Subarea 88.1 SSRUs B, C and G were closed on 19 December 2013, SSRUs H, I and K were closed on 11 January 2014 and SSRUs J and L and the whole fishery were closed on 17 January 2014; the total catch of *Dissostichus* spp. in these management areas ranged from 87% to 100% of the catch limits. In contrast, for Subarea 88.2, the catch limit was 390t and the total reported catch was 426t, with catches in management areas ranging from 103% to 122% of the catch limits. These overruns were attributed to the low catch limits relative to the response time and possibly excessive capacity being attracted into the fishery. Although there was no evidence for overcapacity in the current metrics, it is recognised that there is a potential for excess capacity in Subarea 88.2 as vessels move from Subarea 88.1 after the Ross Sea catch limit is met.

In some cases, the required tag-overlap statistic (60%) was not achieved for some vessels in Subarea 88.2 in 2014, but this represented a sampling artefact due to low catch and fish numbers, rather than compliance concerns. The governing measure has subsequently been modified with a minimum trigger level to recognise this anomaly.

There has been no evidence of recent IUU activity in the Ross Sea up to 2014/2015. Unmarked longline fishing gear sighted in Subarea 88.1 in 2014 was likely to have been from authorised fishing vessels where the marking may have been removed through the abrasive action of sea-ice (CCAMLR 2014). However, three known illegal vessels were active in the Ross Sea in the 2014/2015 fishing season. IUU catch is not included in assessments as the results of simulations on the sensitivity of stock assessments to levels of uncertainty in IUU catch estimates suggest that, in general the inclusion of an overestimate of IUU catch resulted in an overestimate of stock productivity, and hence an overestimate of initial and current biomass (Report of the Joint Assessment Group (Jag) 2006).

Clear documented harvest control rules are in place and are applied annually in CCAMLR advice on TACs. The decision rule procedure requires Monte Carlo simulations of the population biomass over a 35-year projection under a constant catch. Estimates of appropriate catch limits are derived by determining the maximum catch level (fishing mortality) that has a less than 10% chance of reducing the spawning stock biomass to below 20% of the level that would occur in the absence of fishing and at least a 50% chance of being at or above 50% of the biomass without fishing.

Specifically, the rule is

1. Choose a yield, γ1, so that the probability of the spawning biomass dropping below 20% of its median pre-exploitation level over a 35-year harvesting period is 10% (depletion probability).
2. Choose a yield, γ2, so that the median escapement at the end of a 35-year period is 50% of the median pre-exploitation level.
3. Select the lower of γ1 and γ2 as the yield.

In applying the CCAMLR decision rules using the CASAL model, assumptions tended towards increasing the estimate of the probability of depletion. In estimating the unexploited biomass, the initial equilibrium biomass was used.

Note that the CCAMLR decision rules are often misunderstood with a supposition that under the catch limit calculated at each assessment the decline in population size will follow a clear trajectory from the initial year of assessment to a 35 years later where the stock size will be reduced to 50% of pre-exploitation levels. This is not the case and the catch limit is recalculated each time an assessment is conducted based on all available updated or revised information. This approach ensures that the 50% level will be approached slowly during which time appropriate catch levels are continually readjusted as knowledge improves.

5 Principle Two: Ecosystem Background

5.1 Ross Sea Ecosystem Characteristics

The Ross Sea Ecosystem is part of the Southern Ocean, wholly located within the CCAMLR Convention Area. Scientific research has been conducted in the area for many decades, and substantial knowledge has been accumulated regarding the major components of the regional ecosystem, and something of their relationships and interactions. Uncertainty remains about aspects of most ecosystem components and relationships, but there is sufficient knowledge to generally characterise the ecosystem. Descriptions of the ecosystem characteristics of the Ross Sea are available in Pinkerton (2015), Mitchell (2014), the original MSC assessment of the fishery (Moody Marine, 2010) and references therein.

Bathymetry – The Ross Sea includes a major shelf zone, generally ranging between 350 and 500 m. The shelf zone has a few plateaus of less than 400 m. but generally the topography is highly irregular across the shelf. These depths extend quite close to the shoreline on all three land-borders of the Ross Sea, with the band of shallower coastal depths rarely extending more than a few tens of kilometres from the coast and islands (most of which are located near the Antarctic land mass). The shelf break runs irregularly from northwest to southeast beyond the outer edge of the eastern and western land boundaries of the sea (approx. 72 deg S in the west to 77 deg S in the east). Beyond the shelf break depths drop rapidly to over 1,500-2,000 m, continuing somewhat less steeply to depths below 3000 m. beyond the continental margin of Antarctica

Physical Oceanography - A major oceanographic feature of the Ross Sea Ecosystem is the Antarctic Slope Front, a feature linked lightly to the continental slope. This front separates the waters to the south, inside Ross Sea, from the waters of the Antarctic Coastal Current. The front and major currents at the opening of Ross Sea, and complex bottom topography on the shelf create complex patterns of eddies, gyres and upwelling, that contribute to the productivity of the Ross Sea. Much of the Ross Sea's physical oceanography is dominated by the presence of the Ross Sea Polynya, which is a large area of reduced pack ice cover and open water surrounded by denser pack ice concentrations. Large icebergs occasionally become grounded and can restrict the advection of pack ice off the shelf. Very large grounded icebergs in strategic locations may potentially impact the food web.

Primary Productivity – General features of primary and secondary productivity in the Ross Sea are understood. Productivity is highly seasonal, with centres of production taking place along the ice edge as the annual ice cover melts and breaks up, in polynyas, coastal embayments, and the Polar Front and the Antarctic Slope front. Cryophyllic (ice) algae growing under and in the extensive sea ice are also an important source of organic matter in the Ross Sea, contributing approximately 20% of local production (Smith et al., 2007). Temporal dynamics of ice algae are quite different to phytoplankton with the seasonal increase and associated release into the water column and subsequent flux and/or remineralisation occurring prior to planktonic export.

Zooplankton – Antarctic krill (*Euphausia superba*) is not a key structuring species in the Ross Sea and less is known about the dynamics of zooplankton. The biomass of macrozooplankton is generally low but highly patchy and variable, with a relatively small number of taxa generally constituting the large majority of individuals present. Crystal or ice krill (*Euphausia crystallorophias*) are thought to represent an important link between the ice and the water column, owing to their prominence in the diets of upper trophic level species. *E. superba* may be important at greater depths in more open waters.

Fish – The fish community in Ross Sea is relatively species poor. The Ross Sea fish fauna is overwhelmingly dominated by a single family, the notothenioids, dominating 77% of all species and 91% of the biomass. In addition to their taxonomic importance, notothenioids are considered extremely important within the food web of the Ross Sea. The most abundant large fish is the Antarctic toothfish *(D. mawsoni*). Other important teleosts in Ross Sea include at least five species of Macrouridae, all of which are deep-water species, of which only *Macrourus whitsoni* and *M.Caml* are considered to be common. Ten species of icefish, Channichthydae, have also been recorded in the Ross Sea, with different species found in depths from 100 to over 1000 m and several relatively common. Three species of eelcods (*Muraenolepis* sp.) are the only other species group taken in moderate numbers in surveys. At least five species of skates and rays are also present in Ross Sea, with two species, *Bathyraja cf eatonii* and *Amblyraja georgiana*, most common.

Top predators: Birds/Mammals –Over the shelf the cetacean population is composed of minke whales, killer whales and the much less common Arnoux's beaked whales (Smith *et al*., 2007). Avian populations are comprised primarily of Adélie and emperor penguins and petrels, principally Antarctic and snow petrels. Pinniped assemblages are dominated by crabeater seals, but also include Weddell seals, leopard seals, Ross seals and elephant seals. All of these top predators prey primarily on two key species in waters over the shelf – the Antarctic silverfish and crystal krill (Smith et al., 2007), except near the shelf break where Antarctic krill (*E. superba*) and myctophid fish replace crystal krill in top predator diets.

5.2 Retained species and By-catch

Management approach - A range of CCAMLR Conservation Measures (CMs) apply to ecosystem management and target, retained and bycatch species in particular. The Ross Sea toothfish fishery is designated an 'Exploratory Fishery' under CM21-02 (2013) - requiring a data collection plan sufficient to "evaluate the distribution, abundance and demography of the target species, leading to an estimate of the fishery's potential yield; (b) to review the fishery's potential impacts on dependent and related species and (c) to allow the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate". This specifically aims, therefore to develop the fishery in combination with appropriate and relevant information gathering.

Data recording is strongly regulated by CCAMLR, including CM23-07 requiring 5-day

reporting of total catch (of all species) and effort in specific areas; and for exploratory fisheries CM23-07 requires daily reporting of the total green weight, by vessel, of each target species and by-catch species for which there is a catch limit in that area and the number of hooks in the water. Additionally, CM 23-05 requires monthly reporting of samples of length composition measurements of the target species and by-catch species and CM 23-04 requires a comprehensive monthly summary – set by set – being position and effort data, all target and by-catch species by weight and number, any marine mammal or seabird mortalities or releases, and a list of all tagged fish with the associated release and recovery data. CM 41-01 sets additional data requirements for exploratory fisheries.

Conservation Measure 33-03 (2014) sets out measures to achieve the outcome of restrictions on bycatch; the measures are specifically designed for new and exploratory fisheries within the CCAMLR area and contain mechanisms for control of fishing should specified levels of bycatch be exceeded. Bycatch limits and other requirements of CM33-03 are:

- Skates and rays: 152t in 88.1, 50t in 88.2: greater of 5% of catch or 50t per SSRU
- Macrourus spp: 430t in 88.1, 99t in 88.2: greater of 16% of toothfish catch or 20t per SSRU
- All other species combined: 20t per SSRU
- Skates to be released alive if high probability of survival
- Bycatch of any species >1t requires vessel to move at least 5nm and not return for 5 days.
- *Macrourus* by-catch; Should the catch of *Macrourus* spp. taken by a single vessel in any two 10-day periods in a single SSRU exceed 1 500 kg in each 10-day period and exceed 16% of the catch of *Dissostichus* spp. by that vessel in that SSRU in those periods, the vessel shall cease fishing in that SSRU for the remainder of the season.

CM 41-09 sets out limits on the exploratory fishery in subarea 88.1 and CM 41-10 for 88.2, including SSMU limits on bycatches, requirements for 200% observer coverage (that is two observers per vessel licenced to operate in the exploratory fishery), and participation in research and tagging programmes.

5.2.1 Retained species

The only retained species caught in the fishery is Patagonian toothfish (*D eleginoides*); Patagonian toothfish is caught in small amounts (0 to 30t per year) in the extreme north western part of the Ross Sea (88.1A and 88.1B) with total catches of around 130t over the history of the fishery (Pinkerton 2015). Subsequent to that time there have been an additional 10 tonnes reported in 2013/14; figures for 2014/15 indicate a total catch of 566 kilograms from 88.1 and 29 kilograms from one of the vessels taking part in the post-season research in 88.2 A and B north. There has not been an assessment of the Patagonian toothfish stock but all standard reporting requirements apply. The species is also required to be tagged in proportion to its representation in the catch (and although not directly relevant here, a preliminary assessment is apparently planned by New Zealand scientists). As the overall TAC for the Ross Sea is set on *Dissostichus* species rather than *Dissostichus mawsoni*, any Patagonian toothfish caught come off the overall area allocation, so there is not expected to be additional targeting of this species.

Other ‘retained species’ are those used as bait, currently this is almost entirely Humboldt squid *Dosidicus gigas* caught off South and Central America by Client Group vessels (J Fenaughty pers. comm.). Jack mackerel and sardines have also been used at times but in significantly smaller proportions. Recently, *D. gigas* has undertaken a massive expansion in geographic range from its historical centre of Peru to central Mexico and now extend from the tip of Chile to Alaska. There is a very large population in the Gulf of California, Mexico

that has apparently recently established there. Humboldt squid mature quickly and have a high reproductive output. Currently there are no stock assessments, which may be a cause for future concern, but populations are currently thought to be healthy. A significant fishery exists in the Gulf of California, Mexico where catches increased from 14 tons per year in 1974 to over 19,000 tons in 1980 and since then, average under 10,000 tons annually. (http://www.oceanwise.ca/seafood/squid/humboldt-squid-jumbo-squid, http://marinebio.org/species.asp?id=249).

5.2.2 Bycatch

The first MSC surveillance report on the fishery (Moody Marine, 2011) provided a comprehensive listing of bycatch species and their proportion of the total catch.

Species	% total weight
[Antarctic toothfish	93.46%]
Rat tails, Grenadiers	3.68%
Rattail Macrourus whittsoni	1.93%
[Patagonian toothfish	0.23%]
Moray cods	0.23%
Ray Raja georgiana	0.15%
Crocodile icefishes	0.11%
Blue antimora	0.05%
Eaton's Skate	<0.05%
Ridge-scaled rattail	<0.05%
Skates and rays	<0.05%
Smalleye moray cod	<0.05%
Icefish spp.	<0.05%
Rays and skates nei	<0.05%
Invertebrates	<0.05%
Moonfish	<0.05%
Starfishes nei	<0.05%
Antarctic Rockcods	<0.05%
McCain's skate	<0.05%
Blackfin icefish	<0.05%
Marbled moray cod	<0.05%
Octopus spp.	<0.05%
Eelpout	<0.05%
plunderfish	<0.05%
Opah	<0.05%
Crab spp.	<0.05%
Plunderfish	<0.05%
Striped rockcod	<0.05%
Lepidion codlings nei	<0.05%
Scaly rockcod	<0.05%
Pennatulacea sea pens	<0.05%
Sea cucumbers nei	<0.05%
Sea anemones	<0.05%
Hydroids, hydromedusae	<0.05%

Humped rockcod	<0.05%
Grey rockcod	<0.05%
Gorgonians	<0.05%
Black corals and thorny corals	<0.05%

Combined data for the years 1998-2010 were also presented in Hanchet et al 2010, and summarised below.

Species	(t)	(%)
TOA	23 511	89%
TOP	124	0%
GRV	2 342	8%
SRX	279	1%
OTH	278	1%
Total	**26 138**	

(TOA, Antarctic toothfish; TOP, Patagonian toothfish; GRV, grenadiers (rattails); SRX, Rajiids (skates and rays); OTH, includes mainly icefish, morid cods and moray cods).

The fishing vessels within the client group also use different fishing systems; most use autoliner longlines, and one uses the Spanish system longline. The two systems are compared below (based on 2014/15 catch) to determine any differences in amounts of bycatches which may affect designation of bycatch species:

Species	Code	Autoline	Spanish
Antarctic toothfish	TOA	97.89%	93.76%
Macrourus	GRV	1.52%	4.53%
Icefish	ICX	0.28%	0.94%
Moray cods	MRL	0.01%	0.39%
Antimora rostrata	ANT	0.02%	0.22%
Skates	SRX	0.26%	0.09%
Patagonian toothfish	TOP	0.01%	0.03%
Rockcods	NOX	0.00%	0.02%
Starfish	STF	0.00%	0.02%
Octopus	OCT	0.00%	0.00%
Plunderfish	PGR	0.01%	0.00%
Crabs	KCX	0.00%	0.00%

According to MSC guidance, a ‘main’ bycatch species would be one which comprises over 5% of the total catch, is of high value to fishers or is of particular vulnerability.

Of bycatch species macrourids and skates are considered the most vulnerable species. Grenadiers, particularly *Macrourus whitsoni* may approach or exceed 5% of bycatch (possibly higher with Spanish system longlines), and rays, particularly the starry skate *Amblyraja georgiana* are present in much lower quantities but may be vulnerable to fishing pressure due to their life history characteristics.

An initial assessment of *M. whitsoni* suggested indicative estimates of yields in the order of 386-759t, consistent with bycatch limits for all Macrourus spp of 430t in 88.1, 99t in 88.2 and

catches consistently below 50% of this limit (Pinkerton 2015). Although initially thought to be a single species recent work has indicated that there are two species involved. This will be reviewed as more information becomes available in the future.

Initial work has also been undertaken to estimate skate catches, survivorship after release and populations through tagging (Mormede and Dunn 2010). Skates comprised 5-11% of catches in the first three years of the fishery but have since comprised <2% of landed catch. In part this will be due to release of live skates under CM 33-03, with reasonable survival expected. Moray (eel) cods (notably *Muraenolepis evseenkoi*) comprise the next most abundant bycatch. This species may be semelparous (breeding once in its lifetime), which would increase population effects of fishing mortality but it is also a prey species for toothfish and so would also exhibit 'predator release' due to fishing of toothfish (Hanchet et al 2010; Pinkerton 2015).

5.3 Protected, Endangered and Threatened Species

Species of bird and marine mammal are protected either through international agreements such as the Agreement on Conservation of Albatross and Petrels (ACAP), International Whaling Commission, Convention for the Conservation of Antarctic Seals (1972), CITES or national legislation enacted by members of the Client Group.

5.3.1 Birds

The fishery overlaps spatially and temporally with foraging ranges of several species of seabird. The most abundant penguins are Emperor Penguins and Adelie Penguins. Emperor Penguins are primarily piscivorous, with notothenioids as the predominant prey, but euphausiids also important in the diet. Adelie Penguins have similar diets as Emperor Penguins with a greater representation of euphausiids. Petrels number in the millions in Ross Sea; 6 species are present, nearly two-thirds are Antarctic petrels and nearly half the rest being snow petrels. Petrels forage from breeding colonies along the coast during the summer, but are widely distributed throughout the Southern Ocean during the rest of the year. Two species of albatross also forage in the area during the summer, particularly oceanward of the Antarctic Slope Front.

A strategy is in place, implemented through CCAMLR Conservation Measures CM 24-02 and 25-02 to avoid seabird bycatch. These CMs require the use of streamer lines to keep foraging birds away from lines during setting and hauling, weighted lines to achieve fast sink rates and avoidance of the discharge of offal south of 60°S which would attract birds to fishing vessels. Only two seabirds have been caught on a longline in the history of the fishery (Pinkerton 2015) showing the success of this strategy.

5.3.2 Mammals

Both cetaceans and pinnipeds are present in Ross Sea. The most numerous mammal is the crabeater seal. Weddell seals (*Leptonychotes weddellii*) are much less abundant but a significant portion of the population of this uncommon seal is present in the Ross Sea; this seal is also piscivorous and toothfish may play an important role in their diet. The third important pinniped is the leopard seal, which is a major predator on other seals, cetaceans and occasionally large fish. All these pinnipeds remain part of the Ross Sea food web for the entire year, moving as the ice move. Weddell seal are classified by IUCN as being of Least Concern.

In addition, there are several species of both baleen and toothed whales. The major baleen whales are minke, blue, fin and humpback. These are all invertebrate feeders, requiring

high densities of euphausiids. The other whales are thought to be fairly wide-ranging, but for all of them, the Ross Sea represents an important feeding area.

Of the toothed whales, the strongly piscivorous type C killer whales are the most ecologically significant in relation to the fishery, feeding on large toothfish as a common prey. This species unit was thought to have a significant fraction of its population, possibly a separate breeding unit, closely linked to the Ross Sea fish community for the entire year. However recent work by New Zealand and Italian scientists (Eisert *et al* 2015) have found definitive evidence, derived from two independent methods (Satellite tagging and photo identification) that type C killer whales undergo long-distance travel from the southern Ross Sea to New Zealand waters and into sub-tropical regions (31° to 35° south). Other species of toothed whales are uncommon to rare in Ross Sea, including sperm whales and southern bottlenose whales (Mitchell 2014). Killer whales are listed on CITES Appendix II (Appendix I is used to define species as ETP for MSC assessments) and classified by IUCN as Data Deficient (with some populations greatly reduced). For killer whales globally, the combination of potential declines driven by depletion of prey resources and the effects of pollutants is believed sufficient that a 30% global reduction over three generations (77 years; Taylor et al. 2007) cannot be ruled out for some "groups" that may be designated as species. (IUCN at http://www.iucnredlist.org/).

There has been no reported catch of marine mammals on longlines in the history of the fishery (Pinkerton 2015). Any effects of the fishery on mammals will therefore be indirect trophic impacts. Such effects are most likely to affect particular populations at specific times – changes to toothfish availability near Weddell seal colonies between pupping and weaning could affect lactating mothers and so pup survivorship (Eisert, 2013) and toothfish may be a significant prey item for type C killer whales in McMurdo Sound in summer, a time of apparent high incidence of suckling calves. As outlined in Pinkerton (2015) the fishery could affect predators through: a) localised depletion of toothfish within a season, b) reducing the number of subadult toothfish in the southwest Ross Sea and c) by changing the movement patterns of toothfish, particularly by reducing numbers of large toothfish on the slope, causing other large toothfish to move from the shelf, particularly in the south west. In relation to a), fishing closures are in place in waters shallower than 550m and in SSRU 88.1 M; for b) sub adult surveys in the southwest Ross Sea shows no significant change in catch rates. The remaining uncertainty is therefore over potential changes in movement patterns of toothfish. Indirect interactions through damage to the habitats of protected species by the fishing gear are considered to be negligible in these longline fisheries.

5.4 Benthic Habitats

On the continental shelf of the Ross Sea, the role of ice disturbance (e.g. ice-cover persistence, anchor ice and ice scouring) is dominant, facilitating the occurrence of communities dominated by relatively opportunistic species. Where such disturbance is absent, benthic communities exhibit a high level of stability and contain a variety of large and potentially long-lived species controlled by food availability; only below 500m does the downward flux of organic material seem to regulate faunal distributions.

Hard bottom habitat represents only a small portion of the total Ross Sea benthos - largely along the shore and in offshore reefs and seamounts where the bottom currents are intense and sediments are scoured. There is information on habitats and communities in the littoral and shallow sublittoral zone. Below 130m, hard bottom habitats become sparse, where outcrops are present these are mainly colonised by the polychaete *Serpula narconensis* and bryozoans; otherwise hard bottoms are only found on seamounts, ridges or along the shelf break, where sessile species such as stylasterids (*Errina sp.*) and Antarctic acorn barnacle (*Bathylasma corolliforme*) can be found.

Soft sediments in the Ross Sea are relatively course and are characterised by gravel or muddy sand through 400-500m (Smith *et al.*, 2007). At depths up to 500m, bryozoan mats generally dominate soft bottom substrata, forming a deep shelf mixed assemblage but polychaetes and ophiuroids can also dominate locally (Smith *et al.,* 2007).

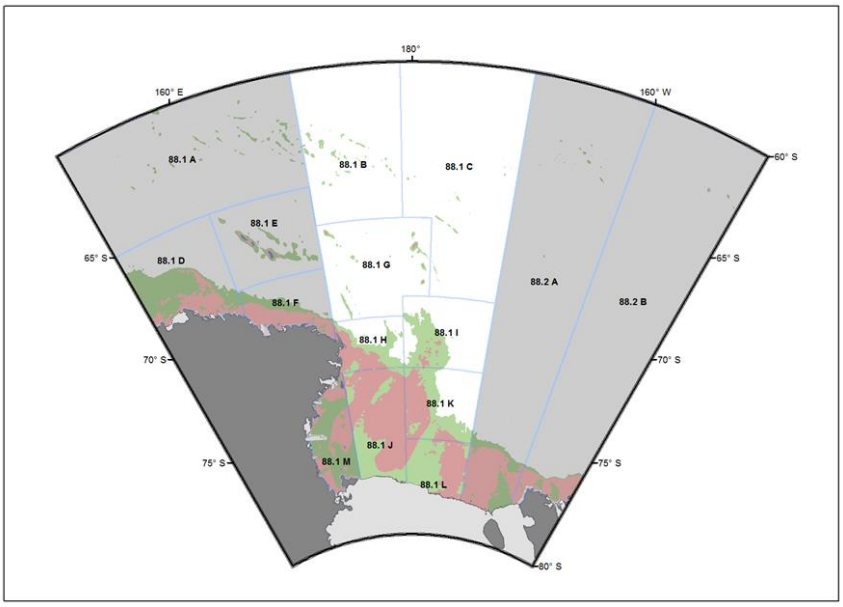


Figure 2: The Ross Sea region and Small Scale Research Units (SSRUs) used for managing the fishery. The shaded SSRUs are currently closed to fishing.

Most fishing in the Ross Sea occurs at depths of 550–1800 m (green areas in figure 2 above), and fishing is prohibited in bottom depths less than 550 m (pink in figure 2 above). The available information suggests that benthic fauna is limited below 500m depth.

The total areas of seabed (km^2) within the Ross Sea are:

	Total	Open to Fishing (550-1800m)	% Fished	Total <1800m	% Fished
88.1	2 852 323	140 598	4.9	579 371	24.2
88.2	4 860 805	106 007	2.2	377 778	28.0

CCAMLR has also introduced a suite of measures to protect habitats, and in particular Vulnerable Marine Ecosystems (VMEs) and potential VMEs in areas beyond national jurisdiction (i.e. high seas):

- CM 22-04 and 22-05 contain provisions for restrictions on 'higher risk' bottom fishing activities by gill net and trawl
- CM 22-06 contains provisions for a) notification of the known and expected effects of the proposed fishing by each Contracting Party (including VMEs, benthos and benthic communities), for preliminary assessment by the Scientific Committee and approval by the Commission; b) cease fishing on encountering VMEs and report such encounters; c) the Scientific Committee maintains a register of VME locations and provides advice for their protection
- CM 22-07 contains provisions for identification of VME 'risk areas' and their closure to fishing by CCAMLR secretariat
- CM 22-08 contains provisions for prohibition of fishing in depths shallower than 550m for the protection of benthic communities.

- CM 22-09 prohibits all bottom fishing activities within defined areas, including two areas within SSRU 'G' in subarea 88.1
- CM 23-07 requires daily reporting of catches of target species and bycatch species, including benthic species/VME 'indicator units'.

Encounters with VMEs in the high seas of the Convention Area are notified under CM 22-06 and agreed instances of VMEs are recorded in the CCAMLR VME Registry. VMEs which occur in areas where bottom fishing is permitted are afforded special protection under Conservation Measure 22-09.
The protocol for monitoring and reporting the incidental take of VME-indicator taxa is described in CM 22-07. The number of VME-indicator units recovered in each line segment of bottom-set longline (or string of pots) is reported to the CCAMLR Secretariat. Line segments with 5 or more VME-indicator units are reported immediately, and VME risk areas are declared within 1 nautical mile of the mid-point of each line segment with 10 or more VME-indicator units. Risk areas are immediately closed to further bottom fishing, and remain closed until reviewed by the Scientific Committee and management actions are determined by the Commission. Scientific research endorsed by the Scientific Committee is allowed in risk areas.

The effect of longline fishing on benthos in the Ross Sea has been estimated by Sharp (2010). His conclusion was that estimates of total cumulative impact by New Zealand bottom fishing vessels in the Ross Sea fishery on benthic organisms remain low, on the order of 0.01% to 0.03% mortality for the most fragile VME taxa in the most heavily fished bioregions (i.e., on the Ross Sea shelf edge and continental slope). Extending this to the whole client group would mean 0.02-0.08% mortality – levels of impact that would not plausibly cause major changes in the structure or diversity of species assemblages.

6 Principle Three: Management System Background

6.1 Area of operation of the fishery and under which jurisdiction it falls

The fishery is located in high seas waters in the area managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The CAMLR Convention developed from concerns amongst Antarctic Treaty Consultative Parties about increased commercial interests developing in fisheries resources around the Antarctic continent. CCAMLR was established in 1982, and currently comprises 25 members. In addition, 11 countries have acceded to the Convention. The objective of the Convention is "the conservation of Antarctic marine living resources"[3]. The link with the Antarctic Treaty System distinguishes CCAMLR from regional fisheries management organisations.

CCAMLR's area of responsibility is shown in Figure 1, and is defined as "all waters bounded by the Antarctic Continent to the south, and to the north by a line starting at 50°S 50°W; thence due east to 30°E longitude; thence due north to 45°S latitude; thence due east to 80°E longitude; thence due south to 55°S latitude; thence due east to 150°E longitude; thence due south to 60°S latitude; thence due east to 50°W longitude; thence due north to the starting point"[4]. The fishery occurs in Sub-areas 88.1[5] and 88.2[6], of the CAMLR

[3] www.ccamlr.org/en/organisation/camlr-convention-text

[4] www.ccamlr.org/en/organisation/convention-area-technical-description

[5] The waters bounded by a line starting at 60°S 150°E; thence due east to 170°W longitude; thence due south to the Antarctic Continent; thence westward along the coast of the Antarctic Continent to 150°E longitude; thence due north to the starting point. (www.ccamlr.org)

[6] The waters bounded by a line starting at 60°S 170°W; thence due east to 105°W longitude; thence due south to the Antarctic Continent; thence westward along the coast of the Antarctic Continent to 170°W longitude; thence due north to the starting

Convention area.

Under the CCAMLR system, the fisheries in the RSR and ASR are categorised as "exploratory". Exploratory fisheries may transition to "established" status. While classified as 'exploratory', fisheries:

- are "not allowed to expand faster than the acquisition of information necessary for managing the fishery within CCAMLR's management objectives", and,
- require notification and permission prior to fishing occurring.

Fisheries remain exploratory until "sufficient information is available on appropriate catch and effort levels and the potential impacts on dependent and related species"[7].

CCAMLR Members are responsible for implementing the requirements of the Commission in their own fishing vessels. Further, member states may develop additional requirements of vessels operating under their flag. The client group to which this assessment relates comprises vessels flagged to five countries (Australia, New Zealand, Norway, Spain, UK). Therefore, the management framework, and commensurately, the requirements that vessels must operationalise, differ to a degree across the client group.

The fishery occurs in the high seas and targets toothfish which are not highly migratory. In accordance with MSC requirements, CCAMLR addresses or exceeds the requirements of the FAO Code of Conduct for Responsible Fisheries (FAO 1995) and the provisions of the United Nations Fish Stock Agreement (UNFSA 1995). Particular examples of alignment amongst these instruments include the objective of the CAMLR Convention, the application of the precautionary approach, emphasis on the use of the best available information, ongoing collection and sharing of scientific and technical information, and cooperation amongst members to manage fish stocks. Therefore, when scoring the management framework of the fishery, the assessment focuses on the CCAMLR requirements, which are more often binding, as well as being prescribed in a greater level of detail.

6.2 Particulars of the recognised groups with interests in the fishery

In addition to the members of CCAMLR, flag state governments, and the client group, broader stakeholder interest in the fishery is extremely high. The development of the fishery continues to be controversial, raising its profile amongst stakeholders including scientists, industry and environmental groups. Amongst the international community, regional fisheries management organisations and some multilateral agreements relating to marine conservation or wildlife management have interests in the activities of CCAMLR, and the Ross Sea fishery. In addition to other components of the Antarctic Treaty System, groups with particular interests in the activities of CCAMLR and the fishery include the following.

International bodies:

- Agreement on the Conservation of Albatrosses and Petrels
- International Whaling Commission
- Regional Fisheries Management Organisations

Environmental non-governmental organisations:

- Antarctic and Southern Ocean Coalition
- World Wide Fund for Nature (WWF) – Antarctic and Southern Ocean Initiative

Industry non-governmental organisations:

- Coalition of Legal Toothfish Operators

point. (www.ccamlr.org)

[7] www.ccamlr.org/en/fisheries/regulatory-framework

These groups have often been represented as observers at CCAMLR meetings (e.g., CCAMLR 2014). Further, member delegations include representatives of additional groups with particular interests. Delegation membership is documented in the reports of the Commission and Scientific Committee (e.g., CCAMLR 2014, SC-CAMLR 2014). Finally, interested groups contributing to this reassessment and surveillance audits following the previous assessment of this fishery include WWF – New Zealand, and Environment and Conservation Organisations of Aotearoa New Zealand (ECO).

6.3 Details of consultations leading to the formulation of the management plan and ongoing consultations with interest groups

The management plan for each fishing season is developed by CCAMLR annually when the Commission meets in Hobart, Australia, in October. Commission meetings consider the findings of the Commission's subsidiary bodies, including the Scientific Committee, and the advisory groups of those bodies (e.g., the Working Group on Fish Stock Assessment). The Commission makes decisions primarily by consensus amongst its members. Therefore, nations not fishing in the Ross Sea are also able to influence and contribute to its management.

The management actions required of the fishery by CCAMLR are articulated in a series of Conservation Measures[8]. Conservation measures are dynamic, in that they can be readily amended between fishing seasons and are reviewed on an ongoing basis. Member states are responsible for implementing these measures on their own fishing vessels. This typically involves enacting CCAMLR requirements in domestic legislation.

The flag states of client group vessels develop their own positions entering into CCAMLR meetings. This is achieved in different ways amongst client group flag states.

Australia: Consultation processes administered by Australian government agencies to develop their position on the Ross Sea fishery involve the Sub-Antarctic Resource Assessment Group, the Sub-Antarctic Fisheries Management Advisory Committee, and the CCAMLR Consultative Forum. These groups include members from government organisations, environmental groups, industry, and scientists. The Australian Antarctic Division leads Australia's involvement in CCAMLR, while the Australian Fisheries Management Authority implements the Commission's requirements. Other government agencies involved in the fishery include the Australian Customs and Border Protection Service, and the Department of Foreign Affairs and Trade.

New Zealand: In New Zealand, consultation processes leading to the state's position taken to CCAMLR, and the development of the management approach in the fishery, include meetings of the Industry Toothfish Committee (government and industry) and the Antarctic Working Group (open membership that includes scientists, government, environmental and industry groups). Government agencies involved in the fishery include the Ministry of Foreign Affairs and trade, the Ministry for Primary Industries and the Department of Conservation. Government agencies meet with stakeholders three times annually (before and after CCAMLR meetings, and on one other occasion). In addition, consultation on scientific matters relating to the fishery occurs on an ongoing basis.

Norway: Responsibility for fishing activities in CCAMLR waters is held by the Ministry of Fisheries and Coastal Affairs Industry, Trade and Fisheries and the Directorate of Fisheries. These agencies implement legislation to enact CCAMLR's requirements. At the legislative level, comprehensive written hearings are undertaken on draft legislation prepared by the Ministry of Industry, Trade and Fisheries. Draft legislation is prepared by committees with

[8] www.ccamlr.org/en/document/publications/schedule-conservation-measures-force-2014/15

broad representation that includes stakeholder groups. The Institute of Marine Research prepares a strategic plan that highlights critical areas for marine research relating to fisheries management research. This is implemented through annual plans developed in consultation with the Ministry of Industry, Trade and Fisheries.

Spain: The requirements of CCAMLR relevant to Spanish activities in the Ross Sea are enacted through legislation of the European Union and domestic policy. Overall responsibility for policy relevant to Spain's participation in CAMLR Convention is held by the Secretariat-General for Fishing (Secretaria General de Pesca) of the Ministry of Agriculture, Food and Environment (Ministerio de Agricultura, Alimentacion y Medio Ambiente). In advance of annual CCAMLR meetings, consultation opportunities are provided for non-government organisations and industry. These meetings include government agencies, policy advisors, industry, non-government organisations, research providers and other interested parties. With respect to science specifically, the Instituto Español de Oceanografía Centro Oceanográfico de Canarias is the main provider. There is additional science input on an ad hoc basis from other research establishments and universities.

UK: Similar to Spain, the requirements of CCAMLR relevant to UK activities in the Ross Sea are enacted through legislation of the European Union and domestic UK policy. Overall responsibility for management of the UK's policy in relation to CCAMLR lies with the Polar Regions Unit of the Overseas Territories Directorate (Foreign and Commonwealth Office (FCO)). The FCO submits the required notifications to CCAMLR for fishing in the Ross Sea. Permits for UK vessels fishing in Antarctic waters are granted by the Secretary of State for Foreign and Commonwealth Affairs. The FCO provides written agreement allowing fishing, when it is satisfied that required conditions for fishing will be met. (Conditions include licensing, safety and insurance, compliance with CCAMLR Conservation Measures, etc.). Consultation processes leading to the position taken to CCAMLR, and the development of the management approach in the fishery, include review of the fishing activities by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). Government agencies consult with and meet with stakeholders as deemed necessary.

6.4 Details of non-fishery users or activities, which could affect the fishery, and arrangements for liaison and co-ordination

CCAMLR as an organisation is well connected to non-fishery users and activities. These may be related to management, science, or the Antarctic Treaty System. Formal connectivity between organisations is most often evident through the presence of observers from these organisations at meetings. With respect to management, the CAMLR Convention specifically excludes whales and seals. These are covered by other conventions: the International Convention for the Regulation of Whaling and the Convention for the Conservation of Antarctic Seals. In the absence of commercial seal take, the Scientific Committee on Antarctic Research (SCAR) monitors scientific take of seals. In addition to attending CCAMLR meetings as an observer, SCAR and CCAMLR collaborate and cooperate on initiatives relating to Antarctic science, and share information on an ongoing basis. Like SCAR, the Science Committee on Oceanic Research (SCOR), which arose from the International Council for Science, has attended CCAMLR meetings in an observer capacity. Finally, as part of the Antarctic Treaty System (ATS), CCAMLR has ongoing linkages with other ATS components, including the Committee for Environmental Protection.

6.5 Details of the decision-making process or processes, including the recognised participants

The management decision-making body in CCAMLR is the Commission. This includes the Scientific Committee, and two subsidiary bodies: the Standing Committee on Implementation and Compliance and the Standing Committee on Administration and Finance. The decision-making process undertaken by the Commission (including the Scientific Committee) is

informed by management advice provided by its working groups.

At the Commission, each member contributes one representative, who can be accompanied by alternate representatives and advisors. Matters of substance are determined by consensus decision-making. A Chair and Vice-chair oversee the Commission. These appointments are two years in term, and are made by election amongst members.

At a national level, government agencies make decisions about fishery activities. Decisions are supported by some level of consultation. For the flag-states of vessels operated by the client group, the main government agencies involved in decision-making processes are:

- Australia: Department of Foreign Affairs and Trade, Australian Antarctic Division (Department for the Environment), Australian Fisheries Management Authority
- New Zealand: Ministry for Foreign Affairs and Trade, Ministry for Primary Industries, Department of Conservation
- Norway: Ministry of Industry, Trade and Fisheries, Directorate of Fisheries
- Spain: Ministry of Agriculture, Food and Environment
- UK: Overseas Territories Directorate of the Foreign and Commonwealth Office

At the level of the client group, decisions on fishery activities are made within fishing companies by which vessels are owned and/or operated [9]:

Australia: Australian Longline Pty Ltd
- *Antarctic Chieftain*

New Zealand: Sanford Ltd
- *San Aspiring* and
- *San Aotea II*

New Zealand: Talley's Longline
- *Janas*

Norway: Stadt Havfiske AS
- *Selijivaer*

Spain: Pesquerias Georgia SL
- *Tronio*

UK: Argos Georgia Ltd,
- *Argos Georgia*
- *Argos Froyanes*

Members of the client group consult each other and make decisions on their activities in the fishery via ongoing communications that are largely electronic in nature. Silvifish Resources Ltd is employed by the Client Group to provide the Group coordinators as well as research and logistic support. Face to face meetings take place annually between the Client Group coordinators and both northern and southern hemisphere members.

6.6 Objectives for the fishery:

The single long-term objective for the fishery is articulated by the CAMLR Convention, Article 2: "the conservation of Antarctic marine living resources". This objective has been operationalised by the harvest strategy such that the lower yield of the following two options

[9] www.ccamlr.org/en/compliance/licensed-vessels

is implemented: (i) the probability of the spawning biomass dropping below 20% of its median pre-exploitation level, over a 35-year harvesting period, is 10%, or, (ii) the median escapement in the spawning stock biomass over a 35-year period is 50% of the median pre-exploitation level, at the end of the projection period (Constable et al. 2000). Objectives for other elements of the fishery (e.g., bycatch) have not been articulated as specifically as this harvest strategy. However, in that case, the existence of limits supports the intent of the fishery's conservation objective.

6.7 Details of those individuals or groups granted rights of access to the fishery, and particulars of the nature of those rights.

The Ross Sea toothfish fishery is a catch-limited Olympic fishery. Vessels are able to enter the fishery when the season opens, and fish until the catch limits are reached in each area. There are no allocated individual or group-based rights to catches of any particular volume. In addition, members of CCAMLR who wish to fish in the Ross Sea must apply, in accordance with the CCAMLR process specified annually. Permission to enter the fishery is granted by the Commission. This makes it possible for, but does not require, vessels to enter the fishery.

For the 2014/15 fishing season, the Commission granted access to the Ross Sea fishery to eight vessels from the client group: *Antarctic Chieftain*, *Argos Froyanes*, *Argos Georgia*, *Janas*, *San Aotea II*, *San Aspiring*, *Seljevaer*, and *Tronio*.

6.8 Description of the measures agreed upon for the regulation of fishing in order to meet the objectives within a specified period.

Fishing is managed through a comprehensive and detailed suite of Conservation Measures. These may be updated annually. Conservation Measures are legally binding instruments, and compliance is assessed against their requirements. They range in scope from generic, applying to all CCAMLR fisheries, through to very specific, for example, focused on catches of certain species, using particular fishing methods or occurring in a particular Sub-area. Components of fishery management covered off by Conservation Measures include, but are not limited to, catch limits for the target species, bycatch limits, the catch documentation scheme, port inspections, requirements of an exploratory fishery, gear restrictions, Vulnerable Marine Ecosystems, catch and effort reporting requirements, measures required to minimise the incidental mortality of seabirds, requirements relating to carrying observers, and waste management.

A list of Conservation Measures in force for the 2014/2015 fishing year, together with the full text of the Measures themselves, is available at: www.ccamlr.org/en/conservation-and-management/browse-conservation-measures. Historic versions of Conservation Measures are also available[10], and illustrate the development of the fishery and its management over time.

In addition to legally-binding Conservation Measures, CCAMLR has developed a number of resolutions over time. Resolutions are non-binding, but members are encouraged to implement them to support the actions required by Conservation Measures.

6.9 Particulars of arrangements and responsibilities for monitoring, control and surveillance and enforcement.

In many respects, CCAMLR led the early development of monitoring, control and surveillance (MCS) regimes amongst international fisheries management bodies. CCAMLR

[10] www.ccamlr.org/en/publications/past-and-present-conservation-measures

MCS requirements are described in detail in Conservation Measures. These include provisions for port-based inspections, the requirement for at least two scientific observers (one of whom is appointed in accordance with the CCAMLR Scheme of International Scientific Observation) to be present on all vessels in the Ross Sea (RSR and ASR), the use of Vessel Monitoring Systems, participation in the toothfish Catch Documentation Scheme, and daily and monthly catch effort reporting[11]. Information captured through the implementation of these measures is scrutinised by SCIC and the Commission on an annual basis. A Compliance Evaluation Procedure (Conservation Measure 10-10 (2014)) provides a structured approach to the identification of compliance issues.

In addition to vessel-based MCS measures, during the fishing season, aerial and at-sea patrols of the Ross Sea are conducted by New Zealand on an ongoing basis. The areas of focus of surveillance patrols are guided by CCAMLR outcomes. Few vessels have been detected fishing illegally in recent years. However, three known illegal vessels were active in the Ross Sea in the 2014/2015 fishing season. These vessels continued fishing illegally in the presence of a New Zealand navy vessel, and were not successfully boarded. They subsequently left the Ross Sea, but have all been relocated outside CCAMLR waters. MCS activities relating to these vessels e.g. detainments and boardings by government authorities, have occurred outside of the CAMLR Convention Area. How CCAMLR responds to this violation of its management measures and approach is important, in terms of ensuring the integrity and robustness of the management system, and also maintaining the ecosystem in the Ross Sea in the longer term.

6.10 Date of next review and audit of the management plan.

CCAMLR meets annually in October, and those meetings provide for the review and audit of the fishery's management plan. Specifically, Conservation Measures are reviewed and amended where deemed appropriate by the Commission. Identifying which components of the management system to amend and update, to better meet the objective of the Convention, is facilitated by considering data collected in the previous year, and new fishery-independent scientific information submitted by members.

When Conservation Measures are amended or new measures developed, members are notified in early November (following the Commission's meeting in October). New or amended Conservation Measures are usually implemented on 1 December. This is in alignment with the start of the fishing season. However, in accordance with the CAMLR Convention (Article IX), measures become binding 180 days after members are notified.

The next meeting of the Commission will take place in October 2016.

6.11 Description of fishery's research plan.

A research plan for the fishery was developed in 2014, by three CCAMLR-member countries from the client group (Delegations of New Zealand, Norway, and the United Kingdom 2014). This plan lays out an extensive body of work, focused on addressing Article 2 of the CAMLR Convention. The plan will be implemented over a three to five-year term. Particular areas of focus relate to reducing uncertainty in toothfish model parameters, reducing uncertainty around stock management more broadly, identifying and clarifying ecological relationships between Ross Sea toothfish and their predators and prey, and exploring the direct impacts of fishing on bycatch species (Delegations of New Zealand, Norway, and the United Kingdom 2014).

[11] www.ccamlr.org/en/conservation-and-management/browse-conservation-measures

7 EVALUATION PROCEDURE

7.1 Harmonised Fishery Assessment

There are no other fisheries certified or undergoing assessment which require harmonisation with this assessment. Other fisheries have been certified under the CCAMLR management system (list) and the outcomes of these assessments are considered here for specific PIs where appropriate (these have been noted in scoring text where relevant).

7.2 Previous assessments

The Ross Sea Toothfish Longline Fishery was previously certified by Moody Marine (now Intertek Fishery Certification) on 16 November 2010 (expiry 15 November 2015[12]).

There were eight conditions of certification, summarised below:

Table 1: Summary of Previous Assessment Conditions

Condition	Closed? (Y/N)	Justification
1. Knowledge of biology and ecology of the target stock	Y Surveillance 3 2013	There is considered sufficient information on life history; knowledge of spawning and nursery areas is rudimentary but this is not essential for the ongoing management of the stock nor for the operation of the population model and so is considered adequate for current needs. The information on sub-adult toothfish is appropriate, however, and is being collected as part of an ongoing programme and is being incorporated into the stock assessment. Similarly, sufficient information is considered available on stock structure and the relationship to reproductive capacity. Information gathering continues on the sex and size structure, including the sub-adult survey. As noted in the original assessment report, genetic or sub-population studies have previously been carried out as appropriate and research continues in this area.
2. Improved stock assessment through wider tagging programme	Y Surveillance 2 2012	The reduction in uncertainties in the tagging data, and increase in the amount of data available for use in the assessment process meant that for the original client group, this PI was rescored from 75 to 80 at Surveillance 1. The provision of similar data from the new client group members at Surveillance 2 means that this PI is confirmed at a score of 80.

[12] Extended by variation till 14th January 2016 – granted by MSC November 2015.

3. Knowledge of benthic habitat	Y Surveillance 3 2013	The identification of VMEs and Fine Scale Rectangles (FSRs) has now been demonstrated to be operating effectively – identifying areas of vulnerable habitat. Finally, the condition required that "if such areas are found, and are considered vulnerable to impacts from fishing gear, then measures to protect these from gear impacts should be implemented". CM 22-06 and 22-07 meet this requirement.
4. Trophic effects	Y Surveillance 3 2013	The uncertainties identified at the original assessment have been reduced. Combined with the precautionary harvest strategy, this level of information is considered sufficient to provide a basis for determining the effects of the fishery on general ecosystem structure and function.
5. By-catch	Y Surveillance 1 2011	The consequences of current levels of mortality on the main non-target stock (macrourids) has been quantified and overall consequences does not suggest an unacceptable impact.
6. Closed areas	Y Surveillance 4 2014	There is a mechanism through CCAMLR to identify and evaluate the appropriateness of closed areas (e.g. CM 22-06, 22-07, 22-08 and 22-09). Some have been implemented and enforced, others (MPAs) are ongoing, but the assessment team have no reason not to expect full Client Group compliance if and when such MPAs are established.
7. Management Responsibilities and Interactions	Y Surveillance 2 2012	This condition was closed for existing client group members at Surveillance 1. Since the previous audit two new members have joined the client group. The new members have provided a summary of the roles of the relevant organisations with management responsibility in the fishery, including key areas of responsibility and interaction. These demonstrate that interactions are effective and operate without serious difficulty.
8. Management Responsibilities and Interactions	Y Surveillance 2 2012	This PI is rescored to 90 on the basis that the management system of each state relevant to client group members appears fully compliant with all relevant national legislation.

7.3 Assessment Methodologies

This assessment was carried out in accordance with CR v1.3 (January 2013) and uses the

MSC Full Assessment Reporting Template v1.3.

The default assessment tree (Annex CB) was used without adjustment. The RBF was not used.

7.4 Evaluation Processes and Techniques

7.4.1 Site Visits and Consultation

Site visits were held by members of the assessment team in UK and New Zealand. Meetings and people interviewed were as follows:

19 September 2014 (London, UK)
A Hough (IMM)
P Thomson (Argos Georgia)
Jack Fenaughty (representing Sanford and NZLL)
Jill Fenaughty (representing Sanford and NZLL)

12 November 2014 (Wellington, NZ)
Client group:
Jack Fenaughty (Client group)
Jill Fenaughty (Client group)
R Currey (Ministry for Primary Industries)
J Akroyd (IFC)
J Pierre (IFC)

Ministry of Foreign Affairs and Trade (NZ):
J Dempster
N Reid
J Akroyd (IFC)
J Pierre (IFC)

Department of Conservation (NZ):
D Stent
J Akroyd (IFC)
J Pierre (IFC)

Environmental Non-Government Organisations:
A McCrone (WWF-NZ)
B Zuur (WWF-Antarctic and Southern Ocean Initiative)
B Weeber (ECO)
J Akroyd (IFC)
J Pierre (IFC)

13 November 2014 (NZ)
Client group and Government fishery management:
Jack Fenaughty (Client group)
Jill Fenaughty (Client group)
D Shaw (Sanford Ltd: Client group)
R Currey (Ministry for Primary Industries)
S Hanchet (NIWA)
A Dunn (NIWA)
M Pinkerton (NIWA)
J Akroyd (IFC)
J Pierre (IFC)

Additional documents, promised during stakeholder consultation and considered very relevant to the assessment were received from Eco on 23 February 2015 and from WWF on 12 March 2015 – effectively the end of the stakeholder consultation period. Scoring was delayed until this information was received and incorporated into the assessment.

A summary of discussions held is presented in Appendix 3. The client group and eNGO stakeholders also both provided extremely useful bibliographies. Although all references listed were not directly cited in this report, this provided an extremely useful information source. Both bibliographies are included in Appendices 7.1 and 7.2.

Appendix 3 also contains stakeholder comments on the Public Comment Draft Report. Submissions were received from ASOC (in relation to specific PIs) and MSC (in relation to some traceability issues). Full responses to the comments made are also included in Appendix 3. It is noted that the ASOC submission was received shortly after the extended deadline, but the CAB has allowed this to be included in this report.

7.4.2 Evaluation Techniques

Public announcements of the re-assessment were made in the MSC website and through direct email contact with existing stakeholders.

The MSC Principles and Criteria set out the requirements of certified fishery. The certification methodology adopted by the MSC involves the interpretation of these Principles and Criteria into specific Performance Indicators and Scoring Guideposts against which the performance of Fishery can be measured. In order to make the assessment process as clear and transparent as possible, these identify the level of performance necessary to achieve 100, 80 (a pass score), and 60 scores for each Indicator.

This assessment used the Standard Assessment Tree set out in MSC Certification Requirements v1.3. Use of this assessment tree has been the subject of stakeholder consultation (direct e-mail from IMM; notification on the MSC website; and notification via the MSC Fishery Updates). No comments were received from any stakeholders on the use of this assessment tree.

For each Performance Indicator, the performance of the fishery is assessed as a 'score'. In order for the fishery to achieve certification, an overall score of 80 is considered necessary for each of the three Principles, 100 represent ideal best practice and 60 a measurable shortfall. A fishery cannot be certified if a score below 60 is recorded. As it is not considered possible to allocate precise scores, a scoring interval of five is therefore used in evaluations. Scores are allocated based on the consensus opinion of the assessment team.

Table 2: Scoring elements

Component	Scoring elements	Main/not main	Data-deficient or not
Antarctic toothfish	1.1.1	Main	Not
Patagonian toothfish	2.1.1	Not main	Data deficient
Rat tails, Grenadiers	2.2.1	Main	Not
Rattail Macrourus whittsoni	2.2.1	Main	Not
Moray cods	2.2.1	Not main	Data deficient
Ray Raja georgiana	2.2.1	Main	Data deficient
Crocodile icefishes	2.2.1	Not main	Data deficient
Blue antimora	2.2.1	Not main	Data deficient
Eaton's Skate	2.2.1	Main	Data deficient

Ridge-scaled rattail	2.2.1	Not main	Data deficient
Skates and rays	2.2.1	Main	Data deficient
Smalleye moray cod	2.2.1	Not main	Data deficient
Icefish spp.	2.2.1	Not main	Data deficient
Rays and skates nei	2.2.1	Not main	Data deficient
Moonfish	2.2.1	Not main	Data deficient
Starfishes nei	2.2.1	Not main	Data deficient
Antarctic Rockcods	2.2.1	Not main	Data deficient
McCain's skate	2.2.1	Not main	Data deficient
Blackfin icefish	2.2.1	Not main	Data deficient
Marbled moray cod	2.2.1	Not main	Data deficient
Octopus spp.	2.2.1	Not main	Data deficient
Eelpout	2.2.1	Not main	Data deficient
Opah	2.2.1	Not main	Data deficient
Crab spp.	2.2.1	Not main	Data deficient
Plunderfish	2.2.1	Not main	Data deficient
Striped rockcod	2.2.1	Not main	Data deficient
Lepidion codlings nei	2.2.1	Not main	Data deficient
Scaly rockcod	2.2.1	Not main	Data deficient
Pennatulacea sea pens	2.2.1	Not main	Data deficient
Sea cucumbers nei	2.2.1	Not main	Data deficient
Sea anemones	2.2.1	Not main	Data deficient
Hydroids, hydromedusae	2.2.1	Not main	Data deficient
Humped rockcod	2.2.1	Not main	Data deficient
Grey rockcod	2.2.1	Not main	Data deficient
Gorgonians	2.2.1	Not main	Data deficient
Black corals and thorny corals	2.2.1	Not main	Data deficient

8 TRACEABILITY

8.1 Eligibility Date

As this is a reassessment, then assuming successful assessment, certification will be continuous. The Eligibility Date will be the date of certification of the fishery - 14 January 2015. This will then allow a new certificate to be issued to coincide with expiry of the existing certificate

8.2 Traceability within the Fishery

8.2.1 Traceability

Member Companies within the Client Group employ different levels of processing styles on their respective vessels resulting in differing final product states. The various processed states will therefore have differing types of package and labelling post processing, but all will be appropriately labelled.

UK vessels apply product-specific labels at the point of processing, recording all required traceability information (as for South Georgia Toothfish). Spain follows the same procedure as the UK applying product specific labels at the point of processing and recording all the required traceability information. Norway follows the same procedure as the UK applying product specific labels at the point of processing and recording all the required traceability information.

NZ Vessels specifically label individuals and secondary products (Collars / Cheeks) at the point of processing. Final dressed product (trunks) are individually labelled during reprocessing ashore with the Chain of Custody (CoC) kept within the Company by Sanford Limited. Talleys Limited contracts out the actual reprocessing to Sealord, so their premises' details also appear on the certificates before exporting. For both companies Chain of Custody is regularly verified by both internal and external (CAB) audits which may include shadow auditing.

Australia specifically labels secondary products (Collars / Cheeks) at the point of processing. Final dressed product (trunks) are individually labelled during reprocessing ashore and each carton for size <10kg fish and each fish for over 10kg is individually labelled. The Chain of Custody (CoC) is kept within the Company. Chain of Custody is regularly verified by both internal and external (CAB) audits which may include shadow auditing.

New Companies / Vessels that enter the Client Group will have to package / label to either the NZ or UK practices or provide an alternate that is suitable to the Client Group and MSC principles of CoC traceability.

Catches from other CCAMLR Subareas are separated from catches from the fishery proposed for certification through labelling and/or physical separation in the vessel. Observers on the vessel will also verify the separation systems put in place.

These measures are in addition to normal CCAMLR Catch Documentation Scheme (CDS) requirements for toothfish. Overall traceability requirements within the Unit of Certification are defined in the Client Group Rules.

Given the CCAMLR and Client Group labelling and traceability requirements, CCAMLR reporting requirements and observer presence on vessels, there is considered no

opportunity for substitution of certified and non-certified product.

8.2.2 At-Sea processing

Product is generally landed as headed and gutted or filleted with only minimal at-sea processing. Nevertheless the traceability specification above will apply to product irrespective of its processed state.

8.2.3 Transhipment

There is no transhipment at sea by any of the Ross Sea Client Group vessels.

8.2.4 Points of Landing

Normal CCAMLR port inspection requirements will apply, in addition to MSC CoC inspections. Toothfish is a very valuable product and so traceability requirements are paramount in future CoC. Prescribed landing points for the fishery are defined in the Client Group Rules.

Client Group members are to unload at the following countries only:

- New Zealand
- Australia
- South Africa
- South Georgia / Falkland Islands
- Montevideo (subject to verification by SGS for all unloads of fish caught under the Ross Sea Client Group rules).

Client Group members are also regulated through CCAMLR Conservation Measure 10-03 (2014). *Port inspections of fishing vessels carrying Antarctic marine living resources*

1. Contracting Parties shall undertake inspections of all fishing vessels carrying Dissostichus spp. which enter their ports. The inspection shall be for the purpose of determining that if the vessel carried out harvesting activities in the Convention Area, these activities were carried out in accordance with CCAMLR conservation measures, and that if it intends to land or tranship Dissostichus spp., the catch to be unloaded or transhipped is accompanied by a Dissostichus catch document required by Conservation Measure 10-05 and that the catch agrees with the information recorded on the document.

4. To facilitate the inspections referred to in paragraphs 1 and 2, Contracting Parties shall require vessels seeking entry to their ports to provide the information contained in the template in Annex 10-03/A and to convey a written declaration that they have not engaged in or supported IUU fishing in the Convention Area and have complied with relevant CCAMLR requirements. The Contracting Party shall require vessels seeking entry to their ports to provide the information contained in Annex 10-03/A at least 48 hours in advance to allow adequate time to examine the required information. Contracting Parties may designate ports to which fishing vessels may seek entry. Any such designations, and any subsequent changes, shall be notified to the Secretariat at least 30 days before they take effect. The Secretariat shall post information regarding designated ports on the CCAMLR website.

The risk of substitution of certified fish with non-certified fish has been evaluated and is considered to be negligible.

8.3 Eligibility to Enter Further Chains of Custody

8.3.1 Eligibility to enter further certified chains of custody

Tracking and traceability information for this fishery is considered sufficient for product to be

eligible to enter further chains of custody.

8.3.2 Parties eligible to use the fishery certificates

Only members of the Client Group are eligible to use the fishery certificate.

8.3.3 Point of change of ownership from which Chain of Custody certification is required

All product is landed into recognised points where DCD inspections are carried out, as detailed in the report. At each port, product is containerised and shipped to customers. All client group members have their own CoC certification and so this containerisation and shipping is already within the CoC regime. The only exception to this is some product landed into NZ which may enter factories belonging to Client Group members for further processing before sale. Such product will, however, be covered by the CoC systems of the Client Group members. The point of change of ownership will be sale from the factory.
All merchants and processors wishing to sell MSC certified fish that has been purchased from this fishery will require their own ongoing Chain of Custody certification.

8.4 Eligibility of Inseparable or Practically Inseparable (IPI) stock(s) to Enter Further Chains of Custody

No IPI stocks are involved in this certification.

Catches of *D eleginoides* are possible (this is a retained species discussed in the report) and catches of toothfish from other areas may also be present. *D. eleginoides* are identified in the factory via crew who are deemed competent via a bespoke and detailed training and ID guide. This will be used on all vessels within the Client Group. The members of the Client Group will have their own systems to keep these separate from Ross Sea Antarctic toothfish - either labelling of product, physical separation or both. Whichever system is used, the assessment team has confidence that product will be properly reported under CCAMLR requirements, including DCD requirements, and separation will be verified by observers.

9 EVALUATION RESULTS

9.1 Principle Level Scores

Final Principle Scores

Final Principle Scores	
Principle	**Score**
Principle 1 – Target Species RSR	93.1
Principle 1 – Target Species ASR	88.8
Principle 2 – Ecosystem (both areas)	89.7
Principle 3 – Management System (both areas)	90.1

9.2 Summary of Scores

Ross Sea Region

Prin-ciple	Wt (L1)	Component	Wt (L2)	PI No.	Performance Indicator (PI)	Score
One	1	Outcome	0.5	1.1.1	Stock status	100
				1.1.2	Reference points	90
				1.1.3	Stock rebuilding	
		Management	0.5	1.2.1	Harvest strategy	95
				1.2.2	Harvest control rules & tools	100
				1.2.3	Information & monitoring	80
				1.2.4	Assessment of stock status	90
Two	1	Retained species	0.2	2.1.1	Outcome	80
				2.1.2	Management	80
				2.1.3	Information	85
		Bycatch species	0.2	2.2.1	Outcome	80
				2.2.2	Management	95
				2.2.3	Information	80
		ETP species	0.2	2.3.1	Outcome	95
				2.3.2	Management	100
				2.3.3	Information	80
		Habitats	0.2	2.4.1	Outcome	90
				2.4.2	Management	95
				2.4.3	Information	80
		Ecosystem	0.2	2.5.1	Outcome	100
				2.5.2	Management	100
				2.5.3	Information	100
Three	1	Governance and policy	0.5	3.1.1	Legal & customary framework	95
				3.1.2	Consultation, roles & responsibilities	85
				3.1.3	Long term objectives	100
				3.1.4	Incentives for sustainable fishing	90
		Fishery	0.5	3.2.1	Fishery specific objectives	95

	specific management system	3.2.2	Decision making processes	90
		3.2.3	Compliance & enforcement	85
		3.2.4	Research plan	80
		3.2.5	Management performance evaluation	90

Principle 1 Scores Amundsen Sea Region (other scores as for RSR)

Prin-ciple	Wt (L1)	Component	Wt (L2)	PI No.	Performance Indicator (PI)	Score
One	1	Outcome	0.5	1.1.1	Stock status	100
				1.1.2	Reference points	90
				1.1.3	Stock rebuilding	
		Management	0.5	1.2.1	Harvest strategy	95
				1.2.2	Harvest control rules & tools	80
				1.2.3	Information & monitoring	80
				1.2.4	Assessment of stock status	75

9.3 Summary of Conditions

Table 3 Summary of Conditions

Condition number	Condition	Performance Indicator	Related to previously raised condition? (Y/N/N/A)
1	For the ASR model, the committees do not have a consensus that the current model and data are appropriate. To meet SG80 requirements for SI a) within the term of this certification, the assessment should be appropriate for the stock and for the harvest control rule.	**PI 1.2.4**	**N**

9.3.1 Recommendations

Two recommendations are made in relation to Principle 2:

Recommendation 1 (PI 2.2.1 SIa). While it is not highly likely that grenadiers or skates are outside of biologically based limits, this is not so well demonstrated for skates as for grenadiers. A risk assessment for bycatch species, as reported in the initial MSC assessment did not consider skates at risk: recommendations have been made for an updated risk assessment and those recommendations are supported by the assessment team.

Recommendation 2 (PI 2.3.1 SIc). It is recommended that possible effects of changing toothfish distribution on foraging success of Weddell seal and type C killer whale, at critical life stages, be considered a suitable focus for research.

9.4 Determination, Formal Conclusion and Agreement

All Principles scored over 80 and no PIs scored below 60. The certification determination recommendation reached by the Assessment Team is that the fishery should be re-certified.

(REQUIRED FOR PCR)

1. The report shall include a formal statement as to the certification action taken by the CAB's official decision-makers in response to the Determination recommendation.

10 REFERENCES

Ainley, D.G. and G. Ballard. 2012. Trophic interactions and population trends of killer whales (Orcinus orca) in the southern Ross Sea. Aquatic Mammals, 39: 153-160.

Bull, B., R.I.C.C. Francis, A. Dunn, A. McKenzie, D.J. Gilbert, M.H. Smith, R. Bian and D. Fu. 2012. CASAL (C++ algorithmic stock assessment laboratory): CASAL user manual v2.30-2012/03/21. NIWA Technical Report, 135: 280 pp.

CCAMLR. (2014). Report of the Thirty-third meeting of the Commission (Hobart, Australia, 20 to 31 October 2014). Preliminary version last updated 18 December 2014. CCAMLR, Hobart.

CCAMLR. 2014. Report of the Thirty-third meeting of the Commission (Hobart, Australia, 20 to 31 October 2014). Preliminary version last updated 18 December 2014. CCAMLR, Hobart.

Constable, A., de la Mare, W., Agnew, D., Everson, I. and Miller, D. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). ICES Journal of Marine Science 57: 778–791.

Constable, A., de la Mare, W., Agnew, D., Everson, I. and Miller, D. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). ICES Journal of Marine Science 57: 778–791.

Delegations of New Zealand, Norway, and the United Kingdom. (2014). Medium-term research plan for the Ross Sea toothfish fishery. WG-FSA-14/60. CCAMLR, Hobart. Available at: https://www.niwa.co.nz/sites/niwa.co.nz/files/fsa-14-60.pdf

Delegations of New Zealand, Norway, and the United Kingdom. (2014). Medium-term research plan for the Ross Sea toothfish fishery. WG-FSA-14/60. CCAMLR, Hobart. Available at: https://www.niwa.co.nz/sites/niwa.co.nz/files/fsa-14-60.pdf

Eisert, R, M.H. Pinkerton, S.D. Newsome & O.T. Oftendal. 2013. A critical re-examination of the evidence for a possible dependence of Weddell seals (Leptonychotes weddellii) on Antarctic toothfish (Dissosticus mawsoni) in the Ross Sea, Antarctica. CCAMLR WG-EMM-13/28.

Eisert, R., M.H. Pinkerton, L Torres, R.J.C. Curry, P.H. Ensor, E.N. Ovsyanikova, I.N. Visser & O.T. Oftendal. 2014. Update on the top predator alliance project, 2013-14 season: killer whales. CCAMLR WG-EMM-14/52. CCAMLR WG-EMM-15/52

Eisert R., G. Lauriano, S. Panigada, E.N. Ovsyanikova, I.N. Visser, P.H. Ensor, R.J.C. Currey, B.R. Sharp, M.H. Pinkerton. 2015. Activity, seasonal site fidelity, and movements of Type-C killer whales between the Ross Sea, Antarctica and New Zealand.

FAO 1995. Code of Conduct for Responsible Fisheries. Food and Agriculture Organization of the United Nations, Rome.

FAO. (1995). Code of Conduct for Responsible Fisheries. Food and Agriculture Organization of the United Nations, Rome.

Fenaughty, J.M., Stevens, D.W., Hanchet, S.M. 2003. Diet of the Antarctic toothfish (Dissostichus mawsoni) from the Ross Sea, Antarctica (CCAMLR Statistical Subarea 88.1). CCAMLR Sci. 10:1–11

Fishery Report 2013: Exploratory fishery for Dissostichus spp. in Subareas 88.1 and 88.2. CCAMLR.

Hanchet, S., K. Sainsbury, D. Butterworth, C Darby, V. Bizikov, O. Rune Godo, T. Ichii, K-H. Kock, L Lopez Abellan & M. Vacchi. 2014. CCAMLR's precautionary approach to management of the Ross Sea toothfish fishery. Draft for publication.

Hanchet, S.M. Rickard, G.J., Fenaughty, J.M., Dunn, A., Williams, M.J. 2008. A hypothetical life cycle for Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea Region.

CCAMLR Science 15: 35–53
Hanchet, S.M., M.L.Stevenson & A. Dunn. 2010. A Characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997-98 to 2009-10. CCAMLR WG-FSA-10/23.
Horn, P.L. 2002. Age and growth of Patagonian toothfish (Dissostichus eleginoides) and Antarctic toothfish (D. mawsoni) in waters from the subantarctic to the Ross Sea, Antarctica. Fisheries Research 56, 275-287
Humboldt squid information at http://marinebio.org/species.asp?id=249).
Humboldt squid information at http://www.oceanwise.ca/seafood/squid/humboldt-squid-jumbo-squid
IUCN at http://www.iucnredlist.org
Kock, K.-H., Barrera-Oro, E., Belchier, M., Collins, M.A., Duhamel, G., Hanchet, S., Pshenichnov, L., Welsford, D. Williams, R. 2012. The Role of Fish as Predators of Krill (*Euphausia superba*) and Other Pelagic Resources in the Southern Ocean. CCAMLR Science, 19: 115–169
Kuhn, K.L., Gaffney, P.M. 2008. Population subdivision in the Antarctic toothfish (Dissostichus mawsoni) revealed by mitochondrial and nuclear single nucleotide polymorphisms (SNPs). Antarctic Science 20(4): 327-338
Mitchell, R.E. 2014. Ross Sea trophic research review. MRAG report to Ross Sea Client Group.
Mormede, S. and A. Dunn. 2010. Characterisation of skate catches in the Ross Sea region. CCAMLR WG-FSA-10/25.
Mormede, S.; Dunn, A.; Hanchet, S.M. (2011a). Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in SSRUs 88.2C-G for the years 2002-03 to 2010-11. CCAMLR, Hobart WG-FSA-11/43. Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR.
Mormede, S.; Dunn, A.; Hanchet, S.M. (2011b). Descriptive analysis of the toothfish (*Dissostichus spp.*) tagging programme in Subareas 88.1 & 88.2 for the years 2000-01 to 2010-11. CCAMLR, Hobart WG-FSA-11/46. Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR.
Mormede, S., Dunn, A., Hanchet, S.M. 2013. Assessment models for Antarctic toothfish (Dissostichus mawsoni) in Subarea 88.2 SSRUs 88.2C–H for the years 2002–03 to 2012–13.
Mormede, S., Dunn, A., Hanchet, S.M. 2014. A stock assessment model of Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea region incorporating multi-year mark-recapture data. CCAMLR Science, 21: 39–62
Mormede, S., Dunn, A., Hanchet, S.M., Parker, S. 2014. Spatially explicit population dynamics models for Antarctic toothfish in the Ross Sea region CCAMLR Science, 21: 19–37
Mormede, S., S.J. Parker, S.M.Hanchet, A. Dunn & S. Gregory. 2014. Results of the third CCAMLR sponsored research survey to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea, February 2014. CCAMLR WG-FSA-14/51.
Mugue, N.S., Petrov, A.F., Zelenina, D.A., Gordeev, I.I., Sergeev, A.A. 2014. Low genetic diversity and temporal stability in the Antarctic toothfish (Dissostichus mawsoni) from near-continental seas of Antarctica. CCAMLR Science 21: 0:0
Pierce, G.J. and A. Guerra 1994. Stock assessment methods used for cephalopod fisheries. Fisheries Research 21: 255-285.
Pinkerton, M, J.M. Bradford-Grieve & S.M. Hanchet 2009. A balanced model of the food web of the Ross Sea, Antarctica. CCAMLR WG-EMM-07/24.
Pinkerton, M. 2015. Effects of fishing for toothfish in the Ross Sea region. Report to WWF. NIWA, 53pp.
Pinkerton, M., S Mormede & S.M. Hanchet. 2010. Towards a minimum realistic model for investigating trophic relationships between Antarctic toothfish and demersal fish in the Ross Sea, Antarctica. CCAMLR WG-SAM-10/21.
Prutko, V.G. & D. A. Chmilevskii 2011. On the pattern of oogenesis, type of spawning and fecundity of moray cod Muraenolepis evseenkoi (Muraenolepidae: Gadiformes). Journal

of Ichthyology, 51: 404-407.
Prutko, V.G. Chmilevskii, D.A. 2011. On the pattern of oogenesis, type of spawning and fecundity of moray cod Muraenolepis evseenkoi (Muraenolepidae: Gadiformes). Journal of Ichthyology, 51: 404-407.
Rickard, G.J., Roberts, M.J., Williams, J.M. Dunn, A., Smith, M.H. 2010. Mean circulation and hydrography in the Ross Sea sector, Southern Ocean: representation in numerical models. Antarctic Science 22(5): 533–558.
SC-CAMLR. (2006). Report of the Twenty-fifth Meeting of the Scientific Committee. 23-27 October 2006. CCAMLR Hobart, Australia.
SC-CAMLR. (2014). Report of the Thirty-third meeting of the Scientific Committee (Hobart, Australia, 20 to 24 October 2014). Preliminary version adopted 24 October 2014. CCAMLR, Hobart.
SC-CAMLR. (2014). Report of the Thirty-third meeting of the Scientific Committee (Hobart, Australia, 20 to 24 October 2014). Preliminary version adopted 24 October 2014. CCAMLR, Hobart.
Sharp, B.R. 2010. Updated impact assessment framework to estimate the cumulative footprint and impact on VME taxa of bottom longline fisheries in the CCAMLR area. CCAMLR WG_FSA-10/31
Smith, P.J., C.D. Roberts, A.L. Stewart, M McVeagh & C.D. Struthers 2007. Identification and speciation of Antarctic skates. CCAMLR WG-FSA-07/27.
Taylor et al. 2007
UNFSA. (1995). Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks. Sixth session. 24 July – 4 August 1995. New York.
UNFSA. (1995). Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks. Sixth session. 24 July – 4 August 1995. New York.
Weddell seal population studies at http://weddellsealscience.com/science.html
WG-EMM-13/28 Eisert, R., Pinkerton, M.H., Newsome, S.D., Oftedal, O.T. 2013. A critical re-examination of the evidence for a possible dependence of Weddell seals (Leptonychotes weddellii) on Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea, Antarctica
WG-FSA-13 Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 7 to 18 October 2013) SC-CAMLR-XXXII/06
WG-FSA-13/48 Hanchet, S., Mormede, S., Dunn, A. 2013. A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997–98 to 2012–13.
WG-FSA-13/49 Parker, S.J., A. Dunn, S. Mormede and S.M. Hanchet. 2013a. Descriptive analysis of the toothfish (Dissostichus spp.) tagging programme in Subareas 88.1 and 88.2 for the years 2000–01 to 2012–13. CCAMLR, Hobart, Australia: 35 pp.
WG-FSA-13/50 Mormede, S. 2013. Pairwise tag performance: testing the sensitivity of the tag detection index and the mortality of tagged fish index.
WG-FSA-13/51 Mormede, S.; Dunn, A.; Hanchet, S.M. (2013). Assessment models for Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea for the years 1997-98 to 2012-13. CCAMLR, Hobart, Australia. 36 p.
WG-FSA-14 Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 6 to 17 October 2014). SC-CAMLR-XXXIII/04
WG-FSA-14/02 Piyanova, S.V., Petrov, A.F. 2014. Analytical data on determination of reproductive potential of Antarctic toothfish D. mawsoni in the Pacific (SSRUs 88.1, 88.2, 88.3), Indian Ocean (SSRUs 58.4.1 и 58.4.2) and Atlantic (SSRU 48.6, 48.5) Antarctic areas
WG-FSA-14/14 (Rev. 1) Goncharov, S.M., Petrov, A.F. 2014. Stock assessment and

proposed TAC for Antarctic toothfish (TOA) in the Subarea 88.2 H in the season 2014–2015.

WG-FSA-14/51 Mormede, S., Parker, S.J., Hanchet, S.M., Dunn, A. Gregory, S. 2014. Results of the third CCAMLR sponsored research survey to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea, February 2014 and development of the time series.

WG-FSA-14/52 Stevenson, M., Hanchet, S., Mormede, S. Dunn, A. 2014. A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997–98 to 2013–14.

WG-FSA-14/55 Rev. 1 Fenaughty, J.M., Parker, S.J. 2014. Quantifying the impacts of ice on demersal longlining; a case study in CCAMLR Subarea 88.1

WG-FSA-14/56 Mormede, S., Dunn, A., Hanchet, S.M. 2014. Investigating emigration in stock assessment models of Antarctic toothfish (Dissostichus mawsoni) in Subarea 88.2 SSRUs 88.2C–H.

WG-FSA-14/57 Mormede, S., Dunn, A., Hanchet, S.M. 2014. Preliminary investigations into a two-area stock assessment model for Antarctic toothfish (Dissostichus mawsoni) in the Amundsen Sea Region

WG-FSA-14/58 Parker, S.J., Mormede, S. 2014. Seamount-specific biomass estimates from SSRU 88.2H in the Amundsen Sea derived from mark-recapture data

WG-FSA-14/59 Hanchet, S.M., Parker, S.J. 2014. Towards the development of an assessment of stock abundance for Subarea 88.2 SSRUs 88.2C–G

WG-FSA-SAM-13/34 Mormede, S. 2013. Further development of pairwise tag detection performance index and its application to the stock assessment of toothfish in the Ross Sea fishery

WG-SAM-05/8 Phillips, N., Hanchet, S.M., Dunn, A. 2005. Stratification of catch-at-length data using tree based regression: an example using Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea

WG-SAM-13/32 Results of a CCAMLR sponsored research survey to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea, February 2013.

WG-SAM-14/26 Parker, S.J., Hanchet, S.M., Horn, P.L. 2014. Stock structure of Antarctic toothfish in Statistical Area 88 and implications for assessment and management

11 APPENDIX 1 SCORING AND RATIONALES

11.1 Principle 1 Evaluation Tables

Two stocks have been identified: RSR (Ross Sea SubAreas 88.1 and 88.2 SSRUs A-B) and ASR (Amundsen Sea SubArea 88.2 SSRUs C-H). These stocks are subject to very similar harvest strategies, so the scoring justification only indicates where there is a difference. However, as these are separate units of assessment, they are scored separately.

Evaluation Table for PI 1.1.1

PI 1.1.1		**The stock is at a level which maintains high productivity and has a low probability of recruitment overfishing**		
Scoring Issue		SG 60	SG 80	SG 100
A	**Guidepost**	It is likely that the stock is above the point where recruitment would be impaired.	It is highly likely that the stock is above the point where recruitment would be impaired.	There is a high degree of certainty that the stock is above the point where recruitment would be impaired.
	Met?	Y	Y	Y RSR and ASR
	Justification	For both stocks, the point of recruitment impairment (PRI) is taken as 20%B_0, which is derived as the limit reference point from the harvest control rule (see PI 1.1.2). **RSR** Unexploited biomass (B_0) was estimated as 68790t (95% credible intervals 59540–78470), and biomass in 2013 (B_{2013}) was estimated as 74.8% B_0 (95% CIs 71–78%). This indicates that there is less than 2.5% probability the stock is less than 71% B_0 and therefore that there is a high degree of certainty that the stock is above the PRI. **ASR** Unexploited biomass (B_0) was estimated as 6590t (95% credible intervals 4800–9190), and biomass in 2013 (B_{2013}) was estimated as 65.1% B_0 (95% CIs 52–75%). This indicates that there is less than 2.5% probability the stock is less than 52% B_0 and therefore that there is a high degree of certainty that the stock is above the PRI.		
B	**Guidepost**		The stock is at or fluctuating around its target reference point.	There is a high degree of certainty that the stock has been fluctuating around its target reference point, or has been above its target reference point, over recent years.
	Met?		Y	Y RSR and ASR

PI 1.1.1		The stock is at a level which maintains high productivity and has a low probability of recruitment overfishing
	Justification	For both stocks, the target reference point is taken as median 50%B_0, which is derived from the harvest control rule (see PI 1.1.2). **RSR** Biomass in 2013 (B_{2013}) was estimated as 74.8% B_0 (95% CIs 71–78%). This indicates that there is less than 2.5% probability the stock is less than 71% B_0 and therefore that there is a high degree of certainty that the stock was above the target reference point. The stock has not yet been at or below the current level since the fishery began in the late 1990s. **ASR** Biomass in 2013 (B_{2013}) was estimated as 65.1% B_0 (95% CIs 52–75%). This indicates that there is less than 2.5% probability the stock is less than 52% B_0 and therefore that there is a high degree of certainty that the stock was above the target reference point.
References		CCAMLR 2013. Fishery Report 2013: Exploratory fishery for Dissostichus spp. in Subareas 88.1 and 88.2 Mormede, S., Dunn, A., Hanchet, S.M. 2014. A stock assessment model of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region incorporating multi-year mark-recapture data. CCAMLR Science, 21: 39–62 WG-FSA-14 2014. Report of the Working Group on Fish Stock Assessment. Hobart, Australia, 6 to 17 October 2014. Preliminary version adopted 17 October 2014.

Stock Status relative to Reference Points			
	Type of reference point	**Value of reference point**	**Current stock status relative to reference point**
Target reference point	50% B_0	RSR 34395t ASR 3295t	RSR 51530/50%B_0 = 1.50 ASR 4280/50%B_0 = 1.30
Limit reference point	20%B_0	RSR 13758t ASR 1318t	RSR 51530/20%B_0 = 3.75 ASR 4280/20%B_0 = 3.25

OVERALL PERFORMANCE INDICATOR SCORE:	**RSR: 100** **ASR: 100**
CONDITION NUMBER (if relevant):	**-**

Evaluation Table for PI 1.1.2

PI 1.1.2		Limit and target reference points are appropriate for the stock		
Scoring Issue		SG 60	SG 80	SG 100
A	**Guidepost**	Generic limit and target reference points are based on justifiable and reasonable practice appropriate for the species category.	Reference points are appropriate for the stock and can be estimated.	
	Met?	Y	Y	
	Justification	Two reference points are defined in the harvest control rule. These are based on the unexploited biomass (B_0), which is estimated by the stock assessment. Since catches have been recorded from the start of the fishery (excepting IUU), unexploited biomass can be estimated with acceptable accuracy. The reference points are not generic, but estimated specifically for this stock.		
B	**Guidepost**		The limit reference point is set above the level at which there is an appreciable risk of impairing reproductive capacity.	The limit reference point is set above the level at which there is an appreciable risk of impairing reproductive capacity following consideration of precautionary issues.
	Met?		Y	N
	Justification	The limit reference point is taken as 20%B_0. This value is used in the harvest control rule described in section 4.4, so that there is a 10% probability of the stock falling below this value for a constant catch. For the Beverton-Holt stock recruitment relationship and steepness of 0.75, the median recruitment would be around 84% of that for the exploited stock. This meets the MSC default criteria for the limit reference point (CB2.3.3.1) and is consistent with the precautionary model assumptions used in the stock assessment. While there is evidence that the limit reference point is set above the level at which there is an appreciable risk of impairing reproductive capacity (SG80), it is not clear that any special precautionary issues have been addressed (SG100). The reference point is set at a default precautionary level only, and no special justification has been provided for this point.		
C	**Guidepost**		The target reference point is such that the stock is maintained at a level consistent with B_{MSY} or some measure or surrogate with similar intent or outcome.	The target reference point is such that the stock is maintained at a level consistent with B_{MSY} or some measure or surrogate with similar intent or outcome, or a higher level, and takes into account relevant precautionary issues such as the ecological role of the stock with a high degree of certainty.
	Met?		Y	Y

PI 1.1.2		Limit and target reference points are appropriate for the stock		
	Justification	The target reference point set in the harvest control rule is 50%B_0. The target reference is set such that the stock should be maintained at a value consistent with a B_{MSY} proxy. B_{MSY} has not been reported, but the 50%B_0 target has the same intent, consistent with CCAMLR's stated purpose (Article II.3.a). A target of 50%B_0 is relatively precautionary, as it is higher than 40% B_0 MSC default (CB2.3.3.1). Precautionary issues have been reviewed and used to justify the reference points. Antarctic toothfish has no known special trophic or other role requiring additional precaution. Therefore, the current level should maintain the stock at highly productive levels with a high degree of certainty.		
D	Guidepost		For key low trophic level stocks, the target reference point takes into account the ecological role of the stock.	
	Met?		Not relevant	
	Justification	The trophic level of *D. mawsoni* is estimated to be 3.9 based on diet (mainly fish, krill, crustacean and squid), and therefore it is not a low trophic species.		
References		Constable, A.J., de la Mare, W.K. 1996. A generalised model for evaluating yield and the long term status of fish stocks under conditions of uncertainty. CCAMLR Science, 3: 31-54. Constable, A.J. , de la Mare, W.K., Agnew, D.J., Everson, I. Miller, D. 2000. Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources. Proc. SCOR/ICES Symposium, Montpelier, France, 1999, ICES J. Mar. Sci, 57: 778-791. CCAMLR 2013. Fishery Report 2013: Exploratory fishery for Dissostichus spp. in Subareas 88.1 and 88.2 Froese, R. Pauly. D. (Ed.) 2014. FishBase. World Wide Web electronic publication. www.fishbase.org (11/2014) WG-FSA-14 2014. Report of the Working Group on Fish Stock Assessment. Hobart, Australia, 6 to 17 October 2014. Preliminary version adopted 17 October 2014.		

OVERALL PERFORMANCE INDICATOR SCORE:	**RSR: 90** **ASR: 90**
CONDITION NUMBER (if relevant):	**-**

Evaluation Table for PI 1.1.3

PI 1.1.3 is not scored because the stock is not rebuilding (PI1.1.1 SG80 are met).

Evaluation Table for PI 1.2.1

PI 1.2.1		There is a robust and precautionary harvest strategy in place		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	The harvest strategy is expected to achieve stock management objectives reflected in the target and limit reference points.	The harvest strategy is responsive to the state of the stock and the elements of the harvest strategy work together towards achieving management objectives reflected in the target and limit reference points.	The harvest strategy is responsive to the state of the stock and is designed to achieve stock management objectives reflected in the target and limit reference points.
	Met?	Y	Y	Y
	Justification	The harvest strategy consists of a biennial process of data collection, stock assessment, scientific advice, management decisions and implementation through the CCAMLR Secretariat and the respective flag states. Data are provided by vessel reporting and scientific observers on board vessels. Stock assessments update stock status and provide management advice. The control on exploitation is primarily achieved through catch limits which are sub-divided among SSRUs. These catch limits are applied to vessels that have made notifications to fish during the season. Catch limits are fixed for two years calculated from the stock assessment projections and pre-determined precautionary rules (the harvest control rule). When a catch limit is reached within an SSRU, it is closed. Various other measures are applied (Subarea 88.1: CM 41-09) to achieve the objectives set out in Article II of the Convention. Although stock assessments are only carried out every two years, the fishery is monitored and reviewed annually. The Scientific Committee makes a recommendation to apply the same catch limit in the second year of the assessment cycle based on a review of findings from the previous year. As well as recommended catch limits, other management recommendations are made from time to time to deal with perceived problems. The different elements of the harvest strategy are monitored by the various working groups and sub-groups covering, among other things, data collection, stock assessments, methods, acoustics, ecosystems, implementation and compliance. There is clear evidence of communication and co-ordination between these groups in their reports and in the report of the Commission which ultimately makes decisions. This provides evidence that the various elements of the harvest strategy work together. The setting of catch limits through the harvest control rule and other measures have been designed to achieve the management objectives reflected in the target and limit reference points. There is also evidence through adjustments in catch limits and other measures that the harvest strategy is responsive to the state of the stock. Because the harvest strategy is responsive to the state of the stock, the elements of the harvest strategy work together, and they are designed to achieve the objectives reflected in the reference points, SG60, SG80 and SG100 are met.		

PI 1.2.1		There is a robust and precautionary harvest strategy in place		
b	Guidepost	The harvest strategy is likely to work based on prior experience or plausible argument.	The harvest strategy may not have been fully tested but evidence exists that it is achieving its objectives.	The performance of the harvest strategy has been fully evaluated and evidence exists to show that it is achieving its objectives including being clearly able to maintain stocks at target levels.
	Met?	Y	Y	N
	Justification	Although it has been evolving over time, the current harvest strategy has been implemented since at least 2000 and evidence has been accumulating to test whether it is working as intended. The harvest control rule has undergone general simulation testing and should work as long as basic assumptions are met. The biennial stock assessments have indicated that the stock has been decreasing towards the target reference point over these years at a rate consistent with that required by the harvest strategy. Although uncertainties remain, the stock assessment for both regions has become more reliable with longer time series and an increasing range of data. No stock assessment had been completed for the ASR stock before 2011, and the current assessment has flaws (see PI1.2.4). For RSR, the stock assessment is more complete and explains the available observations. The stock assessments with accompanying reviews and on-going improvements are valid evaluation tools. The simulation testing, empirical assessment and review through the working group system constitutes a full evaluation of the evidence available so far. While in general the harvest strategy is achieving objectives, it is not yet clear that it will be able to maintain stocks at or above target levels. This is partly because the fishery has not been in existence very long and the stocks have so far apparently been well above the target biomass. However, there remain significant uncertainties over stock structure, which may require further adjustments to the strategy. Further evidence would be required to be certain that the current strategy will be able to maintain the stocks are target levels. This meets SG80, but prevents the SG100 being met.		
c	Guidepost	Monitoring is in place that is expected to determine whether the harvest strategy is working.		
	Met?	Y		

PI 1.2.1		**There is a robust and precautionary harvest strategy in place**		
	Justification	The fishery applies a cycle of stock assessment and review to monitor its performance. The internal review includes international monitoring through CCAMLR requirements, such as the WG-FSA review of the assessment, and monitoring of vessel activity through VMS and "200%" international observer coverage. This is the standard CCAMLR approach to these fisheries. There is also intensive monitoring of the stock through data collection from catches, limited surveys and tagging. The primary tool for assessing the harvest strategy is the stock assessment, which is carried out every two years. In addition, the responsible management authority and fisheries scientists consider a wide range of other issues and impacts, as shown by scientific and meeting reports. Information gathered is sufficient to determine whether the harvest strategy is achieving its objectives.		
d	**Guidepost**			The harvest strategy is periodically reviewed and improved as necessary.
	Met?			Y
	Justification	There is clear evidence of annual review and improvements to the harvest strategy from the meeting reports. Apart from adjustments to catch limits based strictly on scientific advice, more general changes have been made when potential problems have been identified by the Scientific Committee. For example, a new closed area, 88.1M was introduced in 2009, when information suggested this was being used by toothfish for migration.		
References		CCAMLR 2013. Fishery Report 2013: Exploratory fishery for *Dissostichus* spp. in Subareas 88.1 and 88.2 SC-CAMLR 2008. Report of the Twenty-Seventh Meeting of the Scientific Committee Hobart, Australia. 27–31 October 2008 SC-CAMLR-XXVII Report SC-CAMLR 2014. Report of the Thirty-third meeting of the Scientific Committee (Hobart, Australia, 20 to 24 October 2014). Preliminary version adopted 24 October 2014. CCAMLR, Hobart. WG-FSA-14 2014. Report of the Working Group on Fish Stock Assessment. Hobart, Australia, 6 to 17 October 2014. Preliminary version adopted 17 October 2014.		
OVERALL PERFORMANCE INDICATOR SCORE:				**RSR: 95** **ASR: 95**
CONDITION NUMBER (if relevant):				**-**

Evaluation Table for PI 1.2.2

PI 1.2.2		There are well defined and effective harvest control rules in place		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	Generally understood harvest rules are in place that are consistent with the harvest strategy and which act to reduce the exploitation rate as limit reference points are approached.	Well defined harvest control rules are in place that are consistent with the harvest strategy and ensure that the exploitation rate is reduced as limit reference points are approached.	
	Met?	Y	Y	
	Justification	Harvest control rules are implemented as a well-defined decision rule to set the biennial yield. Yield estimates are calculated by projecting the estimated current status for each model under a constant catch using the rules described in section 4.4. The result of the application of this rule will be to reduce the exploitation rate as the stock decreases towards the target level and as the risk of falling below the limit reference point increases, meeting SG80.		
b	**Guidepost**		The selection of the harvest control rules takes into account the main uncertainties.	The design of the harvest control rules takes into account a wide range of uncertainties.
	Met?		Y	RSR: Y ASR: N

PI 1.2.2		There are well defined and effective harvest control rules in place		
	Justification	The harvest control rules are generic for toothfish fisheries in the CCAMLR region. They were designed to be robust to a wide range of uncertainties, and tested through stochastic population simulations before being implemented. The target reference point and the way the decision rule is applied are precautionary. The projections are carried out over a relatively long time period (35 years) with log-normal recruitment, so the resulting catch levels should be biased to lower values. One of the most important uncertainties relate to spatial distribution and movement of toothfish, because the population estimates depend upon a model of tagging data which assumes particular population mixing occurs. Recent simulations of the RSR stock and assessment suggest that the likely types of mixing would lead the current stock assessment to underestimate the true population size. Therefore the determination of stock status and the application of the HCR is likely to be more precautionary in respect of this uncertainty. However, while this precaution may also apply to the ASR stock, similar work has not yet been conducted, so it is unclear whether this uncertainty is addressed, preventing SG100 being met for this stock. Therefore, for the RSR stock, evidence indicates that the harvest control rule has been designed and is implemented to be precautionary, taking into account a wide of uncertainties, meeting the SG100. For the ASR stock, the rule is precautionary and simulations show it should account for main uncertainties for this species, but specific uncertainties for this stock have not been addressed yet, so SG80, but not SG100, is met.		
c	**Guidepost**	There is some evidence that tools used to implement harvest control rules are appropriate and effective in controlling exploitation.	Available evidence indicates that the tools in use are appropriate and effective in achieving the exploitation levels required under the harvest control rules.	Evidence clearly shows that the tools in use are effective in achieving the exploitation levels required under the harvest control rules.
	Met?	Y	Y	RSR: Y ASR:N
	Justification	The tool to implement the harvest control rule in both stocks is the catch limit. Both areas have had overruns of their catch limits, but these overruns have general been small and are taken into account in the stock assessment which affects future catch limits. In the 2013/14 season, for Subarea 88.1 management areas ranged from 87% to 100% of the catch limits, and no overruns occurred. For Subarea 88.2, the catch limit was 390t and the total reported catch was 426t, with catches in management areas ranging from 103% to 122% of the catch limits. The lack of recent evidence of catches exceeding limits recently in 88.1 suggests evidence clearly show current tools are effective in maintaining exploitation at required levels for this stock, meeting SG100. Recent catches exceeding the low catch limits for the ASR stock make evidence less clear in this case, so SG100 cannot be met. However, available evidence from the various assessments still suggest exploitation rates are, overall, most likely around the required level, meeting SG80. Furthermore, with various administrative improvements in their implementation, ASR catch limits are likely to become more effective.		

PI 1.2.2	There are well defined and effective harvest control rules in place	
References	CCAMLR 2013. Fishery Report 2013: Exploratory fishery for Dissostichus spp. in Subareas 88.1 and 88.2 SCIC 2012. Report of the Standing Committee on Implementation and Compliance (SCIC) Annex 6: Report of the Thirty-First Meeting of the Commission Hobart, Australia. 23 October – 1 November 2012 CCAMLR-XXXI SCIC 2014. Report of the Standing Committee on Implementation and Compliance (SCIC) Annex 6: Report of the Thirty-Third Meeting of the Commission Hobart, Australia. 20 to 31 October 2014 CCAMLR-XXXIII WG-FSA-14 2014. Report of the Working Group on Fish Stock Assessment. Hobart, Australia, 6 to 17 October 2014.	
OVERALL PERFORMANCE INDICATOR SCORE:		**RSR: 100** **ASR: 80**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 1.2.3

PI 1.2.3		Relevant information is collected to support the harvest strategy		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	Some relevant information related to stock structure, stock productivity and fleet composition is available to support the harvest strategy.	Sufficient relevant information related to stock structure, stock productivity, fleet composition and other data is available to support the harvest strategy.	A comprehensive range of information (on stock structure, stock productivity, fleet composition, stock abundance, fishery removals and other information such as environmental information), including some that may not be directly related to the current harvest strategy, is available.
	Met?	Y	Y	N
	Justification	Most data are fishery dependent and little information is available out of the fishing season. As the fishery is exploratory, there is a data collection plan (Annex 41-01/A), a research plan (Annex 41-01/B) as well as the tagging programme (Annex 41-01/C). Fisheries data are comprehensive, with tag releases and returns, biological information on the catch, catch and landings quantity, vessel attributes and fishing activity being recorded with relatively high precision. These data are collected through VMS, the observer programme and other standard reporting mechanisms (e.g. catch documentation scheme). Ice cover and other important environmental information is available, but is not yet directly used in the harvest strategy, although research to do so is being conducted. Some aspects of stock structure, particularly in 88.2, remain uncertain despite significant tagging programme. In addition, because it has not been possible to collect substantial fishery independent information, data from out of the fishing season are limited and various issues with the population dynamics remain unresolved, the range of information cannot be considered comprehensive. Because information is sufficient to support the harvest strategy it meets SG80, but it is not comprehensive, so SG100 is not met.		
b	**Guidepost**	Stock abundance and fishery removals are monitored and at least one indicator is available and monitored with sufficient frequency to support the harvest control rule.	Stock abundance and fishery removals are regularly monitored at a level of accuracy and coverage consistent with the harvest control rule, and one or more indicators are available and monitored with sufficient frequency to support the harvest control rule.	All information required by the harvest control rule is monitored with high frequency and a high degree of certainty, and there is a good understanding of inherent uncertainties in the information [data] and the robustness of assessment and management to this uncertainty.
	Met?	Y	Y	N

PI 1.2.3		Relevant information is collected to support the harvest strategy		
	Justification	All information required by the harvest control rule is monitored with high frequency, but not necessarily with a high degree of certainty. Catch-at-age, catch rates and tag-recapture are available for the stock assessment. These data are sufficient to produce a valid stock assessment and therefore apply the harvest control rule. This meets SG80 for RSR and ASR stocks. The catch, catch age and length composition, catch rates and tagging information are all monitored with both high-frequency and high degree of accuracy. In particular, the main indicators monitored with sufficient frequency to support the harvest control rule are derived from the tagging programme. These data are sufficient for the application of the harvest control rule, meeting SG80. Commercial catch and effort data are collected to estimate a standardised CPUE index, but this not considered to track abundance sufficiently well. Therefore, only one abundance index is effectively available through the tagging programme. With currently only one good index of abundance, it is difficult to identify all uncertainties in this information and to test the robustness of the assessment and management to these uncertainties. For the ASR stock, there are also problems with interpretation of tagging data. It is therefore not possible to confirm that there is a good understanding of all inherent uncertainties, so SG100 is not met.		
c	Guidepost		There is good information on all other fishery removals from the stock.	
	Met?		Y	
	Justification	IUU catch levels are estimated with the highest IUU catch (272t) indicated for 2008, which are included in the stock assessment. There has been no evidence of IUU presence or activity reported 2009-2013. Illegal vessel activity has been reported in the 2014/15 season. Estimates of the illegal catch have not yet been estimated. The main other source for unaccounted fishing mortality is ghost fishing by lost gear, which has been estimated for RSR and ASR catches. These suggest an average of 208t may be unaccounted for annually. These estimates were relatively low compared to the overall harvest, but were incorporated as sensitivity analyses in the 2011 stock assessments. While IUU is always of concern and contributes to uncertainty, some account is taken of these catches and other sources of mortality. Overall, good account has been taken of fishery removals and data are adequate for stock assessment, meeting SG80.		
References		CCAMLR 2013. Fishery Report 2013: Exploratory fishery for Dissostichus spp. in Subareas 88.1 and 88.2 Webber, D.N., Parker, S.J. 2012. Estimating Unaccounted Fishing Mortality in the Ross Sea Region and Amundsen Sea (CCAMLR Subareas 88.1 And 88.2) Bottom Longline Fisheries Targeting Antarctic Toothfish. CCAMLR Science, Vol. 19 (2012): 17–30 SCIC 2014. Report of the Standing Committee on Implementation and Compliance (SCIC) Annex 6: Report of the Thirty-Third Meeting of the Commission Hobart, Australia. 20 to 31 October 2014 CCAMLR-XXXIII Welsford, D.C., Ziegler, P.E. 2013. Factors that may influence the accuracy		

PI 1.2.3	Relevant information is collected to support the harvest strategy	
	of abundance estimates from CCAMLR tag-recapture programs for *Dissostichus spp*. and best practice for addressing bias. CCAMLR Science 20: 63–72	
OVERALL PERFORMANCE INDICATOR SCORE:		**RSR: 80** **ASR: 80**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 1.2.4

PI 1.2.4		There is an adequate assessment of the stock status		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**		The assessment is appropriate for the stock and for the harvest control rule.	The assessment is appropriate for the stock and for the harvest control rule and takes into account the major features relevant to the biology of the species and the nature of the fishery.
	Met?		RSR: Y ASR: N	RSR: Y ASR: N
	Justification	The stock assessments are similar for both RSR and ASR stocks. The stock assessments are based on a statistical catch-at-age model implemented in well-developed and well tested software (CASAL; see Bull et al., 2012). The CASAL assessment model is designed to use the catch, age and size compositions, and tag-recapture data. The approach is particularly suited to model this sort of fishery, and can account for some detail in the life characteristics of toothfish, such as growth and mortality rates. The stock assessment models were sex- and age-structured. The models assume a single area population, but account for differences among areas by treating areas as separate fisheries with their own selectivity. For both RSR and ASR, three areas are defined. Differences in selectivity are allowed for between males and females, and for the ASR model, between differences in the average depth fished. The Working Groups (WG-SAM and WG-FSA) and the Scientific Committee indicate consensus that the RSR model is appropriate for the stock and the harvest control rule. Furthermore, the model is able to take account of the available data and what is known about the biology of the species and nature of the fishery in this region, meeting SG100. For the ASR model, these groups do not have a consensus that the current model and data are appropriate. Specifically, most tagging occurs in SSRU H and tagging recaptures in the remaining SSRUs C-G are very low. This creates a problem fitting the model to the tag data. Effectively, SSRUs C-G are not considered to have been adequately assessed yet. The Scientific Committee has proposed a two year research plan to provide additional information to address this issue which commenced during the 2014/15 season.		
b	**Guidepost**	The assessment estimates stock status relative to reference points.		
	Met?	Y		
	Justification	The stock assessments estimate stock status relative to reference points. For each stock, the status is determined by comparing estimates of unexploited and current spawning stock biomass, which are derived from the stock assessment.		

PI 1.2.4		There is an adequate assessment of the stock status		
c	Guidepost	The assessment identifies major sources of uncertainty.	The assessment takes uncertainty into account.	The assessment takes into account uncertainty and is evaluating stock status relative to reference points in a probabilistic way.
	Met?	Y	Y	Y
	Justification	The stock assessment identifies and takes into account major sources of uncertainty. This includes observation and process error (stock recruitment variation), as well as structural error in testing various model assumptions. Based on simulations, stock size estimates are likely to be negatively biased (lower than the true values) mainly due to disparities between model assumptions and spatial structure. This should result in lower catches than can be sustained. The stock assessments take the uncertainty into account by reporting different assessments alongside the base case as well as standard errors and credibility intervals for important estimates. Most importantly, management advice is provided in a probabilistic manner through the harvest control rule, which is defined on the basis of risk. Therefore the status is defined and reported probabilistically for both stocks.		
d	Guidepost			The assessment has been tested and shown to be robust. Alternative hypotheses and assessment approaches have been rigorously explored.
	Met?			N
	Justification	Various model structures have been investigated, and the base case model and sensitivity models for the Ross Sea (RSR) and SSRUs 882C–H (ASR) are described below. The RSR assessment has been tested using a spatially explicit operational model covering likely movement and distribution scenarios, which suggested that the biomass estimates are likely to be underestimates of the true biomass, so the catch limits being set are therefore likely to be precautionary. Several alternative models and assumptions (sensitivities) have been examined, mostly related to the inclusion or exclusion of particular data to test their influence on final results. Several alternative ASR models and assumptions (sensitivities) have been examined including unaccounted mortality due to lost gear, catch and tag data from the southern fishery, and tag data from all trips. The sensitivities suggested that these changes to assumptions either had little impact or increased the biomass estimates. Although in both stocks, testing suggests that the stock assessments are robust, there is insufficient evidence on the alternative sensitivities chosen to conclude that hypotheses and assessment approaches have been rigorously explored.		
e	Guidepost		The assessment of stock status is subject to peer review.	The assessment has been internally and externally peer reviewed.
	Met?		Y	N

PI 1.2.4		There is an adequate assessment of the stock status	
	Justification	The stock assessment has been subject to internal peer review through internal quality assurance mechanisms within CCAMLR through WG-FSA. The software which implements the model has been extensively reviewed and tested on many fisheries. Evidence of a process of effective review is available in the working group reports. There is a consideration of the model and alternative configurations are discussed. The CCAMLR Secretariat has undertaken a validation of the CASAL parameter files, maximum of the posterior density (MPD) estimates, and yield calculations for the Ross Sea and SSRUs 882C–H models. This meets SG80. However, there is no evidence for an external peer review of recent stock assessments, so SG100 is not met.	
References		Bull, B., R.I.C.C. Francis, A. Dunn, A. McKenzie, D.J. Gilbert, M.H. Smith, R. Bian and D. Fu. 2012. CASAL (C++ algorithmic stock assessment laboratory): CASAL user manual v2.30-2012/03/21. *NIWA Technical Report*, 135: 280 pp. CCAMLR 2013. Fishery Report 2013: Exploratory fishery for Dissostichus spp. in Subareas 88.1 and 88.2 Mormede, S., Dunn, A., Hanchet, S.M. 2014. A stock assessment model of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region incorporating multi-year mark-recapture data. CCAMLR Science, 21: 39–62 Mormede, S., Pinkerton, M., Dunn, A., Hanchet, S., Parker, S. 2014. Development of a spatially-explicit minimum realistic model for Antarctic toothfish (*Dissostichus mawsoni*) and its main prey (Macrouridae and Channichthyidae) in the Ross Sea. WG-EMM-14/51 Mormede, S., Dunn, A., Hanchet, S.M., Parker, S. 2014. Spatially explicit population dynamics models for Antarctic toothfish in the Ross Sea region CCAMLR Science, 21: 19–37 Goncharov, S.M., Petrov, A.F. 2014. Stock assessment and proposed TAC for Antarctic toothfish (TOA) in the Subarea 88.2 H in the season 2014–2015. WG-FSA-14/14 Rev. 1. Stevenson, M., Hanchet, S., Mormede, S., Dunn A. 2014. Characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997–98 to 2013–14. WG-FSA-14/52 Mormede, S., Dunn, A., Hanchet, S.M. 2011. Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 88.2C–G for the years 2002–03 to 2010–11. WG-FSA-11/43 Mormede, S., Dunn, A., Hanchet, S.M. 2011. Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRU 88.2E for the years 2002–03 to 2010–11. WG-FSA-11/44 Mormede, S., Dunn, A. 2013. Investigation of potential biases in the assessment of Antarctic toothfish in the Ross Sea fishery using outputs from a spatially explicit operating model. WG-SAM-13/36 Mormede, S., Dunn, A., Hanchet, S.M. 2014. Investigating emigration in stock assessment models of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 88.2C–H. WG-FSA-14/56	
OVERALL PERFORMANCE INDICATOR SCORE:			**RSR: 90** **ASR: 75**
CONDITION NUMBER (if relevant):			**1**

11.2 Principle 2 Evaluation Tables

Evaluation Table for PI 2.1.1

PI 2.1.1		The fishery does not pose a risk of serious or irreversible harm to the retained species and does not hinder recovery of depleted retained species		
Scoring Issue		SG 60	SG 80	SG 100
a	Guidepost	Main retained species are likely to be within biologically based limits (if not, go to scoring issue c below).	Main retained species are highly likely to be within biologically based limits (if not, go to scoring issue c below).	There is a high degree of certainty that retained species are within biologically based limits and fluctuating around their target reference points.
	Met?	Y	Y	N
	Justification	The only retained caught species is Patagonian toothfish. This consistently makes up a small proportion (<0.5%) of the reported catch. It has no greater economic value than Antarctic toothfish and the overall TAC for the Ross Sea is set on *Dissostichus* species rather than *Dissostichus mawsoni*, and so any Patagonian toothfish caught come off the overall area allocation. As a result, this species is not specifically targeted by the fishery. A 'main' species is normally one that comprises over 5% of the catch, is particularly valuable (implying specific targeting) or of particular vulnerability. None of these criteria apply to Patagonian toothfish in the Ross Sea where this is an incidental catch in an Antarctic toothfish targeted fishery. This is not, therefore, considered a 'main' species. Humboldt squid is the bait species used predominantly throughout the fishery, caught in Central and South America. Stock assessments of squid (a short lived, highly fecund species that probably dies after reproducing), particularly over such a large area are complex, usually requiring in-season management. There is no such stock assessment available for Humboldt squid. However, given the recent expansion of the range of this species, and catches, it seems safe to qualitatively assume a greater than 70% probability that the stock is at levels above 20% of its pre-fishing level (i.e. highly likely to be above MSC default biologically based limits). Jack mackerel and sardines are used by some vessels to supplement squid as bait, but in quantities that fall well below levels which would make these main species.		
b	Guidepost			Target reference points are defined for retained species.
	Met?			N
	Justification	Target reference points are not defined for Patagonian toothfish in the Ross Sea nor for Humboldt squid in Central and South America.		

PI 2.1.1		The fishery does not pose a risk of serious or irreversible harm to the retained species and does not hinder recovery of depleted retained species		
c	**Guidepost**	If main retained species are outside the limits there are measures in place that are expected to ensure that the fishery does not hinder recovery and rebuilding of the depleted species.	If main retained species are outside the limits there is a partial strategy of demonstrably effective management measures in place such that the fishery does not hinder recovery and rebuilding.	
	Met?	Y	Y	
	Justification	No main retained species are considered highly likely to be outside of biologically based limits.		
d	**Guidepost**	If the status is poorly known there are measures or practices in place that are expected to result in the fishery not causing the retained species to be outside biologically based limits or hindering recovery.		
	Met?	Y		
	Justification	Patagonian toothfish caught in the Ross Sea fishery (in very low levels) are subject to standard reporting requirements and tagging is underway to inform a future stock assessment if required. Also as the overall TAC for the Ross Sea is set on Dissostichus species rather than *Dissostichus mawsoni*, any Patagonian toothfish caught come off the overall area allocation, so there would not be targeting of this species. The status of Humboldt squid (the bait species used) is also poorly known, but amounts used in the Ross Sea fishery are expected to be minimal relative to the global demand; reduced catches of squid would lead to insufficient supply and/or price increases and switching to another bait.		
References		Pinkerton 2015 http://www.oceanwise.ca/seafood/squid/humboldt-squid-jumbo-squid http://marinebio.org/species.asp?id=249 Pierce and Guerra 1994 Meeting Client		
OVERALL PERFORMANCE INDICATOR SCORE:				80
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.1.2

PI 2.1.2		There is a strategy in place for managing retained species that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to retained species		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	There are measures in place, if necessary, that are expected to maintain the main retained species at levels which are highly likely to be within biologically based limits, or to ensure the fishery does not hinder their recovery and rebuilding.	There is a partial strategy in place, if necessary, that is expected to maintain the main retained species at levels which are highly likely to be within biologically based limits, or to ensure the fishery does not hinder their recovery and rebuilding.	There is a strategy in place for managing retained species.
	Met?	Y	Y	N
	Justification	The only retained species caught is Patagonian toothfish. This is likely to be a species at the edge of its southern range and catches are very low (0 to 30t per year, <0.5% of the catch). There has not been an assessment of the Patagonian toothfish stock but all standard reporting requirements apply, including tagging, to inform future stock assessments if and when required. As the overall TAC for the Ross Sea is set on Dissostichus species rather than *Dissostichus mawsoni*, any Patagonian toothfish caught come off the overall area allocation, so there is not expected to be additional targeting of this species. There are, therefore, no main retained species caught in the fishery.		
b	**Guidepost**	The measures are considered likely to work, based on plausible argument (e.g., general experience, theory or comparison with similar fisheries/species).	There is some objective basis for confidence that the partial strategy will work, based on some information directly about the fishery and/or species involved.	Testing supports high confidence that the strategy will work, based on information directly about the fishery and/or species involved.
	Met?	Y	Y	N
	Justification	A specific (partial) strategy is not required as there are no main retained species, but appropriate information is gathered on the fishery and the species to inform any future strategies.		
c	**Guidepost**		There is some evidence that the partial strategy is being implemented successfully.	There is clear evidence that the strategy is being implemented successfully.
	Met?		Y	N

PI 2.1.2		There is a strategy in place for managing retained species that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to retained species		
	Justification	A specific (partial) strategy is not required, but there is clear evidence (from observer reports and logbook records etc) that all relevant measures are being implemented successfully.		
d	**Guidepost**			There is some evidence that the strategy is achieving its overall objective.
	Met?			N
	Justification	No specific strategy to manage Patagonian toothfish is in place.		
e	**Guidepost**	It is likely that shark finning is not taking place.	It is highly likely that shark finning is not taking place.	There is a high degree of certainty that shark finning is not taking place.
	Met?	Not relevant	Not relevant	Not relevant
	Justification	No retained species are sharks.		
References		Meeting Client CCAMLR Conservation Measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Meeting NIWA		
OVERALL PERFORMANCE INDICATOR SCORE:				80
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.1.3

PI 2.1.3		Information on the nature and extent of retained species is adequate to determine the risk posed by the fishery and the effectiveness of the strategy to manage retained species		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	Qualitative information is available on the amount of main retained species taken by the fishery.	Qualitative information and some quantitative information are available on the amount of main retained species taken by the fishery.	Accurate and verifiable information is available on the catch of all retained species and the consequences for the status of affected populations.
	Met?	Y	Y	N
	Justification	There are no main retained species. However, extremely accurate data on all catches, locations etc is obtained from logbooks, verified by observer reports. There is insufficient information on the status of Patagonian toothfish stocks in and around the Ross Sea to allow the consequences for affected populations to be accurately determined, and so SG100 is not met.		
b	**Guidepost**	Information is adequate to qualitatively assess outcome status with respect to biologically based limits.	Information is sufficient to estimate outcome status with respect to biologically based limits.	Information is sufficient to quantitatively estimate outcome status with a high degree of certainty.
	Met?	Y	Y	N
	Justification	There is highly accurate data on Patagonian toothfish catches from the inception of the fishery, this includes biological measurements (length frequency) and tagging of a proportion of catches. There is considered sufficient data to determine (estimate) the local abundance of Patagonian toothfish and information gathering is continuing at the same intensity and coverage. There is as yet insufficient information to quantitatively estimate outcome status with a high degree of certainty, and so SG100 is not met.		
c	**Guidepost**	Information is adequate to support measures to manage main retained species.	Information is adequate to support a partial strategy to manage main retained species.	Information is adequate to support a strategy to manage retained species, and evaluate with a high degree of certainty whether the strategy is achieving its objective.
	Met?	Y	Y	N
	Justification	There are no main retained species. However, extremely accurate data on all catches, locations, length frequency data etc is obtained from logbooks, verified by observer reports. This is sufficient to support a (partial) strategy. However information on Patagonian toothfish stocks is currently insufficient to allow evaluation of the success of a strategy, and so SG100 is not met.		
d	**Guidepost**		Sufficient data continue to be collected to detect any increase in risk level (e.g. due to changes in the outcome indicator score or the operation of the fishery or the effectiveness of the strategy)	Monitoring of retained species is conducted in sufficient detail to assess ongoing mortalities to all retained species.

PI 2.1.3		Information on the nature and extent of retained species is adequate to determine the risk posed by the fishery and the effectiveness of the strategy to manage retained species		
	Met?		Y	Y
	Justification	Monitoring of retained species (Patagonian toothfish) is conducted in great detail, including CM21-02 requiring a data collection plan sufficient to review the fishery's potential impacts on dependent and related species, CM23-07 requiring daily reporting of the total green weight, by vessel, of each target species and by-catch species for which there is a catch limit in that area, CM 23-05 requiring monthly reporting of samples of length composition measurements of the target species and by-catch species and tagging of toothfish in accordance with CM 41-09 (2014).		
References		Hanchet et al 2010 CCAMLR Conservation Measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Meeting Client		
OVERALL PERFORMANCE INDICATOR SCORE:				85
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.2.1

PI 2.2.1		The fishery does not pose a risk of serious or irreversible harm to the bycatch species or species groups and does not hinder recovery of depleted bycatch species or species groups		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	Main bycatch species are likely to be within biologically based limits (if not, go to scoring issue b below).	Main bycatch species are highly likely to be within biologically based limits (if not, go to scoring issue b below).	There is a high degree of certainty that bycatch species are within biologically based limits.
	Met?	Y	Y	N
	Justification	Grenadiers (which may comprise up to around 5% of the catch) and skates (which are present in much lower numbers, up to 1-2% of catch, but are vulnerable due to life history characteristics) are considered as main bycatch species. An initial assessment of population status of *M whitsoni* suggested indicative estimates of yields in the order of 386-759t, consistent with bycatch limits for all Macrourus spp of 430t in 88.1, 99t in 88.2 and catches consistently below 50% of this limit. Conservation measures as described below will also serve to limit catches of grenadiers. Effects of differentiation of catches of *M whitsoni* and *M caml* are to be monitored, but assuming all catches are *M whitsoni* appears the more precautionary approach. It is therefore considered highly likely (70% probability) that the grenadier population is within biologically based limits. The population status of skates is considered in SIb below. It is also noted that MSC CR v2.0 clarifies that 'sensitive', low productivity species would be considered as 'main' only if they comprise over 2% of the catch, which skates currently do not. SG80 is met. While it is unlikely that all other bycatch species would be outside of biologically based limits, this cannot be demonstrated with a high degree of certainty and so SG100 is not met.		
b	**Guidepost**	If main bycatch species are outside biologically based limits there are mitigation measures in place that are expected to ensure that the fishery does not hinder recovery and rebuilding.	If main bycatch species are outside biologically based limits there is a partial strategy of demonstrably effective mitigation measures in place such that the fishery does not hinder recovery and rebuilding.	
	Met?	Y	Y	

PI 2.2.1		The fishery does not pose a risk of serious or irreversible harm to the bycatch species or species groups and does not hinder recovery of depleted bycatch species or species groups		
	Justification	While it is not highly likely that grenadiers (main species) or skates are outside of biologically based limits, this is not so well demonstrated for skates as for grenadiers. A risk assessment for bycatch species, as reported in the initial MSC assessment did not consider skates at risk: **recommendations have been made for an updated risk assessment and those recommendations are supported by the assessment team.** Nevertheless, the measures prescribed in CMs below (constituting a bycatch strategy) are expected to ensure that the fishery would not cause significant depletion, nor hinder recovery and rebuilding, of any depleted populations. Conservation Measure 33-03 (2014) sets out bycatch limits and other requirements: Skates and rays: total catches of 152t in 88.1, 50t in 88.2: greater of 5% of catch or 50t per SSRU Macrourus spp: 430t in 88.1, 99t in 88.2: greater of 16% of toothfish catch or 20t per SSRU All other species combined: 20t per SSRU Skates to be released alive if high probability of survival Bycatch of any species >1t requires vessel to move at least 5nm and not return for 5 days. CM 41-09 sets out limits on the exploratory fishery in subarea 88.1 and CM 41-10 for 88.2, including SSMU limits on bycatches.		
c	**Guidepost**	If the status is poorly known there are measures or practices in place that are expected to result in the fishery not causing the bycatch species to be outside biologically based limits or hindering recovery.		
	Met?	Y		
	Justification	Bycatch control measures applying to grenadiers and skates also apply to other bycatch species, such as moray cods. Bycatch limits and other requirements of CM33-03 are: Skates and rays: 152t in 88.1, 50t in 88.2: greater of 5% of catch or 50t per SSRU Macrourus spp: 430t in 88.1, 99t in 88.2: greater of 16% of toothfish catch or 20t per SSRU All other species combined: 20t per SSRU Skates to be released alive if high probability of survival Bycatch of any species >1t requires vessel to move at least 5nm and not return for 5 days. CM 41-09 also sets out limits on the exploratory fishery in subarea 88.1 and CM 41-10 for 88.2, including SSMU limits on bycatches. Combined with the limited overall extent of fishing and closed SSRUs, this strategy is expected to be effective in limiting bycatches such that the fishery would not cause the bycatch species to be outside biologically based limits or hinder their recovery.		
References		Pinkerton 2015 Hanchet et al 2010 CCAMLR Conservation Measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Mormede and Dunn 2010 Meeting NIWA Meeting Client Meeting NZ Department of Conservation Meeting stakeholders		

PI 2.2.1	The fishery does not pose a risk of serious or irreversible harm to the bycatch species or species groups and does not hinder recovery of depleted bycatch species or species groups
OVERALL PERFORMANCE INDICATOR SCORE:	80
CONDITION NUMBER (if relevant):	-

Evaluation Table for PI 2.2.2

PI 2.2.2		There is a strategy in place for managing bycatch that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to bycatch populations		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	There are measures in place, if necessary, that are expected to maintain the main bycatch species at levels which are highly likely to be within biologically based limits, or to ensure the fishery does not hinder their recovery and rebuilding.	There is a partial strategy in place, if necessary, that is expected to maintain the main bycatch species at levels which are highly likely to be within biologically based limits, or to ensure the fishery does not hinder their recovery and rebuilding.	There is a strategy in place for managing and minimizing bycatch.
	Met?	Y	Y	Y
	Justification	Conservation Measure 33-03 (2014) sets out measures to achieve the outcome of restrictions on bycatch; the measures are specifically designed for new and exploratory fisheries within the CCAMLR area and contain mechanisms for control of fishing should specified levels of bycatch be exceeded. CM33-03 therefore meets all the requirements of a 'strategy' set out in CR GCB3.3. Bycatch limits and other requirements of CM33-03 are: Skates and rays: 152t in 88.1, 50t in 88.2: greater of 5% of catch or 50t per SSRU Macrourus spp: 430t in 88.1, 99t in 88.2: greater of 16% of toothfish catch or 20t per SSRU (also, should the catch of Macrourus spp. taken by a single vessel in any two 10-day periods in a single SSRU exceed 1 500 kg in each 10-day period and exceed 16% of the catch of Dissostichus spp. by that vessel in that SSRU in those periods, the vessel shall cease fishing in that SSRU for the remainder of the season). All other species combined: 20t per SSRU Skates to be released alive if high probability of survival Bycatch of any species >1t requires vessel to move at least 5nm and not return for 5 days. CM 41-09 also sets out limits on the exploratory fishery in subarea 88.1 and CM 41-10 for 88.2, including SSMU limits on bycatches. Combined with the limited overall extent of fishing and closed SSRUs, this strategy is expected to be effective in limiting bycatches to levels which would maintain affected species' populations above biological limits (biological limits would be the equivalent of limit reference points, such as 20% B0, 'highly likely' requires a 70% probability of the stock being above these levels). SG100 is met.		
b	**Guidepost**	The measures are considered likely to work, based on plausible argument (e.g. general experience, theory or comparison with similar fisheries/species).	There is some objective basis for confidence that the partial strategy will work, based on some information directly about the fishery and/or species involved.	Testing supports high confidence that the strategy will work, based on information directly about the fishery and/or species involved.
	Met?	Y	Y	N

PI 2.2.2		There is a strategy in place for managing bycatch that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to bycatch populations		
	Justification	Assessments of Macrourus stocks and initial assessment, and risk assessment, of skates indicate that these most frequently caught species are not suffering declines that would cause them to approach levels of concern. The CCAMLR management approach for this exploratory fishery is predicated on a carefully managed development of the fishery, with restrictions on total fishing effort, closed SSMUs and bycatch limits as specified in CM33-03. These factors, related to the species and/or the fishery concerned, all provide an objective basis for confidence that the strategy will work. No evidence has been presented, however, that would suggest the strategy has been fully tested. SG80 is therefore met, but SG100 is not.		
c	**Guidepost**		There is some evidence that the partial strategy is being implemented successfully.	There is clear evidence that the strategy is being implemented successfully.
	Met?		Y	Y
	Justification	With regular reporting protocols, 200% observer coverage and no evidence of breaches of CMs by Client Group vessels, there is clear evidence that the strategy is being implemented successfully. SG100 is therefore met.		
d	**Guidepost**			There is some evidence that the strategy is achieving its overall objective.
	Met?			Y
	Justification	Regular reporting protocols, 200% observer coverage and no evidence of breaches of CMs by Client Group vessels show that the strategy is achieving its objectives of limiting fishing effort, enforcing closed SSMUs and limiting bycatches to specified levels. Assessments of Macrourus, and to a lesser extent, skate stocks show that for these, probably the most susceptible species groups, the strategy is successful in maintaining population levels.		
References		CCAMLR Conservation Measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Hanchet et al 2014 Meeting Client Meeting NIWA		
OVERALL PERFORMANCE INDICATOR SCORE:				95
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.2.3

PI 2.2.3		Information on the nature and the amount of bycatch is adequate to determine the risk posed by the fishery and the effectiveness of the strategy to manage bycatch		
Scoring Issue		SG 60	SG 80	SG 100
a	Guidepost	Qualitative information is available on the amount of main bycatch species taken by the fishery.	Qualitative information and some quantitative information are available on the amount of main bycatch species taken by the fishery.	Accurate and verifiable information is available on the catch of all bycatch species and the consequences for the status of affected populations.
	Met?	Y	Y	N
	Justification	Very accurate quantitative data is provided on bycatches through electronic logbooks and observer reports, including benthic species, released skates etc. However, the taxonomy of several affected species groups (including skates and macrourids) is incomplete preventing recording at the species level. There is also not information on the status of all affected populations. SG80 is therefore easily met but SG100 is not met.		
b	Guidepost	Information is adequate to broadly understand outcome status with respect to biologically based limits	Information is sufficient to estimate outcome status with respect to biologically based limits.	Information is sufficient to quantitatively estimate outcome status with respect to biologically based limits with a high degree of certainty.
	Met?	Y	Y	N
	Justification	As described, there is very good information on the areas fished (and not fished, including closed SSMUs) and the catches of bycatch species from commercial fishing and research surveys. There is considered sufficient information to allow managers to estimate what the outcome status of affected populations may be with respect to suitable biologically based limits (which would be equivalent to 20% B0). Information is not sufficient to quantitatively estimate outcome status with a high degree of certainty. SG80 is therefore met, SG100 is not.		
c	Guidepost	Information is adequate to support measures to manage bycatch.	Information is adequate to support a partial strategy to manage main bycatch species.	Information is adequate to support a strategy to manage retained species, and evaluate with a high degree of certainty whether the strategy is achieving its objective.
	Met?	Y	Y	N
	Justification	There is very good information on the levels and species composition of bycatch. There is a strategy in place to limit bycatch amounts and avoid fishing in areas of high population levels, combined with measures to control the overall size and intensity of the fishery, and to limit the areas of the fishery (to open SSMUs). Specific measures for to allow live release of vulnerable skate species have also been implemented. Skate and macrourids population estimates have been made. Information is therefore sufficient to support a strategy appropriate to the scale and intensity of the fishery – catches and fishing locations are closely monitored and the main species affected (skate and macrourids) are monitored in terms of population status. SG80 is therefore met. Information is not sufficient, however, to manage (or identify) each retained species nor to evaluate success with a high degree of certainty. SG100 is not met.		

PI 2.2.3		Information on the nature and the amount of bycatch is adequate to determine the risk posed by the fishery and the effectiveness of the strategy to manage bycatch		
d	**Guidepost**		Sufficient data continue to be collected to detect any increase in risk to main bycatch species (e.g. due to changes in the outcome indicator scores or the operation of the fishery or the effectively of the strategy).	Monitoring of bycatch data is conducted in sufficient detail to assess ongoing mortalities to all bycatch species.
	Met?		Y	N
	Justification	Current levels of reporting and monitoring are expected to continue. Monitoring is more than adequate to detect any changes in the operation of the fishery (areas fished, numbers of vessels, gear used) or changes in the catches of bycatch species. SG80 is met. As discussed, all species affected have not been described, so while ongoing mortality of species groups is achieved, SG100 is not met.		
References		Mormede et al 2014. CCAMLR Conservation Measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Hanchet et al 2014 Pinkerton 2015 Mormede and Dunn 2010 Meeting Client		
OVERALL PERFORMANCE INDICATOR SCORE:				80
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.3.1

PI 2.3.1		The fishery meets national and international requirements for the protection of ETP species The fishery does not pose a risk of serious or irreversible harm to ETP species and does not hinder recovery of ETP species		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	Known effects of the fishery are likely to be within limits of national and international requirements for protection of ETP species.	The effects of the fishery are known and are highly likely to be within limits of national and international requirements for protection of ETP species.	There is a high degree of certainty that the effects of the fishery are within limits of national and international requirements for protection of ETP species.
	Met?	Y	Y	Y
	Justification	The direct effects of the fishery on protected species are *de minimis* – only two seabirds have been caught on longlines in the history of the fishery, and no marine mammals. No targeting of whales or seals takes place. Information is supported by 200% observer coverage and transparent reporting by members of the client group, providing a high degree of certainty that these are accurate numbers and are within any national and international requirements for protection of affected populations.		
b	**Guidepost**	Known direct effects are unlikely to create unacceptable impacts to ETP species.	Direct effects are highly unlikely to create unacceptable impacts to ETP species.	There is a high degree of confidence that there are no significant detrimental direct effects of the fishery on ETP species.
	Met?	Y	Y	Y
	Justification	MSC CR v1.3 s CB3.11.3.1 defines the SG100 requirements as requiring full compliance with all requirements and negligible mortality of ETP species. There is ample evidence of full compliance with CCAMLR conservation measures by members of the client group, and the level of direct mortalities caused by the fishery can be considered negligible. Again, 200% observer coverage and transparent reporting of interactions by client group members provide a high degree of confidence in the information available.		
c	**Guidepost**		Indirect effects have been considered and are thought to be unlikely to create unacceptable impacts.	There is a high degree of confidence that there are no significant detrimental indirect effects of the fishery on ETP species.
	Met?		Y	N

PI 2.3.1		The fishery meets national and international requirements for the protection of ETP species The fishery does not pose a risk of serious or irreversible harm to ETP species and does not hinder recovery of ETP species
	Justification	Indirect effects on protected species would arise through, for example, changes in prey or predator abundance or changes in habitat. For species that could be considered 'ETP' in the Ross Sea, such effects would be expected to arise from the removal of toothfish as a prey species. Such effects are most likely to be seen in Type C Killer Whales (TCKW) and Weddell seals. Wider trophic effects which may affect seals, cetaceans or penguins are considered in PI 2.5.1. Indirect effects have been explicitly considered by CCAMLR. At SG80 it is required that effects are 'unlikely' to create unacceptable impacts, which corresponds to a 30% probability of an unacceptable impact arising (CR v1.3 CB3.11.4.1 d). No effects of the toothfish fishery on Weddell seal populations have been reported, but it is possible that significant changes in toothfish population densities near Weddell seal breeding colonies at the time of pupping and weaning could affect survival of pups and lactating mothers. Similarly, for killer whales, there is a suggestion that lactating females in southwest Ross Sea could be adversely affected by reductions in toothfish availability due to the fishery. The fishery could affect predators through: a) localised depletion of toothfish within a season, b) reducing the number of subadult toothfish in the southwest Ross Sea and c) by changing the movement patterns of toothfish, particularly by reducing numbers of large toothfish on the slope, causing other large toothfish to move from the shelf, particularly in the south west. In relation to a), fishing closures are in place in waters shallower than 550m and in SSRU 88.1 M; for b) a sub adult surveys in the southwest Ross Sea shows no significant change in catch rates. The remaining uncertainty is therefore over potential changes in movement patterns of toothfish. Weddell seals are, however, considered of Least Concern by IUCN. Unacceptable population-level impacts are, therefore, considered unlikely but not with a high degree of confidence. It is also noted that research into both Weddell seal diet and foraging patterns is underway, which would help to discern any potential effects which may arise. For type C killer whales, such effects on lactating females has also not been demonstrated. At present then, this is a possible impact the extent of which has not been determined at a population level within the Ross Sea; indeed, determining such an effect may prove extremely difficult. IUCN estimate that the global worse-case effect of "*the combination of potential declines driven by depletion of prey resources and the effects of pollutants is believed sufficient that a 30% global reduction over three generations (77 years; Taylor et al. 2007) cannot be ruled out for some 'groups'*". IUCN define a population 'vulnerable' (a low category of risk) where there has been a >30% reduction in size. As toothfish exploitation in the Ross Sea is, relatively speaking, extremely light, pollutant effects will be minimal and other prey sources are available (and apparently utilised by TCKW) then such an unacceptable impact is considered unlikely, but cannot be dismissed with a high degree of confidence. SG80 is therefore met – these indirect effects have been considered: they seem unlikely to create unacceptable impacts on affected populations. The uncertainties inherent in estimating such effects do not allow for a 'high degree of confidence' and so SG100 is not met. **It is recommended that possible effects on Weddell seal and TCKW be considered a suitable focus for further research.**
References		IUCN at http://www.iucnredlist.org Pinkerton 2015 Mitchell 2014

PI 2.3.1	The fishery meets national and international requirements for the protection of ETP species The fishery does not pose a risk of serious or irreversible harm to ETP species and does not hinder recovery of ETP species	
	Meeting stakeholders Meeting NIWA Meeting Client Eisert et al 2013, 2014 Ainley and Ballard 2012	
OVERALL PERFORMANCE INDICATOR SCORE:		95
CONDITION NUMBER (if relevant):		-

Evaluation Table for PI 2.3.2

PI 2.3.2		The fishery has in place precautionary management strategies designed to: Meet national and international requirements; Ensure the fishery does not pose a risk of serious harm to ETP species; Ensure the fishery does not hinder recovery of ETP species; and Minimise mortality of ETP species.		
Scoring Issue		SG 60	SG 80	SG 100
a	Guidepost	There are measures in place that minimise mortality of ETP species, and are expected to be highly likely to achieve national and international requirements for the protection of ETP species.	There is a strategy in place for managing the fishery's impact on ETP species, including measures to minimise mortality, which is designed to be highly likely to achieve national and international requirements for the protection of ETP species.	There is a comprehensive strategy in place for managing the fishery's impact on ETP species, including measures to minimise mortality, which is designed to achieve above national and international requirements for the protection of ETP species.
	Met?	Y	Y	Y
	Justification	As noted, there have been no recordings of direct effects on mammals. Effects on seabirds are effectively mitigated by a series of measures included within the CCAMLR ecosystem-based management strategy. Most notable are: CM 24-02 longline weighting CM 25-02 minimisation of incidental mortality of seabirds during longline fishing. These measures require the weighting of lines to achieve rapid sink rates, use of streamer lines and avoidance of offal discharge south of 60oS. CM 41-09 limits the fishery in Subarea 88.1 and CM 41-10 limits the fishery in 88.2, limiting catches of toothfish, bycatches and ensuring seven of the 15 SSRUs remain unfished. There are also measures preventing fishing within waters shallower than 550m which would minimise localised depletion in areas used by breeding mammals (Weddell seals and killer whales in particular). These measures will minimise potential indirect effects. This is considered a comprehensive strategy which would achieve above international requirements for protection of ETP species. SG100 is therefore met.		
b	Guidepost	The measures are considered likely to work, based on plausible argument (e.g., general experience, theory or comparison with similar fisheries/species).	There is an objective basis for confidence that the strategy will work, based on information directly about the fishery and/or the species involved.	The strategy is mainly based on information directly about the fishery and/or species involved, and a quantitative analysis supports high confidence that the strategy will work.
	Met?	Y	Y	Y
	Justification	The strategy is entirely based on information on the fishery and species involved. The fishery and many affected species are closely monitored and the quantitative results obtained are analysed through the CCAMLR Scientific Committee. Analyses to date provide high levels of confidence that the strategy is effective. SG100 is therefore met.		
c	Guidepost		There is evidence that the strategy is being implemented successfully.	There is clear evidence that the strategy is being implemented successfully.

PI 2.3.2		The fishery has in place precautionary management strategies designed to: Meet national and international requirements; Ensure the fishery does not pose a risk of serious harm to ETP species; Ensure the fishery does not hinder recovery of ETP species; and Minimise mortality of ETP species.		
	Met?		Y	Y
	Justification	With regular reporting protocols, electronic logbooks, 200% observer coverage and no evidence of breaches of CMs by Client Group vessels, there is clear evidence that the strategy is being implemented successfully. SG100 is therefore met.		
d	**Guidepost**			There is evidence that the strategy is achieving its objective.
	Met?			Y
	Justification	Regular reporting protocols, 200% observer coverage and no evidence of breaches of CMs by Client Group vessels show that the strategy is achieving its objectives of minimising direct interactions with ETP species and that fishing is constrained within limits set by CMs 41-09 and 41-10.		
References		Pinkerton 2015. CCAMLR Conservation Measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Weddell seal population studies at http://weddellsealscience.com/science.html Meeting Client		
OVERALL PERFORMANCE INDICATOR SCORE:				100
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.3.3

PI 2.3.3		Relevant information is collected to support the management of fishery impacts on ETP species, including: Information for the development of the management strategy; Information to assess the effectiveness of the management strategy; and Information to determine the outcome status of ETP species.		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	Information is sufficient to qualitatively estimate the fishery related mortality of ETP species.	Sufficient information is available to allow fishery related mortality and the impact of fishing to be quantitatively estimated for ETP species.	Information is sufficient to quantitatively estimate outcome status of ETP species with a high degree of certainty.
	Met?	Y	Y	N
	Justification	Information on direct effects of the fishery is sufficient to quantitatively estimate effects on outcome status with a high degree of certainty. While information on indirect effects on predators of removing toothfish can be quantitatively estimated, through trophic models etc, there remain uncertainties over indirect effects on, in particular, Weddell seals and type C killer whales at times of vulnerability to changes in toothfish availability. There is therefore insufficient information to assign a high degree of certainty to the results. Accordingly, SG80 is met, but SG100 is not.		
b	**Guidepost**	Information is adequate to broadly understand the impact of the fishery on ETP species.	Information is sufficient to determine whether the fishery may be a threat to protection and recovery of the ETP species.	Accurate and verifiable information is available on the magnitude of all impacts, mortalities and injuries and the consequences for the status of ETP species.
	Met?	Y	Y	N
	Justification	Information from observers and fishery records is sufficient to accurately and verifiably determine the magnitude of all impacts, mortalities and injuries (i.e. direct effects of the fishery) and the consequences for the status of ETP species (negligible levels of interaction will have negligible consequences for affected populations). The uncertainties surrounding the potential effect of altered toothfish availability to Weddell seals and type C killer whale feeding at particular times, however, may conservatively be considered sufficient to prevent 'all impacts' having fully accurate information.		
c	**Guidepost**	Information is adequate to support measures to manage the impacts on ETP species.	Information is sufficient to measure trends and support a full strategy to manage impacts on ETP species.	Information is adequate to support a comprehensive strategy to manage impacts, minimise mortality and injury of ETP species, and evaluate with a high degree of certainty whether a strategy is achieving its objectives.
	Met?	Y	Y	N

PI 2.3.3		Relevant information is collected to support the management of fishery impacts on ETP species, including: Information for the development of the management strategy; Information to assess the effectiveness of the management strategy; and Information to determine the outcome status of ETP species.
	Justification	Accurate and verifiable information is available on direct effects of the fishery on birds and mammals. Indirect effects are possible, in some circumstances, on populations of Weddell seals and type C killer whales. Weddell seals in the McMurdo sound area have been well studied for several decades and information on population trends has been collected for type B and C killer whales, providing a baseline against which to determine potential changes in population status. Direct interactions would therefore meet the SG100 level, but indirect effects are only sufficient to measure trends. Both are sufficient to support the CCAMLR management strategy. SG80 is therefore met, but SG100 is not fully met.
References		Weddell seal population studies at http://weddellsealscience.com/science.html Ainley and Ballard 2012 Meeting Client Meeting NIWA Pinkerton 2015
OVERALL PERFORMANCE INDICATOR SCORE:		80
CONDITION NUMBER (if relevant):		-

Evaluation Table for PI 2.4.1

<table>
<tr><td colspan="2">PI 2.4.1</td><td colspan="3">The fishery does not cause serious or irreversible harm to habitat structure, considered on a regional or bioregional basis, and function</td></tr>
<tr><td colspan="2">Scoring Issue</td><td>SG 60</td><td>SG 80</td><td>SG 100</td></tr>
<tr><td rowspan="3">a</td><td>Guidepost</td><td>The fishery is unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm.</td><td>The fishery is highly unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm.</td><td>There is evidence that the fishery is highly unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm.</td></tr>
<tr><td>Met?</td><td>Y</td><td>Y</td><td>Partial</td></tr>
<tr><td>Justification</td><td colspan="3">The extent of habitats considered in this evaluation is the Ross Sea (Subareas 88.1 and 88.2).
CR v1.3 GCB 3.14.2 defines ‘serious or irreversible harm’ as the loss (extinction) of habitat types, depletion of key habitat forming species to the point of high risk of extinction or significant alteration of habitat cover/mosaic that causes major changes in the structure or diversity of associated species assemblages. CR Table CB 18 defines the intended probability interpretation of ‘highly unlikely’ as ‘there should be no more than a 30% probability that the true status of the component is within the range where there is risk of serious or irreversible harm’.
Most sensitive benthic taxa (VME taxa) are expected to be associated with hard substrate – found mostly along the shore and in offshore reefs and seamounts. The evaluation of the overall effect of the fishery on habitat structure and function must therefore consider the proportion of the area affected and the impact of fishing in areas that are affected.
Fishing tends to be concentrated in preferred locations within a depth range 600-1800m and fishing is prohibited in bottom depths less than 550 m. The percentages area fished of the total of 88.1 and 88.2, and of areas less than 1800m (which would include all hard substrate likely to be affected) is as follows.

<table>
<tr><td></td><td>% total areas fished</td><td>% area <1800m fished</td></tr>
<tr><td>88.1</td><td>4.9</td><td>24.2</td></tr>
<tr><td>88.2</td><td>2.2</td><td>28.0</td></tr>
</table>

There is, therefore, at least >95% of the total area and >70% of shallower (<1800m) depths that are not affected by the fishery at all.
Of the areas that are affected, Sharp 2010 describes the effect of fishing on the 17 benthic bioregions (corresponding to main habitat divisions) of the Ross Sea, identified based on variables influencing the distribution and abundance of benthic taxa. Of these, the cumulative impact of New Zealand vessels (which currently represent 3 of a total 8 vessels in the client group) is thought to represent impacts in the order of 0.01 to 0.03% mortality for the most fragile VME taxa in the most heavily fished bioregions. Extending this to the whole client group would mean 0.02-0.08% mortality – levels of impact that would not plausibly cause major changes in the structure or diversity of species assemblages. VMEs are further protected by management measures such as move-on rules when VME taxa are encountered.
There is, therefore, a much less than 30% probability that the true status of the component is within the range where there is risk of serious or irreversible harm. Evidence is available on the distribution of bioregions, the concentration of fishing effort within these and the likely effects of this level of effort; SG80 is therefore met and SG100 partly met. Evidence of the nature and distribution of more distinct habitat types (biotopes) is not available, however, nor the specific effects of longline fishing on these. SG100 is not fully met.</td></tr>
<tr><td colspan="2">References</td><td colspan="3">Moody Marine 2013, 2014
Sharp 2010
Mitchell 2014</td></tr>
</table>

PI 2.4.1	The fishery does not cause serious or irreversible harm to habitat structure, considered on a regional or bioregional basis, and function
	Meeting Client
OVERALL PERFORMANCE INDICATOR SCORE:	90
CONDITION NUMBER (if relevant):	-

Evaluation Table for PI 2.4.2

PI 2.4.2		There is a strategy in place that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to habitat types		
Scoring Issue		SG 60	SG 80	SG 100
a	Guidepost	There are measures in place, if necessary, that are expected to achieve the Habitat Outcome 80 level of performance.	There is a partial strategy in place, if necessary, that is expected to achieve the Habitat Outcome 80 level of performance or above.	There is a strategy in place for managing the impact of the fishery on habitat types.
	Met?	Y	Y	Y
	Justification	The CCAMLR ecosystem-based management strategy contains a number of provisions to manage the effects of the fishery on habitat: CM 22-04 and 22-05 contain provisions for restrictions on 'higher risk' bottom fishing activities by gill net and trawl CM 22-06 contains provisions for a) notification of the known and expected effects of the proposed fishing by each Contracting Party (including VMEs, benthos and benthic communities), for preliminary assessment by the Scientific Committee and approval by the Commission; b) cease fishing on encountering VMEs and report such encounters; c) the Scientific Committee maintains a register of VME locations and provides advice for their protection CM 22-07 contains provisions for identification of VME 'risk areas' and their closure to fishing by CCAMLR secretariat CM 22-08 contains provisions for prohibition of fishing in depths shallower than 550m for the protection of benthic communities. CM 22-09 prohibits all bottom fishing activities within defined areas, including two areas within SSRU 'G' in subarea 88.1 CM 23-07 requires daily reporting of catches of target species and bycatch species, including benthic species/VME 'indicator units'. These measures are considered to comprise a comprehensive strategy, in relation to the nature of the fishery, to manage the impact of the fishery on benthic habitats. SG100 is therefore met.		
b	Guidepost	The measures are considered likely to work, based on plausible argument (e.g. general experience, theory or comparison with similar fisheries/habitats).	There is some objective basis for confidence that the partial strategy will work, based on information directly about the fishery and/or habitats involved.	Testing supports high confidence that the strategy will work, based on information directly about the fishery and/or habitats involved.
	Met?	Y	Y	N
	Justification	The development and review of CMs by the Scientific Committee and Commission, the specific development of CMs in relation to the fishery and habitats present and the precautionary and comprehensive nature of the CMs in the Ross Sea provide a basis for confidence that the strategy will work. SG80 is therefore met. No evidence of specific testing of the strategy has been provided (no doubt owing to the nature of the environment) and so SG100 is not met.		
c	Guidepost		There is some evidence that the partial strategy is being implemented successfully.	There is clear evidence that the strategy is being implemented successfully.

PI 2.4.2		There is a strategy in place that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to habitat types		
	Met?		Y	Y
	Justification	With regular reporting protocols, electronic logbooks, 200% observer coverage and no evidence of breaches of CMs by Client Group vessels, there is clear evidence that the strategy is being implemented successfully. SG100 is therefore met.		
d	**Guidepost**			There is some evidence that the strategy is achieving its objective.
	Met?			Y
	Justification	All evidence suggests that the strategy is implemented successfully. Also, evaluation of the impact of fishing on benthic habitats suggests a very low level of effect. There are, therefore, several strands of evidence that the strategy is achieving its objectives. SG100 is met.		
References		Sharp 2010 CCAMLR conservation measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Meeting Client Meeting NIWA		
OVERALL PERFORMANCE INDICATOR SCORE:				95
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.4.3

PI 2.4.3		Information is adequate to determine the risk posed to habitat types by the fishery and the effectiveness of the strategy to manage impacts on habitat types		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	There is basic understanding of the types and distribution of main habitats in the area of the fishery.	The nature, distribution and vulnerability of all main habitat types in the fishery are known at a level of detail relevant to the scale and intensity of the fishery.	The distribution of habitat types is known over their range, with particular attention to the occurrence of vulnerable habitat types.
	Met?	Y	Y	N
	Justification	The identification of benthic bioregions (main habitat types) and establishment of bathymetric data in the Ross Sea, and the evaluation, for each of these, of the effects of longline fishing provides information on the nature, distribution and vulnerability of all main habitat types in the fishery at a level of detail relevant to the scale and intensity of the fishery – i.e. information is sufficient for a relatively restricted and low impact fishery. SG80 is met. While mapping of VMEs takes place as information is gathered, the distribution of all habitat types across the Ross Sea is not fully known. SG100 is not met.		
b	**Guidepost**	Information is adequate to broadly understand the nature of the main impacts of gear use on the main habitats, including spatial overlap of habitat with fishing gear.	Sufficient data are available to allow the nature of the impacts of the fishery on habitat types to be identified and there is reliable information on the spatial extent of interaction, and the timing and location of use of the fishing gear.	The physical impacts of the gear on the habitat types have been quantified fully.
	Met?	Y	Y	N
	Justification	The nature, and extent, of impacts of the fishery on habitat types (bioregions) has been established. CCAMLR reporting protocols, coupled with VMS, observer programme, and bathymetric datasets, provide highly reliable information on the spatial extent of interaction, and the timing and location of use of the fishing gear. SG80 is met. Physical impacts of the gear on the habitat types have not been quantified fully, and so SG100 is not met.		
c	**Guidepost**		Sufficient data continue to be collected to detect any increase in risk to habitat (e.g. due to changes in the outcome indicator scores or the operation of the fishery or the effectiveness of the measures).	Changes in habitat distributions over time are measured.
	Met?		Y	N

PI 2.4.3		Information is adequate to determine the risk posed to habitat types by the fishery and the effectiveness of the strategy to manage impacts on habitat types
	Justification	CCAMLR reporting measures are expected to continue in force as at present. These are sufficient to determine any increase in risk to habitat – e.g. by changes in the size of the fishery, fishing patterns and/or identification (and subsequent protection) of further areas of VME
References		Sharp 2010 Parker et al 2010 CCAMLR conservation measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Intertek Moody Marine 2013, 2014
OVERALL PERFORMANCE INDICATOR SCORE:		80
CONDITION NUMBER (if relevant):		-

Evaluation Table for PI 2.5.1

PI 2.5.1		The fishery does not cause serious or irreversible harm to the key elements of ecosystem structure and function		
Scoring Issue		SG 60	SG 80	SG 100
a	Guidepost	The fishery is unlikely to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm.	The fishery is highly unlikely to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm.	There is evidence that the fishery is highly unlikely to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm.
	Met?	Y	Y	Y
	Justification	'Highly unlikely' means that there is a more than a 30% probability of serious or irreversible harm. Consideration of individual ecosystem components above (retained and bycatch species, ETP species and habitat effects) have not identified any impacts which would disrupt ecosystem structure and function to a point of serious or irreversible harm. Significant effects on the ecosystem structure and function (provision of ecosystem services) would therefore arise from trophic effects (it is noted that indirect (trophic) effects on ETP species have been considered under PI 2.3.1). Potential trophic effects of the fishery have been very usefully summarised in Mitchell (2014) and Pinkerton (2015) and the development of a trophic model for the Ross Sea has allowed testing of the effect of changing toothfish populations on the ecosystem. This analysis has shown the groups with the highest trophic importance in decreasing order were: phytoplankton, mesozooplankton, Antarctic silverfish, small demersal fish, Antarctic krill and cephalopods. Pelagic fish and crystal krill were also likely to have relatively high trophic importance in the Ross Sea food web. These would represent the key elements underlying ecosystem structure and function. Toothfish are considered to be of moderate importance in the food web. Changing abundance of toothfish may affect medium sized demersal fish, but these in turn are of low importance in the food web, and so this would not have knock-on effects. A straightforward cascading effect due to toothfish removal is therefore considered unlikely It is also relevant that this remains an exploratory fishery, developing slowly and in a precautionary manner and toothfish biomass remains at a high level (around 75% B_0). The fishery, as discussed earlier, is also very localised in effect and large parts of the Ross Sea are closed to fishing. So, while ecosystem effects of toothfish removal cannot be ruled out, evidence is available which indicates that disruption of ecosystem structure and function to a point of serious or irreversible harm is highly unlikely. SG100 is therefore met.		
References		Mitchell, 2014 Pinkerton, 2015 Meeting NIWA Meeting Client Meeting stakeholders		
OVERALL PERFORMANCE INDICATOR SCORE:				100
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.5.2

PI 2.5.2		There are measures in place to ensure the fishery does not pose a risk of serious or irreversible harm to ecosystem structure and function		
Scoring Issue		SG 60	SG 80	SG 100
a	**Guidepost**	There are measures in place, if necessary.	There is a partial strategy in place, if necessary.	There is a strategy that consists of a plan, in place.
	Met?	Y	Y	Y
	Justification	The CCAMLR ecosystem-based management strategy contains a number of provisions to manage the effects of the fishery on all ecosystem components, including analysis through modelling of potential trophic effects of the fishery. CCAMLR processes consider these ecosystem components as part of an integral plan for the fishery. SG100 is met.		
b	**Guidepost**	The measures take into account potential impacts of the fishery on key elements of the ecosystem.	The partial strategy takes into account available information and is expected to restrain impacts of the fishery on the ecosystem so as to achieve the Ecosystem Outcome 80 level of performance.	The strategy, which consists of a plan, contains measures to address all main impacts of the fishery on the ecosystem, and at least some of these measures are in place. The plan and measures are based on well-understood functional relationships between the fishery and the Components and elements of the ecosystem. This plan provides for development of a full strategy that restrains impacts on the ecosystem to ensure the fishery does not cause serious or irreversible harm.
	Met?	Y	Y	Y
	Justification	The CCAMLR management strategy contains measures to address all identified impacts of the fishery on the ecosystem; all measures determined to be necessary have been implemented. The plan and measures are based on well understood relationships between the fishery and components (target stock, bycatch, ETP species and habitat) and elements (e.g. key bycatch species, vulnerable ETP species such as seabirds, VME habitats). The CCAMLR management strategy specifically seeks to ensure that harvesting is carried out in a sustainable manner and takes account of the effects of fishing on other components of the ecosystem. SG100 is met.		
c	**Guidepost**	The measures are considered likely to work, based on plausible argument (e.g., general experience, theory or comparison with similar fisheries/ecosystems).	The partial strategy is considered likely to work, based on plausible argument (e.g., general experience, theory or comparison with similar fisheries/ecosystems).	The measures are considered likely to work based on prior experience, plausible argument or information directly from the fishery/ecosystems involved.
	Met?	Y	Y	Y

PI 2.5.2		There are measures in place to ensure the fishery does not pose a risk of serious or irreversible harm to ecosystem structure and function		
	Justification	All measures have been shown to be effectively implemented, are well monitored and, based on information from the fishery and ecosystem affected, are considered likely to work. SG100 is met.		
d	**Guidepost**		There is some evidence that the measures comprising the partial strategy are being implemented successfully.	There is evidence that the measures are being implemented successfully.
	Met?		Y	Y
	Justification	Regular reporting protocols, 200% observer coverage and no evidence of breaches of CMs by Client Group vessels all provide evidence that measures are successfully implemented. SG100 is met.		
References		CCAMLR conservation measures at https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures Hanchet et al 2014 Pinkerton 2015 Meeting Client		
OVERALL PERFORMANCE INDICATOR SCORE:				100
CONDITION NUMBER (if relevant):				-

Evaluation Table for PI 2.5.3

PI 2.5.3		There is adequate knowledge of the impacts of the fishery on the ecosystem		
Scoring Issue		SG 60	SG 80	SG 100
a	Guidepost	Information is adequate to identify the key elements of the ecosystem (e.g., trophic structure and function, community composition, productivity pattern and biodiversity).	Information is adequate to broadly understand the key elements of the ecosystem.	
	Met?	Y	Y	
	Justification	A balanced trophic model for the Ross Sea has been produced, which provides a good understanding of the key elements of the ecosystem and interactions between these.		
b	Guidepost	Main impacts of the fishery on these key ecosystem elements can be inferred from existing information, and have not been investigated in detail.	Main impacts of the fishery on these key ecosystem elements can be inferred from existing information and some have been investigated in detail.	Main interactions between the fishery and these ecosystem elements can be inferred from existing information, and have been investigated.
	Met?	Y	Y	Y
	Justification	There is extremely good information on removals of toothfish and other fish species from the ecosystem. The role of toothfish in the ecosystem is well understood, and it is an integral component of the ecosystem model. The main interactions of the fishery and the receiving ecosystem have therefore been investigated. Specifically here, CB 3.19.1.2 requires that the management system should be capable of adapting management to environmental change and that monitoring of environmental change on the natural productivity of fisheries should be considered best practice, including recognition of the effect of climate change. In this regard, CCAMLR has established the Ecosystem Monitoring Program (CEMP) in 1989. The aims of CEMP are to both detect significant changes in critical components of the marine ecosystem within the Convention Area, to serve as a basis for the conservation of Antarctic marine living resources; and to distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological. CCAMLR has also established specific research initiatives – notably 'Integrating Climate and Ecosystem Dynamics' and 'Southern Ocean Sentinel' programmes. CCAMLR Resolution 30/XXVIII specifically addresses the issue of climate change. SG100 is therefore met.		
c	Guidepost		The main functions of the Components (i.e., target, Bycatch, Retained and ETP species and Habitats) in the ecosystem are known.	The impacts of the fishery on target, Bycatch, Retained and ETP species are identified and the main functions of these Components in the ecosystem are understood.
	Met?		Y	Y

PI 2.5.3		There is adequate knowledge of the impacts of the fishery on the ecosystem		
	Justification	Direct effects of the fishery on target species, retained and bycatch species and ETP species have been identified and are generally understood; for ETP species this extends to considerations of possible effects on nursing Weddell seals and killer whales in specific areas. As this PI considers effects of the fishery on the ecosystem (with individual components being considered earlier), and an ecosystem model has been developed and used to test possible effects of the fishery, knowledge is considered sufficient to meet the SG100 requirement.		
d	**Guidepost**		Sufficient information is available on the impacts of the fishery on these Components to allow some of the main consequences for the ecosystem to be inferred.	Sufficient information is available on the impacts of the fishery on the Components and elements to allow the main consequences for the ecosystem to be inferred.
	Met?		Y	Y
	Justification	As above, there is excellent information on the direct effects (catches and direct mortality of target, bycatch, ETP species and VME taxa) of the fishery on each component/element; sufficient to allow the main consequences for the ecosystem to be inferred. This extends into indirect effects through modelling of the main consequences of fishing for the wider ecosystem.		
e	**Guidepost**		Sufficient data continue to be collected to detect any increase in risk level (e.g., due to changes in the outcome indicator scores or the operation of the fishery or the effectiveness of the measures).	Information is sufficient to support the development of strategies to manage ecosystem impacts.
	Met?		Y	Y
	Justification	Significant data continue to be collected from the fishery to detect changes in risk level, including excellent information on fishing locations, practices and catches and locations of VMEs. Research is ongoing, including research to better characterise demersal fish assemblages. SG80 is met. CCAMLR, principally through the Scientific Committee, have an established track record of keeping such information under review and using this to refine management of all ecosystem components. Information gathered is considered sufficient to support the development of strategies to manage each component. SG100 is also met.		
References		Pinkerton 2015 Pinkerton et al 2009 Meeting Client		
OVERALL PERFORMANCE INDICATOR SCORE:				100
CONDITION NUMBER (if relevant):				-

Principle 3 Evaluation Tables

Evaluation Table for PI 3.1.1

PI 3.1.1		The management system exists within an appropriate legal and/or customary framework which ensures that it: • Is capable of delivering sustainable fisheries in accordance with MSC Principles 1 and 2; and • Observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and • Incorporates an appropriate dispute resolution framework.		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	There is an effective national legal system and a framework for cooperation with other parties, where necessary, to deliver management outcomes consistent with MSC Principles 1 and 2	There is an effective national legal system and organised and effective cooperation with other parties, where necessary, to deliver management outcomes consistent with MSC Principles 1 and 2.	There is an effective national legal system and binding procedures governing cooperation with other parties which delivers management outcomes consistent with MSC Principles 1 and 2.
	Met?	**(Y)**	**(Y)**	**(Y)**
	Justification	The Ross Sea toothfish fishery operates under the auspices of an international treaty - the Convention for the Conservation of Antarctic Marine Living Resources – and is managed by the Commission for the Conservation of Antarctic Living Resources (www.ccamlr.org). The CAMLR Convention, in turn, is an integral component of the Antarctic Treaty System. The objective of the CAMLR Convention is “the conservation of Antarctic marine living resources”, where “conservation” includes rational use. This objective readily aligns with MSC Principles 1 and 2. Any state participating in the Ross Sea toothfish fishery must be a member of CCAMLR. Under the CCAMLR umbrella, members work together to make decisions on matters of substance by consensus. The requirements of CCAMLR relating to the fishery are reviewed and agreed upon annually through an extensive meeting process. Binding measures, under which participants in the fishery must agree to operate and against which compliance is assessed, are enacted at the Commission level. Processes through which binding measures are developed by CCAMLR members are organised and effective. Requirements that must be met by states legally participating in the fishery are clear and agreed prior to the commencement of the fishing season. Member states are obligated to implement the requirements of CCAMLR where these requirements apply to their own fishing operations. This is typically achieved by enacting specific components of domestic legislation. States may also implement additional requirements of their own, i.e., beyond measures developed by CCAMLR. CCAMLR has developed memoranda of understanding other multilateral bodies relevant to achieving its objectives, e.g., the Agreement on the Conservation of Albatrosses and Petrels. Given the overarching CCAMLR structure, domestic legal requirements and binding measures for fisheries management, there is clearly an effective legal system and binding procedures governing cooperation with other parties which delivers management outcomes consistent with MSC Principles 1 and 2. A score of 100 is given.		

PI 3.1.1		**The management system exists within an appropriate legal and/or customary framework which ensures that it:** • **Is capable of delivering sustainable fisheries in accordance with MSC Principles 1 and 2; and** • **Observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and** • **Incorporates an appropriate dispute resolution framework.**		
b	**Guidepost**	The management system incorporates or is subject by law to a mechanism for the resolution of legal disputes arising within the system.	The management system incorporates or is subject by law to a transparent mechanism for the resolution of legal disputes which is considered to be effective in dealing with most issues and that is appropriate to the context of the fishery.	The management system incorporates or subject by law to a transparent mechanism for the resolution of legal disputes that is appropriate to the context of the fishery and has been tested and proven to be effective.
	Met?	(Y)	(Y)	(N)
	Justification	CCAMLR operates by consensus decision-making on matters of substance (and a majority basis for other matters). This *modus operandi* is documented in the Convention text (Article XII). The CAMLR Convention (Article XXV) provides for the resolution of disputes between Contracting Parties on matters relating to the interpretation or application of the Convention by "peaceful means of their own choice", including methods such as negotiation and mediation. Where such methods do not resolve the issues, disputes are to be referred to the International Court of justice or to arbitration. While the consensus-based operating approach has supported the operation of CCAMLR over time, one example of an area in which members' opinions have diverged significantly over several years, and have included points of legal difference, is the development of marine protected areas (CCAMLR 2014). Members' attempts to reconcile these differences are ongoing. The performance review of CCAMLR completed in 2008 identified dispute resolution as an area of weakness and proposed alternative approaches (including the amendment of Article XXV) which are yet to be considered by the Commission. For example, the review proposes tailoring specific dispute resolution processes for Parties to CCAMLR and Non-contracting Parties who are members of UNCLOS. The review panel highlights Non-contracting Parties as particularly relevant in a dispute context given IUU fishing concerns. As the issues relating to dispute resolution highlighted by the review panel have not yet been acted on by CCAMLR, a score of 80 is given.		
d	**Guidepost**	The management system has a mechanism to generally respect the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood in a manner consistent with the objectives of MSC Principles 1 and 2.	The management system has a mechanism to observe the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood in a manner consistent with the objectives of MSC Principles 1 and 2.	The management system has a mechanism to formally commit to the legal rights created explicitly or established by custom of people dependent on fishing for food and livelihood in a manner consistent with the objectives of MSC Principles 1 and 2.
	Met?	(Y)	(Y)	(Y)

PI 3.1.1		**The management system exists within an appropriate legal and/or customary framework which ensures that it:** • **Is capable of delivering sustainable fisheries in accordance with MSC Principles 1 and 2; and** • **Observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and** • **Incorporates an appropriate dispute resolution framework.**
	Justification	There are no people dependent on fishing for food or livelihood in the fishery area, nor are there legal rights established in relation to such people. Therefore, a score of 100 is given.
References		CAMLR Convention. (1980). Accessed 21 January 2015. Available at: https://www.ccamlr.org/en/organisation/camlr-convention CCAMLR. (2014). Report of the Thirty-third meeting of the Commission (Hobart, Australia, 20 to 31 October 2014). Preliminary version last updated 18 December 2014. CCAMLR, Hobart. Review Panel. (2008). CCAMLR Performance Review Panel Report 1 September 2008. Accessed 21 January 2015. Available at: https://www.ccamlr.org/en/system/files/e-Prfrm%20Review%20Report%20Jun09_0.pdf
OVERALL PERFORMANCE INDICATOR SCORE: Two scoring issues are addressed at SG100 and one at SG80. Therefore, a score of 95 is given.		**95**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 3.1.2

PI 3.1.2		The management system has effective consultation processes that are open to interested and affected parties. The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	Organisations and individuals involved in the management process have been identified. Functions, roles and responsibilities are generally understood.	Organisations and individuals involved in the management process have been identified. Functions, roles and responsibilities are explicitly defined and well understood for key areas of responsibility and interaction.	Organisations and individuals involved in the management process have been identified. Functions, roles and responsibilities are explicitly defined and well understood for all areas of responsibility and interaction.
	Met?	(Y)	(Y)	(Y)

PI 3.1.2		**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**
	Justification	Within CCAMLR, subsidiary bodies and individuals involved in the management process are identified, and their functions, roles, and responsibilities are defined and understood. For example, the roles and responsibilities of working groups, committees, and the Commission are all clearly defined and articulated in accessible documentation (e.g., terms of reference, available on the CCAMLR website). Similarly, members of the Commission and Scientific Committee representatives are identified with contact details on the CCAMLR website. Working group participants, e.g., for the Working Group on Fish Stock Assessment that provides management advice, are listed in publicly-available reports. The management processes associated with the operation of vessels under the control of the client group occur across five countries: Australia, New Zealand, Norway, Spain, and the United Kingdom. Commission reports list names and contact details of participants from all those countries, thereby establishing points of contact amongst the home nations of the client fishery. Australia: Agencies involved with Australian activities in the Ross Sea include the Australian Antarctic Division (AAD) (Department of the Environment), Australian Fisheries Management Authority (AFMA), Australian Customs and Border Protection Service, and the Department of Foreign Affairs and Trade. Domestic legislation includes provisions relevant to fishing activities in the Ross Sea focusing on fishing specifically (e.g., the Fisheries Management Act and Fisheries Management Regulations) as well as biodiversity more broadly (e.g., the Environmental Protection and Biodiversity Conservation Act). AFMA implements Conservation Measures agreed by CCAMLR. The responsibilities held by AAD and AFMA in relation to CCAMLR are articulated in Administrative Arrangements Orders made by Australia's Governor General. An Interdepartmental Committee led by AAD and comprising the above agencies together with the Attorney General's Department, Australian Customs and Border Protection Service and the CCAMLR Consultative Forum (a group of government, industry and eNGOs) consult to develop Australia's positions at CCAMLR. New Zealand: New Zealand's activity in the Ross Sea fishery is within the purview of a number of government departments, including the Ministry for Foreign Affairs and Trade (MFAT) (Antarctic Policy Unit), the Ministry for Primary Industries (MPI), and the Department of Conservation. MFAT is responsible for New Zealand's participation in the Antarctic Treaty System overall. MPI issues the AMLR permit and High Seas Fishing Permits necessary for New Zealand-flagged vessels to fish in the CAMLR Convention area. Science developed and reviewed in New Zealand for this fishery is under the guidance of the Antarctic Working Group, convened by MPI. The remits of all government agencies are clearly defined in relation to the fishery. Agencies meet on an ongoing basis through the year to progress issues related to fisheries management, ensuring a joined-up approach across government. Government also meets with industry and other stakeholders on an ongoing basis, to allow for the discussion of management requirements, concerns and issues.

PI 3.1.2		**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**
		Norway: In Norway, responsibility for fishing activities in CCAMLR waters is held by the Ministry of Industry, Trade and Fisheries and the Directorate of Fisheries. The responsibilities of these agencies include: implementation of national legislation to deliver on CCAMLR Conservation Measures, control and monitoring of Norwegian vessels inside and outside CCAMLR waters, submitting notifications to CCAMLR of Norway's intention to fish in CCAMLR waters, and licensing vessels to ensure that CCAMLR and Norwegian domestic requirements are met. Spain: The requirements of CCAMLR relevant to Spanish activities in the Ross Sea are enacted through legislation of the European Union and domestic policy. Overall responsibility for policy relevant to Spain's participation in CAMLR Convention is held by the Secretariat-General for Fishing (Secretaria General de Pesca) of the Ministry of Agriculture, Food and Environment (Ministerio de Agricultura, Alimentacion y Medio Ambiente). This office is also charged with submitting notifications to CCAMLR for Spanish vessels fishing in the Ross Sea. Other responsibilities of this office in relation to CCAMLR fisheries include vessel registration, licensing, vessel safety, compliance, marine pollution, and fisheries observers. UK: Similar to Spain, the requirements of CCAMLR relevant to UK activities in the Ross Sea are enacted through legislation of the European Union and domestic UK policy. Overall responsibility for management of the UK's policy in relation to CCAMLR lies with the Polar Regions Unit of the Overseas Territories Directorate (Foreign and Commonwealth Office (FCO)). The FCO submits the required notifications to CCAMLR for fishing in the Ross Sea. Permits for UK vessels fishing in Antarctic waters are granted by the Secretary of State for Foreign and Commonwealth Affairs. The FCO provides written agreement allowing fishing, when it is satisfied that required conditions for fishing will be met. (Conditions include licensing, safety and insurance, compliance with CCAMLR Conservation Measures, etc.). Because the Argos vessels are registered in St. Helena, the Government of St. Helena issues the licence to fish and this licence carries conditions relating to safety and vessel operations. Interaction amongst the states to which the client group vessels are flagged occurs predominantly at CCAMLR meetings. The client group itself primarily interacts electronically. In addition, client group representatives meet on an approximately annual basis. The Client Group employs an independent fisheries consultancy (Silvifish Resources Ltd) to act as a point of contact for the Client Group in respect to Group business including MSC interactions (surveillance meetings, collation of combined Client Group catch and performance data etc), review and update of Client Group rules, and general Client Group business. Silvifish Resource representatives typically have face-to-face meetings annually with both northern and southern hemisphere Client Group members. Organisations and individuals involved in the management process have been identified. Functions, roles and responsibilities are explicitly defined and well understood for all areas of responsibility and interaction. Therefore, a score of 100 is given.

PI 3.1.2		**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**		
b	**Guidepost**	The management system includes consultation processes that obtain relevant information from the main affected parties, including local knowledge, to inform the management system.	The management system includes consultation processes that regularly seek and accept relevant information, including local knowledge. The management system demonstrates consideration of the information obtained.	The management system includes consultation processes that regularly seek and accept relevant information, including local knowledge. The management system demonstrates consideration of the information and explains how it is used or not used.
	Met?	(Y)	(Y)	(N)
	Justification	CCAMLR: The CCAMLR system operates by consensus-based decision-making on matters of substance (Article XII). All members are able to contribute to discussion and decision-making. At the discretion of members, member delegations often include non-government stakeholders, e.g., representatives from the scientific community, as well as industry and environmental groups. Members submit papers to meetings (including working group meetings) and discussion on papers, together with any management advice or decisions made, are recorded in publicly-available reports. Observers are able to attend meetings of the Scientific Committee and CCAMLR Commission via invitations extended on approved request, and submit documents for the consideration of those meetings. Observers do not participate in decision-making. Commission meetings and meetings of CCAMLR's subsidiary bodies occur regularly, on an annual basis, providing for the ongoing receipt and consideration of information from members and stakeholders. Observers participate in some, but not all, working groups. Australia: There are regular and ongoing opportunities for stakeholder involvement in relation to Australia's fishing activity in the Ross Sea. The CCAMLR Consultative Forum (CCF) is convened three times per year and their meetings are recorded (with records available to participants, though not publicly available). CCF comprises government and non-government members, including industry and conservation agencies. An annual workshop provides the opportunity for managers, policy-makers, scientists, fisheries observers, and industry representatives to meet and share information. *Ad hoc* meetings amongst industry, AAD and AFMA also occur on an ongoing basis. The Sub-Antarctic Fisheries Management Advisory Committee (SouthMAC) is a key advisory committee that meets once per year. Membership comprises government agencies and science providers (AFMA, AAD, CSIRO), as well as industry and conservation interests. Providing stock assessment advice is a key function of SouthMAC. The Sub-Antarctic Resource Assessment Group (SARAG) meets three times per year and focuses on science relating to the fishery. SARAG's membership is comprised of AFMA, AAD, CSIRO, industry and scientists. The functions and roles of SouthMAC and SARAG are provided for in fisheries legislation (Fisheries Management Act 1991) and AFMA policy documents. The Fisheries Management Act specifies mandatory public consultation periods on proposals for any changes made to management plans under this Act. AFMA promulgates its decisions online through the "AFMA Update" which is also circulated to stakeholders signed up electronically. However, a summation of issues contributing to the decisions made are not included in this online circulation. Non-governmental organisations and industry have been included in Australian delegations to CCAMLR.		

PI 3.1.2		**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**
		New Zealand: Extensive opportunities exist for consultation on the fishery involving New Zealand stakeholders. Prior to the October sessions of CCAMLR meetings, government agencies (MFAT, MPI, DOC) meet with industry, environmental groups, and other interested stakeholders to discuss government objectives. (However, stakeholder comments reflect the desire for greater opportunities for involvement in policy-making. See Appendix). Non-government representatives from industry and environmental groups also join New Zealand delegations to CCAMLR meetings on an ongoing basis. Delegation members are approved by the Minister of Foreign Affairs and Trade. The Antarctic Working Group convened by MPI and focusing on science relating to New Zealand's activities in the Ross Sea fishery is open to members of any affiliation. Its discussions are formally documented and meeting records and papers are available online to all members. Norway: At the legislative level, comprehensive written hearings are undertaken on draft legislation prepared by the Ministry of Industry, Trade and Fisheries. Draft legislation is prepared by committees with broad representation that includes stakeholder groups. The Institute of Marine Research prepares a strategic plan that highlights critical areas for marine research relating to fisheries management research. This is implemented through annual plans developed in consultation with the Ministry of Industry, Trade and Fisheries. The Ministry reviews research needs and prioritises these in a budgetary context. Generally, requirements for management-related scientific information that is also relevant for annual regulations are deemed most important amongst identified matters of interest. In addition, industry conducts its own applied research using levied funds. Spain: In advance of annual CCAMLR meetings, consultation opportunities are provided for non-government organisations and industry. These meetings include government agencies, policy advisors, industry, non-government organisations, research providers and other interested parties. Points of specific discussion include fisheries and environmental matters relevant to Antarctica. The meetings contribute to Spain's approach to CCAMLR meetings. With respect to science specifically, the Instituto Español de Oceanografía Centro Oceanográfico de Canarias is the main provider. There is additional science input on an *ad hoc* basis from other research establishments and universities. The Fishing Sector Advisory Committee focuses on discussion and advisory services. It is attached to the Spanish Ministry for the Environment and Rural and Marine Affairs, and covers issues relating to maritime fishing, planning of the fishing sector, planning the commercialisation of fish products, fishing research and aquaculture. The Fishing Sector Advisory Committee brings together representatives from the Ministry itself and from the various employers' and workers' organisations and associations present in the fishing sector. Finally, there are also regular meetings between the industry and the ministry, which have done much to foster proactive dialogue in recent years.

PI 3.1.2		**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**		
		UK: Consultation processes administered by the UK government agencies lead to the position taken by UK to CCAMLR. The development of the management approach in the fishery, includes review of the fishing activities and results of research by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). Government agencies consult with and meet with stakeholders as deemed required and on request. Client Group: Consultation among the client group is carried out primarily via electronic means (by email, phone, or conference calling as appropriate) supported by annual meetings in UK attended by the Client Group representatives (Silvifish Resources Ltd). These meetings are minuted and reported back to the entire Client Group. The UK representative co-ordinates the input from the UK, Spanish and Norwegian client group members for any matter subsequently arising. A New Zealand-based representative coordinates amongst Australian and New Zealand client group members. Decisions are reached by consensus from conference calls, emailed responses or direct individual communication. Research plans formulated by New Zealand scientists are circulated to the European representatives for joint development and feedback; similarly research plans formulated in the UK by CEFAS are disseminated for feedback. Feedback is incorporated into the planning and the finalised research plans are tabled by the CCAMLR members to which the client group vessels subscribe, at CCAMLR Scientific Committee. The management system includes consultation processes that seek local knowledge and can incorporate relevant information. At the CCAMLR level, reports document how decisions are reached in terms of information utilised. All member countries can input their own knowledge through submitting papers to CCAMLR meetings and participating in meeting discussions. However, how local knowledge is sought, as well as how the information is considered and used or not used, is apparent for some but not all member countries of the client group (given the information available for this assessment). For example, for Spain, Norway and the UK, it is not clear how the management system explains use (or lack of use) of local knowledge. Clarifying the objectives, nature and extent of consultation processes operating in the UK would be valuable for addressing the first component of this scoring issue. A score of 80 results.		
c	**Guidepost**		The consultation process provides opportunity for all interested and affected parties to be involved.	The consultation process provides opportunity and encouragement for all interested and affected parties to be involved, and facilitates their effective engagement.
	Met?		(Y)	(N)

PI 3.1.2		**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**
	Justification	CCAMLR: Any interested party can seek to attend CCAMLR as an observer, and attendance occurs on an approved basis. In addition, non-government representation is provided for by some member delegations (and is an option available to all member delegations). Observers can contribute information to meetings, while they are not involved in decision-making *per se.* When observer contributions are discussed in the course of meetings, discussions are documented in meeting reports. Thus, CCAMLR itself provides some opportunities for stakeholder input and disseminates information to stakeholders while not having a specifically consultative role. Australia: Australia's domestic consultation processes provide for stakeholder involvement in a variety of fora, e.g., SouthMAC and SARAG. The availability of information online and through electronic dissemination facilitates stakeholder awareness of fishery activities and therefore, the informed contributions of stakeholders to management processes for these activities. New Zealand: All stakeholders have the opportunity to contribute their views to domestic consultation processes on fisheries science and legislative amendments. Effective engagement is facilitated in the science process through the maintenance of an electronic platform for meeting documents, including agendas, meeting records and reports. Members of science working groups also receive notification of upcoming meetings and other postings on the working group web interface. Meeting records are circulated in draft form and finalised after a specified comment period. Membership is available to all stakeholders. Consultations on proposed legislative amendments are supported by the dissemination of relevant information online. In some cases, consultation meetings may also be held by officials. Submissions on regulatory changes are formally responded to by government. Open consultation processes provide for the input of all stakeholders. Norway: There is provision for stakeholder involvement in consultative processes relating to draft legislation, specifically through their involvement with the committees tasked with the preparation of legislation and opportunities for written hearings. Spain: Consultation opportunities occur in advance of CCAMLR meetings, and involve government, non-government organisations and stakeholders. A specific body (Fishing Sector Advisory Committee) has been established to consider fishing related issues from a workforce and industry standpoint. Further, government and industry meet regularly. UK: From the information available on this fishery, it is noted that stakeholder meetings are held as deemed required. However, it is not clear that the consultation process provides opportunity for all interested and affected parties to be involved. A score of 80 is given. There is some evidence of consultation processes in all Client Group countries and this provides opportunities for the participation of a diversity of stakeholders in the management process. However, it is not clear based on the available information that consultation processes in all countries encourage involvement and facilitate the effective engagement of all interested and affected parties. Therefore, a score of 100 is not reached.
References		Anonymous. (2012). Annual surveillance of the Marine Stewardship Certification for the Ross Sea toothfish longline fishery. Reference document provided by the Client Fishery coordinator to the surveillance team performing the 2012 audit of the Ross Sea toothfish longline fishery.

PI 3.1.2	**The management system has effective consultation processes that are open to interested and affected parties.** **The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties**	
	Australian Fisheries Management Authority. (2014). Submission for Australian export from new and exploratory fisheries in the CCAMLR Ross Sea region. August 2014. Australian Fisheries Management Authority. Accessed 17 February 2015 at: http://www.environment.gov.au/system/files/pages/22a0de37-f3db-4024-96dd-3af1481b8bce/files/ross-sea-agency-application.doc CCAMLR. Undated. Rules of procedure of the Scientific Committee. Accessed 17 February 2015 at: http://www.ccamlr.org/en/document/publications/rules-procedure-scientific-committee CCAMLR. Undated. Rules of procedure of the Commission. Accessed 17 February 2015 at: http://www.ccamlr.org/en/system/files/e-pt3.pdf Hough, A., Akroyd, J. and Medley, P. (2011). Surveillance Report: Ross Sea Toothfish Longline Fishery. Certificate No.: MML-F-087. Intertek Fisheries Certification Ltd. Hough, A., Akroyd, J. and Medley, P. (2014). Surveillance Report: Ross Sea Toothfish Longline Fishery. Certificate No.: MML-F-087. Intertek Fisheries Certification Ltd.	
OVERALL PERFORMANCE INDICATOR SCORE: One scoring issue meets the requirements of SG100, the others reach SG80. A score of 85 results.		**85**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 3.1.3

PI 3.1.3		The management policy has clear long-term objectives to guide decision-making that are consistent with MSC Principles and Criteria, and incorporates the precautionary approach		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	Long-term objectives to guide decision-making, consistent with the MSC Principles and Criteria and the precautionary approach, are implicit within management policy	Clear long-term objectives that guide decision-making, consistent with MSC Principles and Criteria and the precautionary approach are explicit within management policy.	Clear long-term objectives that guide decision-making, consistent with MSC Principles and Criteria and the precautionary approach, are explicit within and required by management policy.
	Met?	(Y)	(Y)	(Y)

PI 3.1.3		The management policy has clear long-term objectives to guide decision-making that are consistent with MSC Principles and Criteria, and incorporates the precautionary approach
	Justification	The management policy is articulated in the first instance, in the text of the CAMLR Convention. The objective of the Convention is "the conservation of Antarctic marine living resources". This includes a management approach that incorporates ecosystem considerations, and the concept of 'rational use'. Specifically, three conservation principles incorporated in the Convention text (Article 2) apply to harvesting "and associated activities" in the Convention Area: "*(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;* *(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and* *(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources*." The management approach is made operational through a variety of mechanisms, including (but not limited to) harvest management rules, bycatch limits, and conservation measures. For example, the harvest of toothfish in the Ross Sea is managed such that the lower yield of the following two options is implemented: (i) the probability of the spawning biomass dropping below 20% of its median pre-exploitation level, over a 35-year harvesting period, is 10%, or, (ii) the median escapement in the spawning stock biomass over a 35-year period is 50% of the median pre-exploitation level, at the end of the projection period (Constable et al. 2000). The precautionary nature of the policy governing the fishery has recently been questioned (e.g., Ainley and Pauly 2013, Abrams 2014). Missing information on various aspects of the target species and associated ecosystem are key parts of that discussion. However, the focus of the Convention text on conservation dictates a precautionary approach to management. Further, the steady development of the fishery through time and ongoing data collection and research provide for feedback into management as new information becomes available. The CCAMLR community reflects on such specific elements of precaution in practice in Hanchet et al. (2015). The Convention text and application of its requirements in practice show that there are clear long-term objectives that guide decision-making, consistent with MSC Principles and Criteria and the precautionary approach, and that these are explicit within and required by management policy. A score of 100 is given.
	References	Abrams, P.A. (2014). Synthesis: How precautionary is the policy governing the Ross Sea Antarctic toothfish (*Dissostichus mawsoni*) fishery? Antarctic Science 26: 2-13. Ainley, D.G. and Pauly, D. (2013). Fishing down the food web of the Antarctic continental shelf and slope. Polar Record. DOI: 10.1017/S0032247412000757. Accessed 18 February 2015 at: http://www.seaaroundus.org/researcher/dpauly/PDF/2013/Journal%20Articles/FishingDowntheFoodWebottheAntarctic.pdf Constable, A., W. de la Mare, D. Agnew, I. Everson, D. Miller. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). ICES Journal of Marine Science 57: 778–791. Hanchet, S.M., Sainsbury, K., Butterworth, D., Darby, C., Bizikov, V., Rune Godø,

PI 3.1.3	**The management policy has clear long-term objectives to guide decision-making that are consistent with MSC Principles and Criteria, and incorporates the precautionary approach**	
	O.; Ichii, T., Kock, K-H, López Abellán, L., Vacchi, M. (2015). CCAMLR's precautionary approach to management of Ross Sea toothfish fishery. Antarctic Science. Antarctic Science, Volume 27, Issue 04, August 2015, pp 333-340	
OVERALL PERFORMANCE INDICATOR SCORE: All requirements of the SG100 are met, resulting in a score of 100 for this scoring issue.		**100**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 3.1.4

PI 3.1.4		The management system provides economic and social incentives for sustainable fishing and does not operate with subsidies that contribute to unsustainable fishing		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	The management system provides for incentives that are consistent with achieving the outcomes expressed by MSC Principles 1 and 2.	The management system provides for incentives that are consistent with achieving the outcomes expressed by MSC Principles 1 and 2, and seeks to ensure that perverse incentives do not arise.	The management system provides for incentives that are consistent with achieving the outcomes expressed by MSC Principles 1 and 2, and explicitly considers incentives in a regular review of management policy or procedures to ensure they do not contribute to unsustainable fishing practices.
	Met?	(Y)	(Y)	(Partial)

PI 3.1.4		The management system provides economic and social incentives for sustainable fishing and does not operate with subsidies that contribute to unsustainable fishing
	Justification	The Ross Sea fishery is a catch limited Olympic fishery, i.e., catch can be landed by any legal participant until the annual catch limit is reached. The review panel evaluating CCAMLR's performance considered that this essentially competitive catch strategy may incentivise the development of excess fishing capacity (Review Panel 2008). However, as long as catch limits are enforced, outcomes relating to MSC Principles 1 and 2 should not be threatened. CCAMLR does not subsidise fishery participants. Instead, members provide financial contributions in order to become parties to the Convention, which in turn, allows them the opportunity to legally seek access to the fishery. (The ongoing payment of member contributions is incentivized with the right to participate in decision-making). There are various incentives for good performance in the fishery, which is classified by CCAMLR as "exploratory". Notification and permission are required annually to participate in the fishery. Agreement to specific operating practices and standards is required, and these help support the delivery of fishing operations aligned with MSC principles. Continuing participation is prohibited in an exploratory fishery if the requirements of an agreed data collection plan have not been submitted to CCAMLR for the most recent season in which fishing occurred. This prohibition remains until the data are submitted to CCAMLR and the Scientific Committee has had opportunity to review them (Conservation Measure 21-02 (2013)). Data collected provide key inputs to fishery management in accordance with MSC principles. The performance of those in the fishery is monitored on an ongoing basis and evaluated annually at a number of levels including compliance, the provision of data, and landed catch. This ongoing monitoring and evaluation would facilitate the identification of actions driven by perverse incentives. The review of CCAMLR's performance completed in 2008 included some consideration of incentives (Review Panel 2008). Agreement was reached at the Commission meeting in 2014 that draft terms of reference for a second performance review would be developed and circulated to members prior to the Commission meeting in 2015 (CCAMLR 2014). Therefore, the management system provides for incentives that are consistent with achieving the outcomes expressed by MSC Principles 1 and 2, and seeks to ensure that perverse incentives do not arise. Incentives were considered in the 2008 review of CCAMLR's performance. The second proposed review provides an opportunity to consider incentives. With one review conducted to date, incentives do not appear to have been considered explicitly in regular reviews of management policy, precluding a score of 100. A score of 90 is given.
References		CCAMLR. (2014). Report of the Thirty-third meeting of the Commission (Hobart, Australia, 20 to 31 October 2014). Preliminary version last updated 18 December 2014. CCAMLR, Hobart. Review Panel. (2008). CCAMLR Performance Review Panel Report 1 September 2008. Accessed 21 January 2015. Available at: https://www.ccamlr.org/en/system/files/e-Prfrm%20Review%20Report%20Jun09_0.pdf
OVERALL PERFORMANCE INDICATOR SCORE: The requirements of SG80 are met, together with some of those for SG100. This scoring issue is given an overall score of 90.		**90**
CONDITION NUMBER (if relevant):		

Evaluation Table for PI 3.2.1

PI 3.2.1		The fishery has clear, specific objectives designed to achieve the outcomes expressed by MSC's Principles 1 and 2		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	Objectives, which are broadly consistent with achieving the outcomes expressed by MSC's Principles 1 and 2, are implicit within the fishery's management system	Short and long-term objectives, which are consistent with achieving the outcomes expressed by MSC's Principles 1 and 2, are explicit within the fishery's management system.	Well defined and measurable short and long-term objectives, which are demonstrably consistent with achieving the outcomes expressed by MSC's Principles 1 and 2, are explicit within the fishery's management system.
	Met?	(Y)	(Y)	(Partial)

PI 3.2.1		The fishery has clear, specific objectives designed to achieve the outcomes expressed by MSC's Principles 1 and 2
	Justification	The objectives of the fishery are dictated by the management system. Therefore, the overall objective guiding the fishery is that of the CAMLR Convention: "the conservation of Antarctic marine living resources". For the target species, the long-term objective is also articulated in the CAMLR Convention text (Article 2): "*(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment*" The short-term objectives of target stock management are articulated by the harvest strategy. This provides for harvest managed such that the lower yield of the following two options is implemented: (i) the probability of the spawning biomass dropping below 20% of its median pre-exploitation level, over a 35-year harvesting period, is 10%, or, (ii) the median escapement in the spawning stock biomass over a 35-year period is 50% of the median pre-exploitation level, at the end of the projection period (Constable et al. 2000). The fishery has been developed progressively over time, and each year, the catch limits applied may include specific precautionary decisions meant to align the fishery's approach to harvesting to the broader CCAMLR context, including a precautionary approach. Ongoing data collection from the fishery, and incorporation of that information base into management approaches, provide evidence that outcomes achieved with these objectives in place are aligned with MSC Principle 1. In relation to the outcomes expressed through Principle 2, the long-term objectives of the fishery, as articulated in the Convention, are in broad alignment with MSC. These are (Article 2): *"(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and* *(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources*." Shorter term objectives aligned with Principle 2 are less clearly articulated. For vulnerable marine ecosystems, members are committed to avoiding significant adverse effects caused by bottom fishing activities (Conservation Measure 22-07 (2013)). Mechanisms for defining and protecting VMEs are explicit and performance against this measure can be demonstrated. While not framed as objectives *per se*, performance against management measures for other non-target species can also be measured, including bycatch limits. Limits for skates, rays, *Macrourus* spp., and any other bycatch species, are articulated in Conservation Measures 41-09 (2014) and 41-10 (2014). For Whitson's grenadier (*M. whitsoni*), a quantitative yield assessment has been undertaken and used as a basis for bycatch limits (Hanchet et al. 2008[13]). For rajids, this has been attempted but has not been successful as yet given data limitations.
		Move-on rules are another component of the bycatch management approach (Conservation Measure 33-03 (2014)), demonstrating an intent to reduce bycatch. While performance against bycatch limits can be demonstrated with data collected from the fishery, limits are not always a biologically-based expression of objectives. Therefore, the appropriateness of bycatch limits for delivering on the objectives of

[13] Note that this was undertaken prior to the taxonomic separation of *M. whitsoni* and *M. caml* (Pinkerton et al. 2014).

PI 3.2.1	The fishery has clear, specific objectives designed to achieve the outcomes expressed by MSC's Principles 1 and 2	
	CCAMLR, and on the outcomes expressed through MSC Principle 2, is not always clear. A score of 95 results.	
References	Constable, A., de la Mare, W., Agnew, D., Everson, I. and Miller, D. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). ICES Journal of Marine Science 57: 778–791. Hanchet, S.M., Fu, D. and Dunn, A. (2008). 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. CCAMLR, Hobart. WG-FSA-08/32. Pinkerton, M.H., Maolagain, C. O., Forman, J. and Marriott, P. (2014). Discrimination of two species of grenadier (Gadiformes, Macrouridae), *Macrourus whitsoni* and *M. caml*, in the Ross Sea region of the Southern Ocean (CCAMLR Subareas 88.1 and 88.2) on the basis of otolith morphometrics. CCAMLR, Hobart. WG-FSA-14/63.	
OVERALL PERFORMANCE INDICATOR SCORE: The requirements of SG80 are met and exceeded, however not all requirements are met at SG100. This scoring issue is given an overall score of 95.		**95**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 3.2.2

PI 3.2.2		The fishery-specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives, and has an appropriate approach to actual disputes in the fishery under assessment.		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	There are some decision-making processes in place that result in measures and strategies to achieve the fishery-specific objectives.	There are established decision-making processes that result in measures and strategies to achieve the fishery-specific objectives.	
	Met?	(Y)	(Y)	
	Justification	Decision-making processes within CCAMLR are well defined and clearly articulated. Management advice to be considered by the Scientific Committee (and potentially ultimately, the Commission), is identified in working group reports. This advice is considered by the Scientific Committee and presented to the Commission as deemed appropriate. The Commission makes decisions that result in measures and strategies to achieve the fishery-specific objectives. The advice of CCAMLR's other subsidiary bodies (e.g., the Standing Committee on Implementation and Compliance) is relayed directly to the Commission for their consideration. Decision-making processes take place annually at Commission meetings, held in October and prior to the commencement of the fishery. Decisions on matters of substance are made by consensus in CCAMLR – a mechanism that illustrates CCAMLR's relationship with the Antarctic Treaty System. The limitations of this approach have been recognised. For example, progress on especially polarizing issues may be slow. However, the success of the consensus approach lies in the development of better cooperation and need for effective negotiation (Review Panel 2008). A score of 80 is given, because there are established decision-making processes that result in measures and strategies to achieve the fishery-specific objectives.		
b	**Guidepost**	Decision-making processes respond to serious issues identified in relevant research, monitoring, evaluation and consultation, in a transparent, timely and adaptive manner and take some account of the wider implications of decisions.	Decision-making processes respond to serious and other important issues identified in relevant research, monitoring, evaluation and consultation, in a transparent, timely and adaptive manner and take account of the wider implications of decisions.	Decision-making processes respond to all issues identified in relevant research, monitoring, evaluation and consultation, in a transparent, timely and adaptive manner and take account of the wider implications of decisions.
	Met?	(Y)	(Y)	(N)

PI 3.2.2		**The fishery-specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives, and has an appropriate approach to actual disputes in the fishery under assessment.**		
	Justification	Decision-making processes thoroughly consider information relevant to the fishery, as submitted to working groups, and the Commission and its subsidiary bodies, on an annual basis. Reports of bodies integral to the decision-making process (i.e., working groups, and the Commission and its subsidiary bodies) are publicly available. These reports document the discussions and conclusions that occurred, and reference the key sources of information used as a basis for those discussions. Working group papers are typically not publicly available in full, but can be acquired on request, e.g., to the CCAMLR secretariat or the report authors. Abstracts of many working group papers are publicly available. There is ongoing controversy amongst some stakeholders about components of this fishery (e.g., as discussed by Hanchet et al. (2015)). The decision-making process responds to such issues formally when papers are submitted to meetings, in the content of papers submitted by members, and/or in meeting records (e.g., SC-CAMLR 2012). The public availability of reports from advisory and decision-making bodies provides transparency in terms of identifying issues identified, capturing discussions around these issues, and describing decisions and actions taken. Decisions are made in the context of wider implications. For example, catch limits for the target species are developed with reference to an assessment of its ecological role (Constable et al. 2000, Hanchet et al. (2015)). The opportunity for, and application of, adaptive decision-making is apparent given the annual meetings of working groups and the large volume of new information considered annually, together with the similarly regular and frequent consideration of management advice at the Commission level. Decision-making processes typically respond to issues in a timely way. However, this cannot be said to apply to *all* issues, as would be required to reach a score of 100. For example, some matters raised by the 2008 performance review (Review Panel 2008) are yet to be considered[14]. A score of 80 results, as decision-making processes effectively respond to serious and other important issues identified in relevant research, monitoring, evaluation and consultation, in a transparent, timely and adaptive manner and take account of the wider implications of decisions.		
c	**Guidepost**		Decision-making processes use the precautionary approach and are based on best available information.	
	Met?		(Y)	

[14] www.ccamlr.org/en/publications/combined-commission-scientific-committee-scic-and-scaf-responses-performance-review

PI 3.2.2		**The fishery-specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives, and has an appropriate approach to actual disputes in the fishery under assessment.**		
	Justification	The CAMLR Convention includes a specific requirement (Article IX, 1f) to "formulate, adopt and revise conservation measures on the basis of the best scientific evidence available". The quality of information presented, e.g., at working group meetings, is reviewed by those in attendance, as an integral part of the development of management advice contributed to decision-making processes. Identification of information needed to improve the basis for decision-making is a specific role of working groups and is described in the terms of reference for those groups[15]. Compliance decision-making is also evidence-based, as described in reports of the Standing Committee on Implementation and Compliance, a subsidiary body of the Commission. There are specific, documented examples of a precautionary approach being applied to the management of this fishery. These include the development of the target stock assessment (e.g., where there was uncertainty in model parameters, values were chosen which would lead to more conservative estimates of biomass and sustainable yields (e.g., Mormede et al. 2013)). Overall, decision-making processes use the precautionary approach and are based on best available information. A score of 80 applies.		
d	**Guidepost**	Some information on fishery performance and management action is generally available on request to stakeholders.	Information on fishery performance and management action is available on request, and explanations are provided for any actions or lack of action associated with findings and relevant recommendations emerging from research, monitoring, evaluation and review activity.	Formal reporting to all interested stakeholders provides comprehensive information on fishery performance and management actions and describes how the management system responded to findings and relevant recommendations emerging from research, monitoring, evaluation and review activity.
	Met?	(Y)	(Y)	(Y)

[15] www.ccamlr.org/en/science/working-group-fish-stock-assessment-wg-fsa; www.ccamlr.org/en/science/working-group-ecosystem-monitoring-and-management-wg-emm

PI 3.2.2		**The fishery-specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives, and has an appropriate approach to actual disputes in the fishery under assessment.**		
	Justification	Reporting is very thorough under the CCAMLR management regime. Fishery reports (relating to all fishing activity in 88.1 and 88.2, a subset of which is carried out by the client group) are submitted every year, and these are available publicly online. Fishery reports document the number of vessels participating in the 88.1 and 88.2 fishery, the reported catch by *Dissostichus* species and weight, estimates of illegal catch, when the fishery was closed, data collected, updates to time series such as toothfish length-frequency distributions, bycatch by species group (Macrourids, rajids, others), VMEs encountered, seabirds and marine mammals captured, etc (e.g., CCAMLR 2014). Discussion and analysis of fishery performance and management occurs in CCAMLR working groups and the Commission's subsidiary bodies. This is formally reported in detailed documents publicly available online. Therefore, it is readily available to all stakeholders. A score of 100 is given because formal reporting to all interested stakeholders provides comprehensive information on fishery performance and management actions and describes how the management system responded to findings and relevant recommendations emerging from research, monitoring, evaluation and review activity.		
e	**Guidepost**	Although the management authority or fishery may be subject to continuing court challenges, it is not indicating a disrespect or defiance of the law by repeatedly violating the same law or regulation necessary for the sustainability for the fishery.	The management system or fishery is attempting to comply in a timely fashion with judicial decisions arising from any legal challenges.	The management system or fishery acts proactively to avoid legal disputes or rapidly implements judicial decisions arising from legal challenges.
	Met?	(Y)	(Y)	(Y)
	Justification	The management system operates by consensus on substantive matters. This is expected to promote the resolution of challenges by negotiation, prior to legal challenges occurring. In addition, the system has a documented dispute resolution process that provides mechanisms for the settlement of disputes without their escalation to legal challenges. Specifically, dispute resolution is to be attempted by "negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means". If unresolved, the dispute may then be referred to the International Court of Justice or to arbitration. The approach to dispute resolution is articulated in the CAMLR Convention (Article XXV). A score of 100 is given, as the management system has mechanisms in place to proactively avoid legal disputes.		
References		CCAMLR. (2014). Fishery report 2013: Exploratory fishery for *Dissostichus* spp. In Subareas 88.1 and 88.2. CCAMLR, Hobart. Available at: http://www.ccamlr.org/en/system/files/08%20TOT881%20882_2.pdf. Constable, A., de la Mare, W., Agnew, D., Everson, I. and Miller, D. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). ICES Journal of Marine Science 57: 778–791. Hanchet, S.M., Sainsbury, K., Butterworth, D., Darby, C., Bizikov, V., Rune Godø,		

PI 3.2.2	**The fishery-specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives, and has an appropriate approach to actual disputes in the fishery under assessment.**	
	O., Ichii, T., Kock, K-H, López Abellán, L., Vacchi, M. (2015). CCAMLR's precautionary approach to management of Ross Sea toothfish fishery. Antarctic Science. Antarctic Science / Volume 27 / Issue 04 / August 2015, pp 333-340 Mormede, S., Dunn, A. & Hanchet, S. M. (2013). Assessment models for Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea for the years 1997/98 to 2012/13. CCAMLR, Hobart. WG-FSA-13/51. Review Panel. (2008). CCAMLR Performance Review Panel Report 1 September 2008. Accessed 21 January 2015. Available at: https://www.ccamlr.org/en/system/files/e-Prfrm%20Review%20Report%20Jun09_0.pdf SC-CAMLR. (2012). Report of the thirty-first meeting of the Scientific Committee. Hobart, Australia, 22 to 26 October 2012. Annex 7. Report of the Working Group on Fish Stock Assessment. (Hobart, Australia, 8 to 19 October 2012). CCAMLR, Hobart. Accessed 18 February 2015 at: http://www.ccamlr.org/en/system/files/e-sc-xxxi-a07.pdf	
OVERALL PERFORMANCE INDICATOR SCORE: The requirements of SG80 are met for all scoring issues. Two scoring issues are met at SG100. An overall score of 90 results.		**90**
CONDITION NUMBER (if relevant):		**-**

Evaluation Table for PI 3.2.3

PI 3.2.3		Monitoring, control and surveillance mechanisms ensure the fishery's management measures are enforced and complied with		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	Monitoring, control and surveillance mechanisms exist, are implemented in the fishery under assessment and there is a reasonable expectation that they are effective.	A monitoring, control and surveillance system has been implemented in the fishery under assessment and has demonstrated an ability to enforce relevant management measures, strategies and/or rules.	A comprehensive monitoring, control and surveillance system has been implemented in the fishery under assessment and has demonstrated a consistent ability to enforce relevant management measures, strategies and/or rules.
	Met?	(Y)	(Y)	(N)
	Justification	The monitoring, control and surveillance (MCS) regime developed by CCAMLR and implemented in the client fishery includes the requirement for at least two observers (one of whom is appointed in accordance with the CCAMLR Scheme of International Scientific Observation) to be present on all vessels, the use of VMS, participation in the Catch Documentation Scheme, and daily and monthly catch effort reporting. Measures to improve the MCS (and overall compliance) system were recommended by the panel conducting the performance review of CCAMLR (Review Panel 2008) and the majority of these have been, or are being, considered or actioned[16]. In addition to vessel-based MCS measures, during the fishing season, aerial and at-sea patrols of the Ross Sea are conducted by New Zealand on an ongoing basis. The areas of focus of surveillance patrols are guided by CCAMLR outcomes. Information captured through the implementation of these measures is scrutinised by SCIC and the Commission on an annual basis. Very few illegal fishing vessels have been detected in the Ross Sea in recent years. However, in the 2014/2015 season, illegal fishing activity was detected and documented in the Ross Sea during a surveillance vessel patrol. The vessels undertaking this activity were on CCAMLR's IUU vessel list. The illegal vessels were not boarded, and fishing continued in the presence of the surveillance vessel. New Zealand contacted Interpol requesting the issue of a Purple Notice in relation to this illegal fishing activity[17]. Since their observation in the Ross Sea, vessels have been the subject of law enforcement activities in other locales (e.g., Thailand). The CCAMLR MCS regime implemented amongst the client group's vessels is recognized. However, the recent IUU activity appeared to challenge the management regime's consistent ability to enforce relevant management measures, strategies and/or rules. Subsequent actions taken by CCAMLR require particular attention in this regard. A score of 80 is applied.		
b	**Guidepost**	Sanctions to deal with non-compliance exist and there is some evidence that they are applied.	Sanctions to deal with non-compliance exist, are consistently applied and thought to provide effective deterrence.	Sanctions to deal with non-compliance exist, are consistently applied and demonstrably provide effective deterrence.

[16] www.ccamlr.org/en/publications/combined-commission-scientific-committee-scic-and-scaf-responses-performance-review

[17] www.ccamlr.org/en/news/2015/new-zealand-initiates-action-against-iuu-vessels-southern-ocean

PI 3.2.3		Monitoring, control and surveillance mechanisms ensure the fishery's management measures are enforced and complied with		
	Met?	(Y)	(Y)	(N)
	Justification	Sanctions must be applied by consensus in accordance with the CCAMLR approach to decision-making on matters of substance. This makes applying sanctions to members inherently challenging. Further, sanctions must be implemented at a domestic level by members themselves. Sanctions have been imposed by CCAMLR in the past, e.g., on vessels inspected at sea that were violating CCAMLR requirements, and vessels over-catching the target species (Review Panel 2008, SCIC 2011). Work is underway at the Commission level to systematically archive details of instances in which sanctions have been applied[18]. Sanctions have never been imposed nor required on vessels operated by the client group. The use of sanctions within the management framework of the fishery is documented. However, the consistent application of these is not readily apparent, and is vulnerable under a consensus-based approach. A consistent deterrent effect of sanctions within the management framework is also not readily apparent. A score of 80 is given.		
c	**Guidepost**	Fishers are generally thought to comply with the management system for the fishery under assessment, including, when required, providing information of importance to the effective management of the fishery.	Some evidence exists to demonstrate fishers comply with the management system under assessment, including, when required, providing information of importance to the effective management of the fishery.	There is a high degree of confidence that fishers comply with the management system under assessment, including, providing information of importance to the effective management of the fishery.
	Met?	(Y)	(Y)	(Y)
	Justification	The performance of fishers comprising the client group is monitored in several ways. This includes the required deployment of (at least) two observers (one of whom is appointed in accordance with the CCAMLR Scheme of International Scientific Observation), the use of VMS, participation in the Catch Documentation Scheme, and daily and monthly catch effort reporting. Compliance with the requirements in these areas is examined annually, and documented in reports of the Commission. In addition, fishery reports provide information on data collected, for example, allowing an examination of how effectively vessels have delivered on the data collection requirements set out in advance of the fishing season, e.g., tagging requirements (CCAMLR 2014). For surveillance audits conducted following the certification of this fishery, each member of the client group provided an annual signed declaration confirming that they had not received any complaints or acquired knowledge of problems relating to their activities, including with respect to meeting the regulatory requirements (Hough et al. 2014). A score of 100 is given, because there is a high degree of confidence that fishers comply with the management system under assessment, including providing information of importance to the effective management of the fishery.		

[18] www.ccamlr.org/en/publications/combined-commission-scientific-committee-scic-and-scaf-responses-performance-review

PI 3.2.3		**Monitoring, control and surveillance mechanisms ensure the fishery's management measures are enforced and complied with**		
d	**Guidepost**		There is no evidence of systematic non-compliance.	
	Met?		(Y)	
	Justification	Compliance is examined annually, when the Standing Committee on Implementation and Compliance (SCIC) and the Commission convene. In addition, observers deployed on fishing vessels collect information during the fishing season, and monitoring relating to compliance (e.g., using VMS) occurs. Compliance issues are documented in the reports of SCIC and the Commission, and these reports (e.g., SCIC 2011, 2012) contain no evidence of systematic non-compliance amongst the client group. The introduction of a Compliance Evaluation Procedure for the 2012/2013 fishing season (CCAMLR 2013) provided an opportunity to address compliance breaches in a more structured and transparent way. This Procedure will be implemented by the Commission on ongoing basis. Further, and specific to the client fishery in the Ross Sea fishery, each member of the client group has produced an annual signed declaration of compliance confirming that they have not received any complaints or acquired knowledge of problems relating to their activities, including with respect to meeting the regulatory requirements (Hough et al. 2014). As there is no evidence of systematic non-compliance in the fishery, a score of 80 is given.		
References		CCAMLR. (2013). Report of the thirty-second meeting of the Commission. 23 October to 1 November 2013. CCAMLR, Hobart. CCAMLR. (2014). Fishery report 2013: Exploratory fishery for *Dissostichus* spp. In Subareas 88.1 and 88.2. CCAMLR, Hobart. Available at: http://www.ccamlr.org/en/system/files/08%20TOT881%20882_2.pdf. Hough, A., Akroyd, J. and Medley, P. (2014). Surveillance Report: Ross Sea Toothfish Longline Fishery. Certificate No.: MML-F-087. November 2014. Intertek Fisheries Certification Ltd. Available at: http://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/southern-ocean/ross-sea-toothfish-longline/assessment-downloads-1/20141216_SR4_TOO100.pdf Review Panel. (2008). CCAMLR Performance Review Panel Report 1 September 2008. Accessed 21 January 2015. Available at: https://www.ccamlr.org/en/system/files/e-Prfrm%20Review%20Report%20Jun09_0.pdf SCIC. (2011). Report of the Standing Committee on Implementation and Compliance. 24 October 2011 to 28 October 2011. CCAMLR, Hobart. SCIC. (2012). Report of the Standing Committee on Implementation and Compliance. 23 October 2012 to 25 October 2012. CCAMLR, Hobart.		
OVERALL PERFORMANCE INDICATOR SCORE: Three scoring issues are addressed at SG80 and one is addressed at SG100. An overall score of 85 is given.				**85**
CONDITION NUMBER (if relevant):				**-**

Evaluation Table for PI 3.2.4

PI 3.2.4		The fishery has a research plan that addresses the information needs of management		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	Research is undertaken, as required, to achieve the objectives consistent with MSC's Principles 1 and 2.	A research plan provides the management system with a strategic approach to research and reliable and timely information sufficient to achieve the objectives consistent with MSC's Principles 1 and 2.	A comprehensive research plan provides the management system with a coherent and strategic approach to research across P1, P2 and P3, and reliable and timely information sufficient to achieve the objectives consistent with MSC's Principles 1 and 2.
	Met?	(Y)	(Y)	(N)
	Justification	Since its initiation, the Ross Sea fishery has hosted an enormous body of research, in subject areas consistent with MSC Principles 1 and 2 (e.g., ecosystem-related work reviewed by Mitchell 2014). In 2014, a research plan authored by three CCAMLR member countries from the client group (Delegations of New Zealand, Norway, and the United Kingdom 2014) was presented to CCAMLR's Working Group on Fish Stock Assessment, and also acknowledged by the Scientific Committee (SC-CAMLR 2014). This research plan lays out an extensive body of work, focused on Article 2 of the CAMLR Convention, which will be undertaken over a three to five year term. Particular areas of work planned relate to reducing uncertainty in toothfish model parameters and around stock management, identifying and clarifying ecological relationships between Ross Sea toothfish and their predators and prey, and exploring the direct impacts of fishing on bycatch species. The research plan readily addresses the requirements of SG80, in that it provides the management system with a strategic approach to research and reliable and timely information sufficient to achieve the objectives consistent with MSC's Principles 1 and 2. However, P3-related research as required at the SG100 level is not evident in this or another plan. Therefore, a score of 80 is given.		
b	**Guidepost**	Research results are available to interested parties.	Research results are disseminated to all interested parties in a timely fashion.	Research plan and results are disseminated to all interested parties in a timely fashion and are widely and publicly available.
	Met?	(Y)	(Y)	(N)

PI 3.2.4		The fishery has a research plan that addresses the information needs of management
	Justification	The medium-term research plan for the Ross Sea toothfish fishery was submitted to CCAMLR in 2014 (Delegations of New Zealand, Norway, and the United Kingdom 2014). The plan is publicly available online[19]. The results of research conducted in the fishery are disseminated using a variety of means. Results are reported back to CCAMLR's working groups (and therefore are picked up by members of CCAMLR bodies and meeting observers) annually. However, papers reporting on research that are submitted to working groups are not always publicly available. They are available on request, e.g., to the authors or the CCAMLR Secretariat. Further, the abstracts of working group papers are often available on the CCAMLR website, thereby providing a snapshot of the work done to all interested parties. In addition, the results of research may be published in peer-reviewed scientific journals. These papers are publicly and widely available. A score of 80 is given because research results are disseminated to interested parties in a timely fashion. However, while much of the research conducted is accessible, working group papers that contain detailed findings are not always widely or publicly available in full. That is not to say they are inaccessible. However, it does preclude a score of 100.
References		Delegations of New Zealand, Norway, and the United Kingdom. (2014). Medium-term research plan for the Ross Sea toothfish fishery. WG-FSA-14/60. CCAMLR, Hobart. Available at: https://www.niwa.co.nz/sites/niwa.co.nz/files/fsa-14-60.pdf Mitchell, R.E. (2014). Ross Sea Trophic Research Review. August 2014. Unpublished report. MRAG Ltd. SC-CAMLR. (2014). Report of the thirty-third meeting of the Scientific Committee. Hobart, Australia, 20 to 24 October 2014. CCAMLR, Hobart. Preliminary version adopted on Friday, 24 October 2014. Accessed 18 February 2015 at: http://www.ccamlr.org/en/system/files/e-sc-xxxiii-end-of-meeting.pdf
OVERALL PERFORMANCE INDICATOR SCORE: Two scoring issues are addressed at SG80, leading to an overall score of 80.		**80**
CONDITION NUMBER (if relevant):		**-**

[19] https://www.niwa.co.nz/sites/niwa.co.nz/files/fsa-14-60.pdf

Evaluation Table for PI 3.2.5

PI 3.2.5		There is a system of monitoring and evaluating the performance of the fishery-specific management system against its objectives There is effective and timely review of the fishery-specific management system		
Scoring Issue		**SG 60**	**SG 80**	**SG 100**
a	**Guidepost**	The fishery has in place mechanisms to evaluate some parts of the management system.	The fishery has in place mechanisms to evaluate key parts of the management system	The fishery has in place mechanisms to evaluate all parts of the management system.
	Met?	(Y)	(Y)	(Y)
	Justification	**CCAMLR:** Annual meetings of CCAMLR and its subsidiary and advisory bodies provide a mechanism to review all parts of the management system. This includes target species catch and effort information, bycatch, mitigation measures, conservation measures and compliance, observer deployments, and the performance of Conservation Measures against their intent. Within the broad agenda, the content of meetings is dictated in large part by the submissions of members, in addition to matters raised by the Secretariat. Where members raise issues that are not naturally homed within an existing structural component of CCAMLR, *ad hoc* working groups can be formed and/or members can take the lead to work with others who are interested or involved. Specific examples of evaluation approaches applied to the fishery, and that reflect on the management system, are the Compliance Evaluation Procedure (Conservation Measure 10-10 (2014)) and the stepwise Management Strategy Evaluation proposed as a component of the medium term research plan (Delegations of New Zealand, Norway, and the United Kingdom 2014). The performance review conducted in 2008 provided a comprehensive review of the management system. Outside CCAMLR, the evaluation approaches of each client-group country include: **Australia:** An annual workshop provides the opportunity for managers, policy-makers, scientists, fisheries observers, and industry representatives to meet and share information. Advisory groups (SouthMAC and SARAG) also provide some evaluative function. **New Zealand:** The performance of the fishery, together with the associated components of the management system, is evaluated on an ongoing basis. Government agencies with responsibility for fishery management meet with industry three times per year. In addition, the Industry Toothfish Committee meets twice per year. Broader stakeholder meetings provide additional perspectives on the fishery management system. Meetings follow agendas developed case by case, and thereby provide a mechanism for participants to raise any matters of interest or concern. **UK/Spain/Norway:** Research needs are identified on an ongoing basis, which requires an evaluation of the information requirements of the fishery. A score of 100 is given as the fishery has in place mechanisms to evaluate all parts of the management system. These are most apparent at the Commission level, but are also known to be in place in member countries that support the Client Group, all of which have been successfully assessed separately against the MSC standard.		

PI 3.2.5		**There is a system of monitoring and evaluating the performance of the fishery-specific management system against its objectives** **There is effective and timely review of the fishery-specific management system**		
b	**Guidepost**	The fishery-specific management system is subject to occasional internal review.	The fishery-specific management system is subject to regular internal and occasional external review.	The fishery-specific management system is subject to regular internal and external review.
	Met?	(Y)	(Y)	(N)
	Justification	The fishery management system is subject to regular and ongoing internal review. This is part of the normal CCAMLR management approach. For example, the detailed review of catch-effort information and compliance with conservation measures may expose issues with the management system. External reviews of the management system, or components of it, have been conducted over time (e.g., Gilman et al. 2012), including one external review conducted on request of the Commission itself (Review Panel 2008). Further, agreement was reached in 2014 that draft terms of reference for a second performance review would be developed and circulated to CCAMLR members prior to the Commission meeting in 2015 (CCAMLR 2014). While external reviews have been conducted, they are not yet regular. Therefore, the requirements of Scoring Guidepost 80 are met, while 100 is not. That is, the fishery-specific management system is subject to regular internal and occasional external review.		
References		Delegations of New Zealand, Norway, and the United Kingdom. (2014). Medium-term research plan for the Ross Sea toothfish fishery. WG-FSA-14/60. CCAMLR, Hobart. Available at: https://www.niwa.co.nz/sites/niwa.co.nz/files/fsa-14-60.pdf CCAMLR. (2014). Report of the Thirty-third meeting of the Commission (Hobart, Australia, 20 to 31 October 2014). Preliminary version last updated 18 December 2014. CCAMLR, Hobart. Gilman, E., Passfield, K. and Nakamura, K. (2012). Performance assessment of bycatch and discards governance by regional fisheries management organizations. IUCN, Gland. Available at: https://portals.iucn.org/library/efiles/documents/2012-034.pdf Review Panel. (2008). CCAMLR Performance Review Panel Report 1 September 2008. Accessed 21 January 2015. Available at: https://www.ccamlr.org/en/system/files/e-Prfrm%20Review%20Report%20Jun09_0.pdf		
OVERALL PERFORMANCE INDICATOR SCORE: One scoring issue is met at SG80 and one at SG100. An overall score of 90 results.				**90**
CONDITION NUMBER (if relevant):				**-**

11.3 Appendix 1.2 Risk Based Framework (RBF) Outputs

The RBF was not used for this reassessment.

11.4 Appendix 1.3 Conditions

Table 4: Condition 1

Performance Indicator	PI 1.2.4 There is an adequate assessment of the stock status
Score	ASR: 75
Rationale	The stock assessments for both RSR and ASR stocks are based on a statistical catch-at-age model implemented in well-developed and well tested software (CASAL; see Bull et al., 2012). The CASAL assessment model is designed to use the catch, age and size compositions, and tag-recapture data. It is particularly suited to model this sort of fishery, and can account for some detail in the life characteristics of toothfish, such as growth and mortality rates. The stock assessment models were sex- and age-structured. The models assume a single area population, but account for differences among areas by treating areas as separate fisheries with their own selectivity. For the RSR three areas are defined - shelf, slope and northern hills. For the ASR, catch limits set by CCAMLR for 2012 and 2013 were determined from yield estimates from an integrated stock assessment model of Antarctic toothfish in SSRUs 88.2C–H with data up to the end of the 2011 season (Mormede et al. 2011a). This was the first time SSRUs 88.2C–H had been assessed together using a formal stock model. The 2011 model was based on age and length data assuming two fisheries; SSRU 88.2H consisting of seamounts in the north and SSRUs 88.2C–G on the southern continental slope and shelf; and included total catch data (C2 data); catch-at-age frequencies reported by Hanchet et al. (2013); and tag-release and recapture data in 88.2H through the 2011 season (Mormede et al. 2011b). Differences in selectivity are allowed for between males and females, and for the ASR model, between differences in the average depth fished. Working Groups (WG-SAM and WG-FSA) and Scientific Committee (SC) indicate consensus that the RSR model is appropriate for the stock and the harvest control rule. Furthermore, the model is able to take account of the available data and what is known about the biology of the species and nature of the fishery in this region, meeting SG100. For the ASR model, these groups do not have a consensus that the current model and data are appropriate. Specifically, most tagging occurs in SSRU H and tagging recaptures in the remaining SSRUs C-G are very low. This creates a problem fitting the model to the tag data. Effectively, SSRUs C-G are not considered to have been adequately assessed yet. The Scientific Committee has endorsed a two year research plan - the first year of which has been carried out to provide information in order to address this issue.
Condition	To meet SG80 requirements for SIa within the term of this certification, the assessment should be appropriate for the stock and for the harvest control rule. This requires completion of an appropriate stock assessment for the ASR stock (Sub-Area 88.2 SSRUs C-H). This should be accepted through WG-FSA review and used to determine stock status and set

	catch limits.
Milestones	First annual surveillance: An appropriate stock assessment development/research programme should be developed. Score unchanged. Second surveillance: The development/research programme should be underway. Score unchanged. Third surveillance: An initial ASR stock assessment should be completed for review (for example by WG-FSA). Score unchanged Fourth surveillance: A new ASR stock assessment, appropriate for the stock and for the harvest control rule, shall be in place and used to determine stock status and set catch limits. Score 80 minimum.
Client action plan	The Client Group operates under the CCAMLR Management regime and as such is regulated by and abides by all current conservation measures. To every extent possible while working within a multinational fisheries management regime In addition the Client Group will work closely with its component flag state scientific representatives to bring about the stated outcomes and to meet the milestones specified. In addition, the client group members will undertake as opportunity presents the provisionto assist in the provision of any agreed specific information; particularly that information as can be collected by Client Group vessels at sea, to inform a stock assessment under the advice and direction of Science Working Groups or requested by individual flag state research providers or government organisations. Data collection to be carried out following consultations identifying feasibility and operational practicality; and undertaken as opportunity presents. A number of research priorities were identified by the Delegations of New Zealand, Norway, and the United Kingdom in the Medium-term research plan for the Ross Sea toothfish fishery (2014, WG-FSA-14/60) for Subareas 88.1 and 88.2 including the reduction of uncertainty in toothfish model parameters – specifically the delineation of stock structure in relation to SSRUs 88.2C-I. Current examples of data provided by industry and cooperation with CCAMLR research initiatives include the ongoing toothfish tagging programme, assistance in the currently operating two-year 88.2 research, participation in the exploratory work in the north of 88.2, and by providing effective working platforms for the collection of appropriate biological and other data to inform model input parameters for a stock assessment. The following action plan is presented with the qualification that these tasks will be carried out to the full extent of the client group's ability, working closely with their flag state scientific representatives, while noting that full CCAMLR Member consensus is required by the management organisation. The following action plan is presented with qualification that these tasks will be carried out within the limits of the client group's ability to influence flag state scientific representatives and ultimately the management organisation, CCAMLR. To meet the first milestone members of the Ross Sea Toothfish Client Group (RSCG) or their delegated science representatives should

	engage in planning with appropriate flag state research agencies to discuss the development of an appropriate research programme for the ASR stock assessment. Development of such a programme will include identifying any additional research data or supplementary information that could be potentially supplied by members of the client group from vessels at sea. These discussions will continue into the second surveillance period but with a focus on implementation of any research programme developed. The third surveillance period during which a pilot programme will be carried out and from this data should be available to fine tune any further information requirements or data collection protocols. An initial ASR assessment to be conducted by appropriate research agencies with a draft model presented for review at CCAMLR WG-SAM in the midyear. Following review by CCAMLR WG-SAM and the collection of a further year of data a full stock assessment should be presented to CCAMLR WG-FSA – prior to the fourth year surveillance period. To meet the first milestone members of the Ross Sea Toothfish Client Group (RSCG) or their delegated representatives should engage in planning with appropriate flag state research agencies to discuss the development of an appropriate research programme for the ASR stock assessment. Development of such a programme will include identifying any additional research data or supplementary information that could be potentially supplied by members of the client group from vessels at sea. These discussions will continue into the second surveillance period but with a focus on implementation of any research programme developed. The third surveillance period, during which data should be available from a pilot programme, will be used to fine tune any further information requirements or data collection protocols with an initial ASR assessment piloted by appropriate research agencies with any draft model presented for review at CCAMLR WG-SAM in the midyear. Following review by CCAMLR WG-SAM and the collection of a further year of data a full stock assessment should be presented to CCAMLR WG-FSA in year 4.
Consultation on condition	At the time of release of this report to Peer Review, confirmation had been received from delegations and scientists of New Zealand, Australia, UK, Spain and Norway of support for producing an Antarctic toothfish stock assessment for the Amundsen Sea region (SSRUs 88.2 C-H) within the required timeframe.

12 APPENDIX 2. PEER REVIEW REPORTS

PEER REVIEW 1

Summary of Peer Reviewer Opinion

Has the assessment team arrived at an appropriate conclusion based on the evidence presented in the assessment report?	**Yes**	**CAB Response**
Justification: This Ross Sea toothfish fishery remain categorized as an exploratory fishery. This categorization is a result of a decision to apply the precautionary approach in earnest including development a management system which includes both continuous monitoring and research, as well as stringent management measures which allow for control of the impact of the fishery. The uncertainties associated with this fishery are well-documented and accounted for in the assessment of the fishery. Information about the research in support of improved management are included under all PIs. Other specific comments presented under PIs below. The three client actions recommended by the Assessment Team, is the condition relating to PI 1.2.4, and the recommendations on PI 2.2.1 and PI 2.3.1 are reasonable and should be supported. The justification for these are also adequate and well references including academic publications by national experts and CCAMLR working groups papers and peer reviewed publications.		Comments acknowledged

Do you think the condition(s) raised are appropriately written to achieve the SG80 outcome within the specified timeframe? [Reference: FCR 7.11.1 and sub-clauses]	**Yes**	**CAB Response**
Justification: Yes. The condition as set out, for PI 1.2.4, is justified and the supporting information from scientific publications including CCAMLR's Scientific Committee and Working Groups reports including up to date information from research on the RSR and ASR. CCAMLR has also highlighted in detail the issues relating to the current data/assessment method for the ASR stock and the challenge that CCAMLR faces in trying to reach consensus on the current model and data. The condition proposed is a key development in the re-assessment and if achieved within the timeframe will contribute to improved and future management of the stock. This condition is justified.		Comments acknowledged

If included:

Do you think the client action plan is sufficient to close the conditions raised? [Reference FCR 7.11.2-7.11.3 and sub-clauses]	**Yes/No**	**CAB Response**
Justification: ***N/A***		

Performance Indicator Review

Please complete the appropriate table(s) in relation to the CAB's Peer Review Draft Report:

- For reports using one of the default assessment trees (general, salmon or enhanced bivalves), please enter the details on the assessment outcome using Table 2.

- For reports using the Risk-Based Framework please enter the details on the assessment outcome at

.

- For reports assessing enhanced fisheries please enter the further details required at **Error! Reference source not found.**.

Table 2 For reports using one of the default assessment trees:

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
1.1.1	Y	Y	N/A		
1.1.2	Y	Y	N/A		
1.2.1	Y	Y	N/A		
1.2.2	Y	Y	N/A		
1.2.3	Y	Y	N/A		
1.2.4	Y	Y	Y		
2.1.1	Y	Y	N/A		
2.1.2	Y	Y	N/A		
2.1.3	Y	N	N/A	The justifications for PI 2.,1.3 a-c are inconsistent in relation to information on the main retained species, which is listed at Patagonian toothfish under this PI 2.1.3. and previous PIs under P2. . The information for	Patagonian toothfish is not a 'main' retained species – as stated in the report. Several SG80 requirements relate to 'main' species – and so as there are no main species, these criteria are met.

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
				the justification of each sub- bullet under PI 2.1.3 is repeated. In the case of PI.2.1.3, there is confliction information presented in the justifcation e.g. reference to no 'main retained species' and informaton availlable on the species. Is the only retained species, the main retained species?	SG100 criteria, however, regularly relate to <u>all</u> species. While exploitation may be light, there is not sufficient information to determine 'consequences for affected populations' etc, and so SG100 criteria are not met. So while there are retained species other than 'main' species, these do not affect scoring at SG80.
2.2.1	Y	Y	N/A		
2.2.2	Y	Y	N/A		
2.2.3	Y	Y	N/A		
2.3.1	Y	Y	N/A		
2.3.2	Y	Y	N/A		
2.3.3	Y	Y	N/A		
2.4.1	Y	Y	N/A		

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
2.4.2	Y	Y	N/A		
2.4.3	Y	Y			
2.5.1	Y	Y	N/A		
2.5.2	Y	Y	N/A		
2.5.3	Y	Y	N/A		
3.1.1	Y	Y	N/A		
3.1.2	Y	Y	N/A		
3.1.3	Y	Y	N/A		
3.2.1	Y	Y	N/A		
3.2.2	Y	Y	N/A		
3.2.3	Y	Y	N/A		
3.2.4	Y	Y	N/A		

Optional: General Comments on the Peer Review Draft Report (including comments on the adequacy of the background information if necessary) can be added below and on additional pages

The draft report is thorough and comprehensive. The report includes all relevant back ground information including references, qualitative and quantitative information in support of the scores allocated. The fisheries for toothfish in the Ross Sea has attracted increasing commercial interest from Contracting Parties since the fisheries since the outset, however, CCAMLR adopted a precautionary approach 1) in the categorization of the fishery as exploratory until there is sufficient evidence to upgrade the fishery to an established fishery 2) in its approach to adopting conservation measures to ensure minimum impact of the fisheries on both target and non-target species including adaptive management and 3) the commitment to research and monitoring to address data gaps and modifications to the assessments in line with the objectives of CCAMLR. Specific action to be undertaken by the Client in the proposed condition under PI 1.2.4 is key to the future development and sustainability of the fishery. The proposed steps to meet the condition and the timeframe as outlined in the Client Action Plan are significant. The initial support from Government means that achievement of this condition is likely within the timeline. The recommendations relating to P2 (P2.1.2 and P2.4.1) are noted as positive actions in support of additional improvements to management of these fisheries. The synergistic approaches supported by the Client Group with CCAMLR objectives and plans for better management and governance of the Ross Sea fisheries are well documented and highlighted under P3 and PIs.

PEER REVIEW 2

Summary of Peer Reviewer Opinion

Has the assessment team arrived at an appropriate conclusion based on the evidence presented in the assessment report?	**Yes**	**CAB Response**
Justification: The report is well researched and the scorings well justified. An overall score above 80 is achieved for all three principles and there is no individual score below 60.		Comments acknowledged

Do you think the condition(s) raised are appropriately written to achieve the SG80 outcome within the specified timeframe? [Reference: FCR 7.11.1 and sub-clauses]	**Yes**	**CAB Response**
Justification: The condition addresses the identified shortcomings in an appropriate manner, and the milestones are clearly operationalized and achievable.		Comments acknowledged

If included:

Do you think the client action plan is sufficient to close the conditions raised? [Reference FCR 7.11.2-7.11.3 and sub-clauses]	**Yes**	**CAB Response**
Justification: The client actions plan addresses the requirements laid out for each milestone in the condition, and will lead to an 80 score if properly implemented.		Comments acknowledged

Performance Indicator Review

Please complete the appropriate table(s) in relation to the CAB's Peer Review Draft Report:

- For reports using one of the default assessment trees (general, salmon or enhanced bivalves), please enter the details on the assessment outcome using Table 2.
- For reports using the Risk-Based Framework please enter the details on the assessment outcome at

.

- For reports assessing enhanced fisheries please enter the further details required at **Error! Reference source not found.**.

Table 3 For reports using one of the default assessment trees:

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
1.1.1	Yes	Yes	NA		
1.1.2	Yes	Yes	NA		
1.2.1	Yes	Yes	NA		
1.2.2	Yes	Yes	NA		
1.2.3	Yes	Yes	NA		
1.2.4	Yes	Yes	Yes		
2.1.1	Yes	Yes	NA		
2.1.2	Yes	Yes	NA		
2.1.3	Yes	Yes	NA		
2.2.1	Yes	Yes	NA		

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
2.2.2	Yes	Yes	NA		
2.2.3	Yes	Yes	NA		
2.3.1	Yes	Yes	NA		
2.3.2	Yes	Yes	NA		
2.3.3	Yes	Yes	NA		
2.4.1	Yes	Yes	NA		
2.4.2	Yes	Yes	NA		
2.4.3	Yes	Yes	NA		
2.5.1	Yes	Yes	NA		
2.5.2	Yes	Yes	NA		
2.5.3	Yes	Yes	NA		
3.1.1	Yes	Yes	NA		

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
3.1.2	Yes	No	NA	It is not quite clear to me why SG100 is not met for 3.1.2 b), in particular why it is met 'for some [which?] but not all member countries of the client group', and why the processes operating in the UK in particular need to be further clarified.	We have amended the text to clarify these points. In short, the information available about consultation processes in the UK did not confirm that these processes seek and accept relevant information including local knowledge. Further, it was not evident how Spain, Norway and the UK explain the use or lack of use of information received.
3.1.3	Yes	Yes	NA		
3.1.4	Yes	Yes	NA		
3.2.1	Yes	Yes	NA		
3.2.2	Yes	Yes	NA		
3.2.3	Yes	No	NA	While I cannot say that an 80 score is not correct for 3.2.3 b), I would have liked the justification to be more specific in arguing why SG100 is not met. As it stands, the argument is that the use of sanctions within the management of the fishery is documented, but that 'the consistent	We focus on sanctions in the management system overall. Consistency is not evident in the sanctions applied although work is underway which could contribute to rectfying this. This lack of consistency precludes a score of 100.

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
				application of these is not readily apparent, and is vulnerable under a consensus-based approach'. At the same time, it is stated that sanctions have never been required for vessels operating by the client group. So how can one say that sanctions are not consistently applied and do not demonstrably provide effective deterrence? Arguing that the application of sanctions 'is vulnerable under a consensus-based approach' is not documentation to the effect that this is not the case. At a more general level, I would have expected the national enforcement agencies to have been consulted here (see comment at the end of this PR report).	Demonstrating that sanctions do or don't have a deterrent effect is challenging however. On occasion, sanctions continue to be necessary which shows they are not 100% effective as a deterrent. While it would be reasonable to assume a partial deterrent effect, evidence documenting this was not available. National enforcement agencies did have an opportunity to contribute to the process but none of the countries agiences made any specific contribution.
3.2.4	Yes	Yes	NA		
3.2.5	Yes	Yes	NA	I do not necessarily disagree with an 80 score for 3.2.5 b), but it could be argued that	In our view, an ongoing commitment to review at (even broadly) specified time

Performance Indicator	Has all available relevant information been used to score this Indicator? (Yes/No)	Does the information and/or rationale used to score this Indicator support the given score? (Yes/No)	Will the condition(s) raised improve the fishery's performance to the SG80 level? (Yes/No/NA)	Justification Please support your answers by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary. Note: Justification to support your answers is only required where answers given are 'No'.	CAB Response
				the initiative to commission a second external review satisfies the requirement of regular external review – how many times are necessary for the review to be regular?	intervals could be considered regular. Given the review activities to date, it may be that CCMAMLR intends to pursue regular reviews. However, in our view, the commitment to regular and ongoing external reviews is not evident at this time.

Optional: General Comments on the Peer Review Draft Report (including comments on the adequacy of the background information if necessary) can be added below and on additional pages

At a general level, it is difficult to decide to what extent the national level should be addressed in a multi-client assessment of an international fishery. In this assessment, the national level is not drawn into the discussion under 3.2, which in principle is fine since it is the fishery-specific management regime that is at issue – however, it would have been relevant to approach national enforcement agencies under 3.2.3. Under 3.1 on the general management system, the national level is addressed under 3.1.2, but not under the other PIs. This seems a bit arbitrary to me, but I am well aware of the challenges here and accept the pragmatic view taken by the assessment team:

A few minor comments:

- Information on eligible points of landing is missing. Section 8.2.4 refers to an Appendix E, which doesn't exist. (Or is it not an appendix to the current report, but to other documents referred to in the report?)
- The Norwegian Ministry of Fisheries/Ministry of Fisheries and Coastal Affairs became part of the wider Ministry of Industry, Trade and Fisheries in 2013.
  Acoura: We have edited as appropriate, thank you.
- Reference is made to three illegal vessels that were active in the Ross Sea in 2014/2014 (p. 19 and p. 34) – I would have liked to see a little bit more information about these incidents.
  Acoura: We have added some further information on p. 34.
- It is stated that 'the client group makes decisions amongst themselves' (p. 32) – what kind of decisions?
  Acoura: We have added text to clarify that these are decisions relating to the Client Group's activities in the fishery.
- There are a few editing issues outstanding – e.g. the figures are not numbered.

13 APPENDIX 3. STAKEHOLDER SUBMISSIONS

3.1 Site Visit Meeting Records

MSC Fishery Assessment Check List

Ross Sea Toothfish Longline Fishery
MML-F-087

MSC Fishery Assessment Stakeholder Interview Record

Assessment Team	Names
Lead Assessor	Andrew Hough
P1 Team Member	Paul Medley
P2 Team Member	Andrew Hough
P3 Team Member	Jo Akroyd* / Johanna Pierre*

* Team members in attendance

Meeting Location	NIWA, Greta Point, Wellington	
Date	12 November 2014	
Stakeholders Name		Affiliation
Jack Fenaughty		Client Group Coordinator
Jill Fenaughty		Client Group Coordinator
Rohan Currey		Ministry for Primary Industries

Comments:
The assessment team attended an initial meeting with representatives of the Client Group (CG) and the Ministry for Primary Industries (MPI). This meeting was the first of the New Zealand site visit relating to the fourth surveillance audit, with a view to the reassessment of the Ross Sea Toothfish Longline fishery. The team members in attendance clarified the make-up of the audit and reassessment team, including remote members. The team confirmed the planned timeframe with the CG. That is, for the surveillance report to be completed prior to the end of 2014, and, should reassessment ensue, for a draft reassessment report to be made available to the CG around March 2015.

2. Status
What is the nature of the organisations interest in the fishery (e.g. client / science / management / industry / eNGO, etc)

Client (CG)

Science, management (MPI)

3. Stakeholder Key Issues

What, if any, specific substantive issues or concerns are identified regarding the fishery? (P1 – P2 – P3) and what information is available to allow us to determine the status of the fishery in relation to each issue?

- Tag overlap statistics amongst the vessels operated by the CG: One vessel's activities resulted in a tag overlap of 59%, rather than the required 60%. Investigation determined that this resulted from the tagging requirement amongst different sizes of fish. As a result, the Conservation Measure (CM) was amended such that tagging requirements are aligned with fish numbers not tonnage. - The Antarctic Chieftain now operated by Australia, a new flag state entrant to the client group, was still under its New Zealand flag during the last toothfishing season. - All CG members (except New Zealand Longline – to come) have provided signed affidavits confirming that vessel activities only occurred outside the boundaries of closed areas. This is relevant to Condition 6 of certification. - Future work is planned in 88.2 A, B to address stock structure uncertainties. A proposal for a two-year experiment aimed to maximise tag recaptures, and involving increasing the deployment rate of tags, fishing in specified areas, and documenting bathymetry, has been agreed by CCAMLR. This involves NZ, UK, Norway and Russia. - The release of smaller toothfish by Ukrainian vessels was identified as a newly emergent issue. The reason for releases are as yet unknown however this activity is expected to cause problems for scientific work (e.g., stock assessment). - While not a part of the CG, anomalous catch rate data were reported by Russia at CCAMLR. These data are subject to further internal investigation (by Russia). - Is preliminary work on ecosystem effects of toothfish harvesting being undertaken. This is showing some promise and results are expected to develop over a 3-5 year timeframe. In addition, a one year project looking at orca in the Ross Sea was conducted last summer, and involved biopsies, photo identification and helicopter surveys of the region. - CCAMLR fishery reports are not verified, but are edited by members during the meeting where errors are identified. However, there is no process through which CCAMLR formally accepts these reports. Errors can remain. - Antarctic research is continuing in New Zealand supported (in part) by MPI contracting NIWA. MPI noted that the next contract, to be developed in the very near future, would include provision for management strategy evaluation. - Pertinent changes to CMs at the October 2014 CCAMLR meeting included the removal of the requirement to conduct bottle tests to confirm line sink rates, unless changes occurred in the fishing gear deployed. Also, CMs 41-09 and 41-10 are now more detailed. - Marine protected areas: The joint proposal developed by New Zealand and the USA was tabled for the second time. Opponents to the proposal included Russia and China.

4. IFC Assessment Team Questions

Assessment team questions for stakeholders

The team enquired about the availability of information for its own purposes and to stakeholders more broadly. The CG was of the view that making information available to stakeholders was not necessary, given stakeholders also attended CCAMLR meetings where the relevant science is discussed and many management decisions are made.

5. Other issues
(e.g. any other stakeholders we should contact, any written submissions to follow?)

The assessment team will meet with the CG, MPI and scientists from the National Institute of Water and Atmospheric Research (NIWA) on 13 November. Beyond the flagging of new issues and changes in the fishery raised at this opening meeting, the substantive discussion relating to the fishery will be addressed at that subsequent meeting.

MSC Fishery Assessment Check List

Ross Sea Toothfish Longline Fishery
MML-F-087

MSC Fishery Assessment Stakeholder Interview Record

Assessment Team	Names
Lead Assessor	Andrew Hough
P1 Team Member	Paul Medley
P2 Team Member	Andrew Hough
P3 Team Member	Jo Akroyd* / Johanna Pierre*

* Team members in attendance

Meeting Location	Ministry of Foreign Affairs and Trade, Wellington
Date	12 November 2014
Stakeholders Name	Affiliation
Jillian Dempster	Ministry of Foreign Affairs and Trade
Nicola Reid	Ministry of Foreign Affairs and Trade (MFAT)

Comments: MFAT provides New Zealand's Commissioner to CCAMLR.

2. Status

What is the nature of the organisations interest in the fishery (e.g. client / science / management / industry / eNGO, etc)

Government agency: management

3. Stakeholder Key Issues

What, if any, specific substantive issues or concerns are identified regarding the fishery? (P1 – P2 – P3) and what information is available to allow us to determine the status of the fishery in relation to each issue?

- NZ's focus at the government level is on improving the performance standard across the whole fleet fishing in the CAMLR Convention Area. - The NZ delegation to CCAMLR this year included industry and eNGO participants, in addition to government officials. The Minister of Foreign Affairs and Trade approves the delegation members. - MFAT officials meet with the Industry Toothfish Committee twice each year, and also meet three times per year to at Industry Roadmap meetings (that also involve the Department of Conservation and Ministry for Primary Industries). In addition, broader stakeholder meetings take place. - At the October 2014 CCAMLR meeting, a stock assessment was agreed for 88.2. In addition, a joint research proposal was developed for 88.2, to address stock-related issues for that area. - Russia reported some anomalous catch-effort data, which they have undertaken to investigate intercessionally. The anomalous data previously reported by South Korea was examined by South Korea with assistance from NZ and USA scientists. - MFAT's focus is on fostering science to develop a broader ecosystem understanding, i.e., not only fishery-related. MFAT's relationship with NZ's Ministry for Business, Innovation, and Employment includes discussions about potential science initiatives relating to Antarctica and the focal point programme undertaken between NZ and South Korea on Antarctic science. - The October CCAMLR meeting was the second at which the Compliance Evaluation Procedure (CEP) approach had been taken by CCAMLR's Standing Committee on Implementation and Compliance (SCIC). CEP seemed to encourage a more proactive approach to declaring compliance issues and reporting actions taken by flag states to rectify non-compliance. There were no major compliance issues relating to the CG vessels in the past year. - The increasingly routine scientific investigation of potential misreporting of catch is a constructive development and little opposition to this investigative now occurs. Where investigations are occurring of anomalous data reported at the October 2014 CCAMLR meeting, results are expected to be scrutinized at CCAMLR in 2015, with the potential for follow-up actions if warranted. - NZ continues to conduct surveillance in the Ross Sea both from sea and aerial flights. The focus of surveillance is reviewed in light of CCAMLR priorities, findings and issues. Ongoing dialogue between New Zealand and others has also contributed to efforts to combat IUU activities. A very small number of IUU vessels has been spotted in the Ross Sea in recent

years. The amount of legal vessel traffic in the region is relatively high, increasing the likelihood of detecting illegal operators.
- Plans are underway to conduct a second performance review of CCAMLR. The first review was conducted in 2008. Intercessionally, the European Union will lead the development of Terms of Reference for the review. Part of the review will include assessing the outcomes of the first performance review. It is intended that the Terms of Reference will be agreed at the next CCAMLR meeting (i.e., October 2015).
- NZ and Australia have an annual bilateral meeting that encompasses Antarctic issues, and contact is also maintained with Norway through the year. NZ and Spain have less contact.
- In 2015, a celebration of 35 years of CCAMLR is planned. This is to be funded by Chile, Australia, and the US.
- NZ tabled a proposal at CCAMLR 2014 to delay the start of the Ross Sea fishing season for one month, given safety concerns around the prevalence of ice cover and the use of vessels that are not strongly ice-strengthened. The risk of environmental damage e.g., due to oil or fuel spill should vessels sink, was also relevant. This proposal was not supported by consensus and therefore did not proceed.

4. IFC Assessment Team Questions
Assessment team questions for stakeholders

5. Other issues
(e.g. any other stakeholders we should contact, any written submissions to follow?)

Contact MPI, to comment on traceability and the catch documentation scheme.

6. Closing

IFC Lead Assessor:
- Summary of key points – stakeholder to confirm in writing (sign if hard copy)
- Are comments to be attributed?
- Timescale for completion, including further opportunities for stakeholder input

---

Ross Sea Toothfish Longline Fishery
MML-F-087

MSC Fishery Assessment Stakeholder Interview Record

Assessment	Names

Team	
Lead Assessor	Andrew Hough
P1 Team Member	Paul Medley
P2 Team Member	Andrew Hough
P3 Team Member	Jo Akroyd* / Johanna Pierre*

* Team members in attendance

Meeting Location	Department of Conservation Head Office, Manners St, Wellington
Date	12 November 2014
Stakeholders Name	Affiliation
Danica Stent	Department of Conservation (DOC)

Comments:

2. Status

What is the nature of the organisations interest in the fishery (e.g. client / science / management / industry / eNGO, etc)

Government agency: management

3. Stakeholder Key Issues

What, if any, specific substantive issues or concerns are identified regarding the fishery? (P1 – P2 – P3) and what information is available to allow us to determine the status of the fishery in relation to each issue?

- Generally consider that the target stock is in a good position. May be some issue with the changing male/female distribution.
- Gaps in knowledge of target species at some stages of their life history. This affects the biological basis for identifying MPA locations, if those locations are intended to protect toothfish together with other components of the biodiversity and ecosystem.
- Fishing in heavier ice conditions increases the risk of losing gear. This has environmental consequences. Proposal to delay the start of the Ross Sea fishing season would most likely reduce the risk of losing gear as ice cover would be reduced. There would also be a reduction in environmental risk due to oil spills, for example.
- Momentum around research/science on VMEs has stalled. More information is desirable on the impacts of longline gear on benthos, and trotlines cf. longlines.
- More information on the vulnerability to harvest of skates and rays is desirable. These species are known to be vulnerable to fishing pressure.
- While shark catch is very low, the extent of impact is unknown.
- Some concern re the reductions in size of the MPA proposed. All CG countries support the current proposal.

- Plans are underway to conduct a second performance review of CCAMLR. The first review was conducted in 2008. Intercessionally, the European Union will lead the development of Terms of Reference for the review. Part of the review will include assessing the outcomes of the first performance review. It is intended that the Terms of Reference (ToR) will be agreed at the next CCAMLR meeting (i.e., October 2015). DOC is to participate in the preparation of the ToR.
- The IUU situation is improving with information sharing between countries facilitating this. Ongoing surveillance is beneficial for improving performance amongst all vessels, as well as detecting or dissuading IUU activities.
- NZ is very involved in the examination of catch rate data where anomalous data have been reported. This is a positive development.
- Concern about CCAMLR's lack of efficacy in relation to broader issues referred from other parts of the Treaty System, e.g., climate change. The Commission is very focused on fishing, to the extent that other issues are hardly addressed.

4. IFC Assessment Team Questions
Assessment team questions for stakeholders

5. Other issues
(e.g. any other stakeholders we should contact, any written submissions to follow?)

- IFC to discuss compliance further with MPI.

6. Closing

IFC Lead Assessor:

- Summary of key points – stakeholder to confirm in writing (sign if hard copy)
- Are comments to be attributed?
- Timescale for completion, including further opportunities for stakeholder input

---

Ross Sea Toothfish Longline Fishery
MML-F-087

MSC Fishery Assessment Stakeholder Interview Record

Assessment Team	Names
Lead Assessor	Andrew Hough
P1 Team	Paul Medley

Member	
P2 Team Member	Andrew Hough
P3 Team Member	Jo Akroyd* / Johanna Pierre*

* Team members in attendance

Meeting Location	WWF offices, Boulcott St, Wellington
Date	12 November 2014

Stakeholders Name	Affiliation
Bob Zuur (by phone)	WWF, Antarctic and Southern Ocean Initiative
Barry Weeber (by phone)	ECO
Ann McCrone	WWF-NZ

Comments:

2. Status

What is the nature of the organisations interest in the fishery (e.g. client / science / management / industry / eNGO, etc)

eNGOs

3. Stakeholder Key Issues

What, if any, specific substantive issues or concerns are identified regarding the fishery? (P1 – P2 – P3) and what information is available to allow us to determine the status of the fishery in relation to each issue?

- There was concern about the lack of information provided by the Client Group (CG) for this audit and also the potential reassessment of the fishery.
- The timing of the audit was such that CCAMLR had only just ended, and this was recognized as a potential difficulty in terms of preparing information. Delaying the audit for 2 weeks would ameliorate this issue.
- While stakeholders can participate in NZ working groups – e.g., the Antarctic Working Group – these groups have restrictions around the sharing of information beyond group members.
- No information about the activities of the Norwegian and Spanish members of the CG. No information on their research activities either.
- Concern about the compliance of the Tronio with the offal management requirements of CCAMLR.
- Indications in 88.2 that overfishing could be occurring.
- Anomalous data presented at CCAMLR relating to Russia's activities in the Weddell Sea, where the vessel in question had travelled subsequent to fishing in the Ross Sea. Concern that misreporting of catch may be occurring. Russia has committed to investigate this

intercessionally. Russia also revealed the practice of releasing small toothfish, which has implications for management including the scientific basis for management.
- Closure of 88.2 also raised questions re the ability of CCAMLR to manage within catch limits when a number of vessels are active in an area. The past season, the catch limits were exceeded and the fishery closed relatively rapidly. The EU has some interest in discussing capacity issues (i.e., number of vessels active).
- The MPA process did not progress at the 2014 CCAMLR meeting. The discussion is ongoing, although with decreasing protection outcomes given the increasingly smaller area are under discussion.
- Potential concerns about the conclusions drawn re the role of toothfish in the Ross Sea ecosystem. While toothfish have been identified as not significant to top predators on an annual scale or over the region, there may be smaller scale importance that has not been identified to date.
- At CCAMLR 2014, NZ presented a paper about delaying the start of the toothfishing season in the Ross Sea. This related to concerns around vessel safety in ice. Amongst the CG, some states supported and some opposed this proposal. The proposal is expected to result in the fishery being spread over a broader area, which would improve information quality over time also. Russia did not support the proposal as they wanted to first fish the Ross Sea, then the Weddell Sea. The proposal may have been seen as self-serving for countries with ice-strengthened vessels. The next steps for this proposal are intercessional work and the consideration of a staged approach (e.g., a two-week delay to the current start date).
- eNGOs do not have input into the development of NZ's Antarctic policy. Working Groups provide the opportunity to contribute to science.
- At CCAMLR 2014, discussions included a proposal to increase controls over transshipment. This was not agreed. There is no requirement currently to monitor transshipment outside the CAMLR Convention Area. There were also discussions around increasing the strength of VMS requirements. A request for tender has been issued for a VMS review.
- An independent review of the Catch Documentation Scheme is underway.
- A review of the Ross Sea stock assessment is also underway, by a graduate student at Victoria University of Wellington.
- A requirement for accreditation of all CCAMLR observers has been proposed. Russia did not support this.
- The Spanish member of the CG operates the FV Tronio. This vessel notified to use trot lines and bottom longlines. It is not clear why, when the UoC is for longlines only.
- In 88.1, there seem to be areas in which tags are missing or not reported. It is worth checking that all CG vessels contribute tagging data to the stock assessment.
- A review of the Conservation Measures (CMs) relating to vulnerable marine ecosystems (VMEs) was proposed in the past, but this has yet to be progressed.
- It is unclear what the consequences of a breach of compliance are for vessels in the CG (and outside it).

4. IFC Assessment Team Questions

Assessment team questions for stakeholders

- Clarified potential interest in additional communication with the remote audit team via Skype. This was considered useful by eNGOs in mid-December or late-January.

5. Other issues

(e.g. any other stakeholders we should contact, any written submissions to follow?)

- In deciding whether to make written submissions, it would be helpful to have a common information base with the CG, e.g., specific management information relating to their vessels and processes. An update to the Client Action Plan would also facilitate engagement. Lack of information on the non-NZ members of the CG is especially problematic.

6. Closing

IFC Lead Assessor:

- Summary of key points – stakeholder to confirm in writing (sign if hard copy)
- Are comments to be attributed?
- Timescale for completion, including further opportunities for stakeholder input

---

Ross Sea Toothfish Longline Fishery
MML-F-087

MSC Fishery Assessment Stakeholder Interview Record

Assessment Team	Names
Lead Assessor	Andrew Hough
P1 Team Member	Paul Medley
P2 Team Member	Andrew Hough
P3 Team Member	Jo Akroyd* / Johanna Pierre*

* Team members in attendance

Meeting Location	NIWA, Greta Point, Wellington
Date	13 November 2014
Stakeholders Name	Affiliation
Jack Fenaughty	Client Group Coordinator
Jill Fenaughty	Client Group Coordinator
Alistair Dunn	NIWA
Stuart Hanchet	NIWA
Matt Pinkerton	NIWA
Darryn Shaw	Sanford Ltd (Client Group)
Rohan Currey	Ministry for Primary Industries

Comments: The meeting took place over approximately 5 hours with participants attending and departing as the areas of their expertise were discussed.

2. Status

What is the nature of the organisations interest in the fishery (e.g. client / science / management / industry / eNGO, etc)

Client Group (CG)
Government (management)
Science provider

3. Stakeholder Key Issues

What, if any, specific substantive issues or concerns are identified regarding the fishery? (P1 – P2 – P3) and what information is available to allow us to determine the status of the fishery in relation to each issue?

Principle 1:
- All CG vessels were confirmed to be contributing tagging data to the stock assessment.
- CG to confirm that FV Tronio only fished using longlines (not trotlines, which were also notified).
- CCAMLR's Working Group on Fish Stock Assessment conducts the stock assessment for Ross Sea toothfish. There were no substantive changes to the 88.1 stock assessment in the past year, and the same harvest control rules were utilized. Catch limits were also set the same way as in previous years.
- The 88.1 assessment is considered to be relatively stable, and the biological parameters relatively robust. Information on recruitment will be highly informative for the assessment in future. Next steps for this assessment include management strategy evaluation.
- In 88.2, there is considerably more uncertainty than in 88.1. The long-term yield and biomass of the stock are uncertain. Fishing activity has been largely focused in the northern hills, with 300 – 400 T taken annually. In the last 2-3 years, tag recaptures have been increasing, to an extent suggesting that the exploitation rate may be inappropriately high. As a result, the TAC was reduced to 250 T, and a further TAC proposed but not agreed. A 2-year research project to improve the information base relevant to stock structure in 88.2 was agreed at CCAMLR 2014. This project involves increasing tag rates of fish, and focusing fishing in areas where tags have been deployed.
- A spatial population model (paper to be published in CCAMLR Science) exploring the fine-scale dynamics of toothfish populations found that the current stock assessment method is precautionary, in that it underestimates biomass by 20-40%.
- Work on the comparative biology of toothfish has found that the current management approach of identifying two separate stocks is appropriate. There appears to be no wholesale mixing between the stocks, although some fish may transfer between stocks.

Principle 2:
- The Patagonian toothfish caught in the Ross Sea are most likely from a widely distributed stock encompassing Macquarie Island, parts of the Campbell Plateau and areas in the high seas. There are two SSRUs where catches of Patagonian toothfish are greatest (88.1A, currently closed) and 88.1B (in which catch is approximately 20% Patagonian and 80% Antarctic toothfish).

- The Ross Sea is managed as a *Dissostichus* fishery so there is no need to avoid catching Patagonian toothfish. In the period 2011 – 2014, catches of Patagonian toothfish ranged from <1 – 4 T annually. There are no other retained species on CG vessels.
- Bait used in the Ross Sea is Humboldt squid (all vessels except FV Tronio) caught on the west coast of the USA, and sardines (FV Tronio) (source to be confirmed).
- There are tag recapture data available from the CCAMLR Year of the Skate programmes (2008) that could be analysed to provide useful information on these low information stocks. It would be possible to use the data available to investigate relative abundance and relative mortality. The survival of skates released after being hooked has not been investigated in the Ross Sea as yet.
- A four-year programme investigating ecosystem effects of the Ross Sea fishery is concluding. This programme investigated:

1. The ecosystem effects of fishing on prey species

-Species that are prey for toothfish are also often bycatch species in the fishery. The potential effects of predation release on prey species are considered to be greater than through bycatch of these species. For example, the relative abundances of bycatch species could change if the predation pressure from toothfish is reduced/removed. The relative proportions of the two *Macruorus* species (*M. whitsoni* and *M. caml*) consumed by toothfish are unknown. These two recently-separated species are known to have different life history characteristics. Modelling work indicates that insufficient *Macruorus* may be present on an area basis to satiate toothfish, and therefore *Macruorus* are moving through habitats over time and being consumed.
- A research trawl survey is being conducted this (upcoming) season using the RV Tangaroa. This survey will include tows on the slope which will allow an exploration of relative abundance of the two *Macruorus* species, unaffected by longline catchability issues. In addition, novel methods are being investigated (e.g., acoustic signals) to index rattail abundance over time.
- Where rattails are moving through habitats, CPUE is not a reliable indicator of biomass as hyperstability may occur.
- Ongoing monitoring includes toothfish stomach contents. This work is expected to show whether toothfish diet has changed over time.
- It seems likely that there will be a change in the relative abundance of bycatch species as toothfish are the major predators in this area.
- More broadly, whether toothfish is managed as a predator or prey species in the CCAMLR context is a worthwhile discussion.

2. The effects of fishing on toothfish predators

- Both Weddell seals and Type C killer whales are known to eat toothfish. Seals eat flesh and tend not to eat bones, which makes detecting toothfish remains in scats impossible. Through the year, seal diets may include 5-10% toothfish. However, toothfish may be an important food source for female Weddell seals following pup birthing and nursing stages, during which time females may lose around 40% of their body weight. Predation of toothfish by such females seems to be focused where the seal colonies are. Therefore, the location doesn't overlap with the concentrations of toothfish are. Further, Weddell seals are relatively shallow divers (whereas toothfish can occur at depth). However, if a stock contraction of toothfish occurred (e.g., as a consequence of fishing activity), it is reasonable to expect this would have some impact on some female seals at a critical time of their annual cycle (in that they have high energetic needs in order to recover their lost body weight).
- SSRU 88.1M has an allocated catch of 0 given the proximity of this SSRU to breeding seals. This will stop any in-season local depletion of toothfish, but cannot address the issue of stock contraction.

- The subadult survey of toothfish that has occurred in recent years was conceived to inform the stock assessment. However, this survey has additional value in providing an index of abundance where toothfish may be important to predators.

3. Wider ecosystem effects of toothfish fishing, including potential trophic cascades.

- A food web model has been constructed for the Ross Sea (mixed trophic impact assessment). The model shows that toothfish removal due to fishing is unlikely to result in trophic cascades through the ecosystem. The effects of fishing are expected to be restricted to toothfish prey and predators. (In this system, most energy is with krill and silverfish). Note that this does not mean that a lack of toothfish won't destabilize the system. If this happened however, it would not be expected to be a consequence of trophic effects.
-To document and understand ecosystem impacts of the fishery overall, ongoing monitoring is important. If there are going to be effects, they would be expected to manifest in the next 10 years.

Principle 3:
- Sanford Ltd provides crew training to support the correct identification of Antarctic and Patagonian toothfish at sea. Processed states include headed and gutted fish, cheeks, etc., and fish are frozen. Other species go to meal. Toothfish species are separated in the hold, and weights documented. In port, a Ministry for Primary Industries observer supervises the unload, and conducts a port-state verification of landed weight. The Catch Documentation Scheme is implemented. Landed weights are compared with onboard weights. The catch is kept separated and barcode labelling is implemented.
- Communication amongst the CG occurs electronically throughout the year, and representatives meet once per year in person.
- No complaints have been made or compliance issues reported from the CG vessels.
- The recovery of toothfish tags is incentivized by the Coalition of Legal Toothfish Operators (COLTO) through a sponsored lottery, whereby prize money is awarded annually to the person who recovered a randomly-drawn numbered tag from a captured toothfish.
- Work tabled by New Zealand scientists at the Working Group on Fish Stock Assessment (FSA) has first been reviewed by the Antarctic Working Group, which includes scientists and managers and is also open to all other stakeholders. The FSA process is another form of review.
- There have been no changes to bycatch recording practices on CG vessels.
- There have been no significant changes to management measures on CG vessels (but note minor amendments to CCAMLR CMs).

Principle 1/2:
- The impacts of potential ghost fishing by lost gear have been examined in the context of toothfish stocks. While there is not CCAMLR requirement to recover lost gear there is a financial incentive given the cost. Potential effects of lost gear on other species have not been investigated.

Principle 2/3:
- The review of Conservation Measures relating to VMEs that was proposed at their inception has not been prioritized amongst the work programme related to CCAMLR to date.

4. IFC Assessment Team Questions

Assessment team questions for stakeholders

5. Other issues

(e.g. any other stakeholders we should contact, any written submissions to follow?)

A list of pertinent references will be provided subsequently to the assessment team. The estimated timeframe for this is mid-January.

6. Closing

IFC Lead Assessor:

- Summary of key points – stakeholder to confirm in writing (sign if hard copy)
- Are comments to be attributed?
- Timescale for completion, including further opportunities for stakeholder input

3.2 Stakeholder comments on Public Comment Draft Report

3.2.1 MSC Technical Oversight

Grade	Requirement Version	Oversight Description	CAB Comment
Guidance	CR-27.12.1.1 v1.3	The report states on page 37, "Catches from other CCAMLR Subareas are separated from catches from the fishery proposed for certification through labelling and/ or physical separation in the vessel. Observers on the vessel will also verify the separation systems put in place." Page 9 also mentions, "D.mawsoni dominates catches in sub-areas 88.1 and 88.2." Both statements suggest there are catches from areas outside the UoC and also species caught that are not part of the UoC on board vessels at the same time, possibly including the other other toothfish species D. eleginoides. The systems of identification and segregation of certified and non-certified product on board could be explained in more detail to document how these risks are addressed.	Catches of D eleginoides are indeed possible (this is a retained species discussed in the report) and catches from other areas may also be present. The members of the Client Group will have their own systems to keep these separate from Ross Sea Antarctic toothfish - either labelling of product, physical separation or both. Whichever system is used, the assessment team has confidence that product will be properly reported under CCAMLR requirements, including CDS requirements, and separation will be verified by observers. This has been clarified in the main report.

Minor	CR-27.12.2.1 v1.3	The report is not clear about when change of ownership occurs and the point at which chain of custody is needed. As the Client Group includes companies/ vessels of 5 different countries, change of ownership and when CoC begins should be explained for each scenario and should cover all points of landing. For example, what happens in South Africa, South Georgia and Montevideo - at what point is chain of custody needed? Is all certified catch from NZ and Australia landed/ sold directly to the companies with CoC mentioned in the report? The report explains the process after landing in NZ and Australia to some extent, in that processors have their own CoC, but not for the other countries/ companies in the Client Group. For instance are auctions or agents involved and are they intended to be covered by the fishery assessment?	All product is landed into recognised points where DCD inspections are carried out, as detailed in the report. At each port, product is containerised and shipped to customers. All client group members have their own CoC certification and so this containerisation and shipping is already within the CoC regime. The only exception to this is some product landed into NZ where this may enter Client Group member factories. The only exception to this is some product landed into NZ which may enter factories belonging to Client Group members for further processing before sale. Such product will, however, be covered by the CoC systems of the Client Group members. The point of change of ownership will be sale from the factory. This has been clarified in the main report.
Guidance	CR-27.6.1 v1.3	While the intention is understood in the report, CR 27.6.1 requires the CAB to nominate an eligibility date. If certification is expected to be continuous, the eligibility date could be the date of expiry of the current certificate, 15th November 2015. In selecting this date, the CAB should consider how any gap between the current and subsequent certificates would cover product harvested in that period.	An eligibility date has been included in the report. This is taken as 14 January 2016 - the date the current certificate expires. As such, there will be no gap between the current and subsequent certificates.

3.2.2 Comments from ASOC

Contact Information Make sure you submit your full contact details at the first phase you participate in within a specific assessment process. Subsequent participation will only require your name unless these details change.			
Contact Name	First	Claire	Last Christian

Title	Director, Secretariat			
1. On behalf of (organisation, company, government agency, etc.) – *if applicable*				
Organisation	Please enter the legal or registered name of your organisation or company. Antarctic and Southern Ocean Coalition			
Department				
Position	Please indicate your position or function within your organisation or company. Director of the ASOC Secretariat (headquarters).			
Description	Please provide a short description of your organisation. ASOC is an international eNGO working full time on protection of the Antarctic environment and is an official observer organisation in the Antarctic Treaty System.			
Mailing Address, Country	1320 19th St. NW, Fifth Floor			
Phone	**Tel**	+1 202 234 2480	**Mob**	+
Email	**Clairechristian47@gmail.com**		**Web**	www.asoc.org

Assessment Details	
Fishery	Ross Sea toothfish longline
CAB	Acoura Fisheries

• SECTION 4 •

Assessment Stage	Fishery	Date	Name of Individual/Organisation Providing Comments
☒ Public review of the draft assessment report[20] Opportunity to review and comment on the draft report, including the draft scoring of the fishery.	Ross Sea toothfish longline fishery	November 6, 2015	Antarctic and Southern Ocean Coalition (including input from ECO New Zealand).

☒ I wish to comment on the evaluation of the fishery against specific Performance Indicators.
A table with these indicators and the scores and rationales provided by CABs can be found in Appendix 1 of the draft assessment report.

Nature of comment *(Please insert one or more of these codes in the second column of the table below for each PI.)*

1. I do not believe all the relevant information[21] available has been used to score this performance indicator *(please provide details and rationale)*.
2. I do not believe the information and/or rationale used to score this performance indicator is adequate to support the given score[22] *(please provide details and rationale)*.
3. I do not believe the condition set for this performance indicator is adequate to improve the fishery's performance to the SG80 level[23] *(please provide details and rationale)*.
4. Other *(please specify)*

20 MSC Fisheries Certification Requirements, v2.0 section 7.15
21 MSC Fisheries Certification Requirements, v2.0 section 7.10
22 MSC Fisheries Certification Requirements, v2.0 section 7.10
23 MSC Fisheries Certification Requirements, v2.0 section 7.11

Performance Indicator	Nature of Comment Indicate relevant code(s) from list above.	Justification Please support your comment by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary.
PI 1.1.2 Limit and target reference points for the stock	2	The CAB gave a score of 90 for this PI, suggesting that the fishery has appropriate reference points, above the level at which there is an risk of impairing reproductive capacity, and taking into account the ecological role of the stock with a high degree of certainty. However, due to the lack of life history information about the Ross Sea toothfish stock, managers are forced to set quotas and management measures based on a host of assumptions and often using reference points for other related species, such as the Patagonian toothfish. Scientists have yet to find an egg or larvae or fish less than 40cm of a Ross Sea Antarctic toothfish. They have yet to determine when, where and how often they spawn, forcing managers to assume an annual spawning, when increasing evidence suggests that these fish may actually skip spawn (Hanchet et al. 2015) with no real knowledge of if they spawn every other year or even less than that (Ainley et al. In Review). Further complicating their life history, and not acknowledged by the CAB or largely considered by toothfish fishery scientists and managers, is the proportion of “axe-handle fish” that are found in the fishery and the potential consequences for the fish stock assessment. These depleted, post-spawning fish, are predominantly found in the northern part of the Ross Sea toothfish range around ridges and seamounts where they purportedly spawn. Here axe-handle fish compose ~50% of the toothfish caught on longlines (Fenaughty et al. 2008; Hanchet et al. 2008). Scientists have no idea what happens to these axe-handle fish, but population models assume that they return to the shelf and slope to regain condition (Hanchet et al. 2008). Yet, these fish have fully depleted their metabolic stores through migration and spawning and the oligotrophic northern waters lack the necessary food that toothfish would need to regain condition to make the long migration back to the southern Ross Sea slope (Fenaughty et al. 2008). Very few fish tagged at the seamounts have been recovered (Hanchet et al. 2015), thus its possible that these fish simply drift in the currents and perish, with severe consequences for the breeding population. The uncertainty around axe-handle fish must be factored into fish stock assessments and into the CAB scoring. Finally, it is worth pointing out that most of what we think we know about Ross Sea toothfish is confined in space and time to relatively short austral season and location. The Ross Sea’s heavy ice cover limits commercial fishing to December to January or February and spatially confines vessels to seasonally ice-free parts of the Ross Sea region where they target the Ross Sea slope. Thus, knowledge about Ross Sea toothfish is confined to early summer months and skewed towards fish caught by longlines in the limited areas the fishery occupies (e.g., large fish that occupy the slope) with little known about fish that occur elsewhere or not captured by longlines (e.g., fish that life deeper and shallower than the fishery targets, fish smaller than 60 cm, and larger fish in the water column; Ainley et al. In Review).

Performance Indicator	Nature of Comment Indicate relevant code(s) from list above.	Justification Please support your comment by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary.
		Acoura Team response: The reference points are appropriate, precautionary and meet international standards. The points raised above are valid, but not appropriate to be scored under reference points. Reference points are used to determine stock status using standard indicators. To score SG100 on 1.1.2c, the target reference point needs to be relatively precautionary. We believe that it has been set at a default precautionary level, which takes into account the many uncertainties associated with this species. However, how the indicators are estimated, which we believe the comments are more pertinent to, are more considered under PI 1.2.3 and 1.2.4. For 1.2.3, the fishery scores 80 because information, we believe, is sufficient to support the precautionary harvest strategy, but does not score higher for the sorts of reasons raised above by the stakeholder. Stock structure remains uncertain, as does the way to determine spawning stock size and the stock-recruitment relationship. We note, however, that the parameters used for the Ross Sea model assessment were derived for Antarctic toothfish in the Ross Sea, with the exception of release mortality. This uses estimates based on an experiment for Patagonian Toothfish from South Georgia which suggested a release mortality of about 5%, and this was used to make the more precautionary assumption of 10%. Similarly, 1.2.4c is not met because these sorts of hypotheses have not been explored. So we believe these general points have been taken into account and have influenced the scores appropriately. We would note that the issues raised by the stakeholder are hypotheses, and point to uncertainties rather than matters of fact. It might well be appropriate that these hypotheses form the basis for future sensitivity runs in the stock assessment models. These can be raised with the appropriate stock assessment scientists to include in future stock assessments if the scientists consider it appropriate. We, as MSC assessors, require that this process exists, not that any particular hypothesis should be favoured over any other. The MSC is not an external technical review (hence the fishery does not meet PI 1.2.4e SG100). One issue with which we are concerned is whether decisions on the null hypothesis are precautionary. For example, in the case of “axe-handle fish”, an increased natural mortality post spawning could be introduced into the stock assessment as a sensitivity run. However, it would most likely be a less precautionary hypothesis because a substantial proportion of the catch would be destined to die anyway. Of more concern would be, again for example, that fish became more catchable after spawning because they are more attracted by bait, which might be detected in the selectivity models. However, the precautionary level of exploitation and extensive data collection suggests that this and similar effects should be detected as the fishery proceeds. Finally, we agree there are significant gaps in knowledge in the stock dynamics, but also note that the enforced closure for much of the year limits the amount of fishing on this stock as well as the amount of information. This does not provide adequate protection alone, but does offset some of the risk due to this effect on the available information. No changing of scoring is therefore considered necessary.

Performance Indicator	Nature of Comment Indicate relevant code(s) from list above.	Justification Please support your comment by referring to specific scoring issues and any relevant documentation where possible. Please attach additional pages if necessary.
PI 2.5.1 **The fishery does not cause serious or irreversible harm to the key elements of ecosystem structure and function**	1, 2	The CAB gave a score of 100 for this PI, suggesting that there is sufficient evidence that that fishery is highly unlikely to disrupt the key elements underlying ecosystem structure and function. Yet the CAB provided little to no robust evidence to support this fact. There is a paucity of accurate information on the role of Antarctic toothfish as both predator and prey in the Ross Sea ecosystem, thus it is impossible to attest with much confidence that the fishery is highly unlikely to disrupt the ecosystem. Further, published literature has come to the fore in recent years suggesting that the fishery is already, or highly likely to, have an impact on the ecosystem. For example, Lyver et al. (2014; also Ainley et al. 2013) suggest that a possible depletion of Antarctic toothfish, may at least in part explain the sharp increase in Adélie penguins numbers in southwest Ross Sea over the last decade and a half. In this area, they may be in trophic competition as both forage heavily on Antarctic silverfish (Eastman 1985, Ainley et al. 2003). Note also, that despite many studies on toothfish diet, there is still significant disagreement in the scientific literature on the composition of the prey consumed by Antarctic toothfish in the Ross Sea. Fishery data, based mostly on toothfish caught on benthic longlines on the Ross Sea slope, suggests that toothfish primarily forage on benthic fishes (Hanchet et al. 2015). Yet fishery independent studies of toothfish diet at McMurdo Sound (off the Ross Sea shelf) indicated that toothfish's primary prey item is neutrally buoyant Antarctic silverfish (*Pleuragramma antarcticum;* 71% frequency of occurrence, 90% diet composition by mass; Eastman 1985). Yet ecosystem models of toothfish utilized by managers at CCAMLR and its working groups use fishery dependent data and thus do not consider the potential large role that silverfish play in the diet of Ross Sea toothfish. This discrepancy, not noted by managers, was also not noted by the CAB.

PI 2.5.1 **The fishery does not cause serious or irreversible harm to the key elements of ecosystem structure and function**	1, 2	Continuing on from the above points, there is also increasing evidence that Antarctic toothfish are an important prey item to many Ross Sea predators, especially Weddell seals (e.g., Ainley & Siniff 2009). Weddell seals feed mainly on silverfish and toothfish, though it has been difficult to quantify the relative consumption of toothfish (because the seals do not consume their hard parts, thus rendering scat analyses insufficient; Goetz 2015). However, using biochemical analyses of Weddell seal diet, Goetz (2015) estimated that toothfish represent ~15% of the total biomass consumed by Weddell seals in the western Ross Sea. Further it is worth noting that silverfish only provide half the energetic content of toothfish (Lenky et al. 2012) and that toothfish are three orders of magnitude larger (e.g., average consumed silverfish is 50g versus a 25,000g toothfish; Burns et al. 1998, Ainley and Siniff 2009). Thus catching one toothfish makes a much larger energetic benefit (in terms of foraging effort and efficiency) than catching the equivalent in silverfish. Toothfish may be particularly important to female Weddell seals during the summer breeding period due to energetic demands from lactation (e.g. females can lose < 100kg during lactation; Eisert 2003). Though the reproductive rates of Weddell seals being monitored in McMurdo Sound have not shown a decline (LaRue et al. 2011), counts of molting seals along the coast of the western Ross Sea may be declining or dispersing more widely (Ainley et al. 2015). Though the toothfish fishery dominants the Ross Sea slope, rather than the shelf (close to where the seals breed and molt), some shelf fishing still occurs and further, fishery effects are not necessarily localized. An overall decrease in the toothfish biomass (even if in line with CCAMLR fishery management goals) will lead to less toothfish available to Weddell seals. Ainley et al. (2013) suggested the decline of large energy-dense toothfish from McMurdo Sound corresponding to the onset and growth of the Ross Sea longline fishery for toothfish. The potential reduction of these fish, and the resounding effect on female Weddell seals, must be considered by the CAB. It is critical to gather more information about the role of toothfish in the Weddell Seal's diet, especially for females during the breeding season and the degree to which toothfish could be replaceable in the Weddell Seal diet. Beyond their potential importance to Weddell seals, Antarctic toothfish are also key prey for a particular population of Orcas, known as Type-C Orcas or "Ross Sea killer whales" (Pinkerton et al. 2010, Pitman and Ensor 2003). Recent observations suggest that these Orcas may be decreasing, or no longer frequenting McMurdo Sound, potentially in correlation with the reduction in large fish from McMurdo Sound (Ainley et al. 2009; Ainley and Ballard 2012; Ainley et al. 2013). There is little to no information on how much these Ross Sea killer whales depend on Antarctic toothfish and until there is, a score of 100 is completely unwarranted for this PI. Acoura Team response: It must first be borne in mind what the MSC requirements for this PI are. 'Highly unlikely' means that there is a more than a 30% probability of serious or irreversible harm. Serious or irreversible harm is interpreted by the MSC (CR v1.3 GCB 3.17) in terms such as: • (Fishing) "…does not impact the abundance levels of more than 15% of other species and trophic groups by more than 40% and does not reduce the level of any other species or trophic group by more than 70% • Trophic cascade caused by depletion of top predators • Severely truncated size composition of the ecological community to the extent that recovery would be slow due to increased predation by intermediate-sized predators • Gross changes in species diversity (loss of species, major changes in species evenness) The same section also notes that "relatively few fisheries would have the information needed to address ecosystem effects quantitatively..." With this MSC guidance in mind, it is noted that there is a balanced Ross Sea trophic model and (quantitative) mixed trophic impact (MTI) analyses have been undertaken to investigate the potential for changes in toothfish abundance to cascade through the ecosystem (see Pinkerton 2015). The results of the analysis were that:

		• Antarctic toothfish have moderate trophic importance • Changing toothfish abundance may substantially affect demersal fish, but that this effect is unlikely to cascade through the ecosystem It must also be remembered that the toothfish stock is currently around 75% B0, so using the MSC guidance, even the target stock (let alone any indirect trophic effects) has not been reduced by more than 70%. So in relation to the PI 2.5.1 scoring guideposts, SG80 requires that "the fishery is highly unlikely to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm" and based on the evidence above, this is considered to be met. SG100 requires "evidence that the fishery is highly unlikely to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm". The trophic model and MTI analysis provides this evidence. As the MSC guidance acknowledges, it is relatively uncommon for such evidence to be available. In relation to global fishery science and management, then, the fishery clearly meets SG100. Effects on Weddell seals and orcas have been considered explicitly in PI 2.3.1, SI c) – Indirect effects of the fishery on ETP species. The consideration here was "*As outlined in Pinkerton (2015) the fishery could affect predators through: a) localised depletion of toothfish within a season, b) reducing the number of subadult toothfish in the southwest Ross Sea and c) by changing the movement patterns of toothfish, particularly by reducing numbers of large toothfish on the slope, causing other large toothfish to move from the shelf, particularly in the south west. In relation to a), fishing closures are in place in waters shallower than 550m and in SSRU 88.1 M; for b) sub adult surveys in the southwest Ross Sea shows no significant change in catch rates. The remaining uncertainty is therefore over potential changes in movement patterns of toothfish*." The MSC assessment report also notes that "*…recent work by New Zealand and Italian scientists (Eisert et al 2015) have found definitive evidence, derived from two independent methods (Satellite tagging and photo identification) that type C killer whales undergo long-distance travel from the southern Ross Sea to New Zealand waters and into sub-tropical regions (31° to 35° south)*". It is entirely accepted that toothfish will feature in the diet of both Weddell seals and Orca; but with the stock currently at around 75% B0, with measures in place to ensure fishing does not take place in water shallower than 550m and with no indication of declines in reproductive rates of seals (or orcas), the conclusion of PI 2.3.1 SI c was that indirect effects have been considered and are thought to be unlikely to create unacceptable impacts. The SG100 requirement of "a high degree of confidence that there are no significant detrimental indirect effects of the fishery" was not considered to be met – there is not a high degree of confidence. Of course, some effects are inevitable, but based on the evidence it is not considered plausible that indirect effects are likely to create unacceptable impacts. Nevertheless a recommendation was made that possible effects on Weddell seal and TCKW be considered a suitable focus for further research. There is, nevertheless, no indication that effects on Weddell seals or Orcas are at any level that would cause the 'serious or irreversible harm' to the ecosystem addressed by this PI and so the score of 100 would not be changed by this consideration.

PI 2.5.2 **Measures in place to ensure fishery does not pose a risk to ecosystem structure and function**	1, 2	The ultimate justification stated for giving PI 2.5.2 a 100 score suggested that CCAMLR's management strategy manages for fishery effects on all components of the ecosystem. While CCAMLR strives to do so, the lack of uncertainty about the role of toothfish in the ecosystem (as described above) makes this impossible. Further, while the krill fishery does in fact have specific provisions for monitoring the effects on predators (e.g., through the CCAMLR Ecosystem Monitoring Program or CEMP) no such program exists for the toothfish fishery. Acoura Team response: In MSC assessments, ecosystem components are retained species, bycatch species, ETP species and habitats. As discussed under each relevant PI, there are management strategies in place to address each of these components. There is undoubtedly uncertainty around the functioning of the Ross Sea ecosystem, this has not prevented CCAMLR instituting a management strategy relevant to each of these components, nor monitoring the status of the ecosystem, including top predators. The allocated score is therefore still considered to be appropriate.

PI 2.5.3 **There is adequate knowledge of the impacts of the fishery on the ecosystem**	1	See above comments for PI 2.5.1, which would strongly apply here as evidence of there NOT being adequate knowledge of the impacts of the fishery on the ecosystem. Also, strangely, PI 2.5.3 references the CCAMLR CEMP program as one of its justifications for the 100 score, even though there is no CEMP for toothfish. Attempts to establish fishery reference areas that would seek to measure the impacts of the fishery on the ecosystem (via a Ross Sea marine protected area) have yet to be adopted by CCAMLR. Further, previous Ross Sea toothfish MSC assessment included a condition for closed areas. This condition is still relevant as there has been no final determination of the shape and coverage of a Ross Sea MPA. In addition, there are no MPAs being considered for the Amundsen Sea part of 88.2 (C to G). Further, two recommendations in relation to principles 2 on page 41 are supported: A risk assessment of skates; and Effects of toothfish distribution on foraging success of weddell seals and type C killer whales. The effect of abundance as well as distribution should be included in the recommendation for action. Both these recommendation indicate that P2.5.3 on adequate knowledge of impacts of the fishery on the ecosystem cannot be scored as 100. Acoura Team response: The SG100 requirements for this PI are not predicated on perfect knowledge of the ecosystem. Instead, the requirements are such as "Main interactions between the fishery and these ecosystem elements can be inferred from existing information, and have been investigated" and "Sufficient information is available on the impacts of the fishery on the Components and elements to allow the main consequences for the ecosystem to be inferred" (my emphasis). The thrust of these scoring guideposts is that potential sources of impact have been considered, identified and investigated such as to allow some conclusions to be inferred. This is clearly the case for this fishery and the team had no reservations in awarding a score of 100 for this PI. CEMP provides part of the data resource available to CCAMLR. A condition was raised previously on MPAs as this was a specific component of the assessment tree used in the original MSC assessment. This re-assessment was undertaken using the default assessment tree of CR v1.3 which does not have this specific requirement. Instead, all management measures relevant to habitats (PI 2.4.2) are considered in the round. We welcome support of the two recommendations and commend the suggestion of monitoring abundance as well as distribution. However, it should be remembered that these recommendations are to provide greater confidence in respect to some specific species – skates, Weddell seals and Orca (elements) within two ecosystem components (bycatch species and ETP species). None of these scored below 80 and these do not compromise there being adequate knowledge of the impacts of the fishery on the ecosystem for PI 2.5.3. The allocated score for this PI is therefore still considered to be appropriate.

PI 3.1.1	1, 2	88.2A and B are managed in the assessment as part of 88.1 but are currently managed for CCAMLR purposes as part of 88.2. This leads to problems and confusion over the application of conservation measures, how catch limits apply to both areas, and how enforceable are any research regime for these areas. This is relevant for a number of P3 criteria and there should be a condition to resolve the management arrangements between these two areas. Acoura Team response: PI 3.1.1 addresses the following: The management system exists within an appropriate legal and/or customary framework which ensures that it: • Is capable of delivering sustainable fisheries in accordance with MSC Principles 1 and 2; and • Observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and • Incorporates an appropriate dispute resolution framework. The assessment team notes the concerns raised regarding the spatial approach to the stock assessment of toothfish and the application of management actions under the CCAMLR system. The focus in PI 3.1.1 is on how the management system is supported by the legal and customary framework, and whether that framework is adequate to underpin the delivery of sustainable fisheries outcomes. The focus is not on the quality of that advice and confidence with which it can be considered to deliver sustainable fisheries outcomes. Obviously these considerations are of critical importance however, and they are dealt with under P1 and P2 PIs such as (but not limited to) PIs 1.2.1, 1.2.2, 1.2.4 and PI 2.1.3, 2.2.1, 2.2.2. As described in its report, the assessment team considers that the legal framework within which the management systems sits is broadly capable of delivering sustainable fisheries outcomes in accordance with MSC Principles 1 and 2. For example, at a high level the objective of the CAMLR Convention provides for sustainable fisheries outcomes (more specifically, it requires “the conservation of Antarctic marine living resources”, where “conservation” includes rational use). At a more operational level, the schedule of legally binding conservation measures in force for 2014/15 identifies which areas the various measures apply to, including distinguishing the application of measures applying to 88.1 and 88.2. Where research activities are defined in conservation measures, the ability to enforce them is analogous to the implementation of other conservation measures. Enforcement is considered specifically under PI 3.2.3 regarding monitoring, control and surveillance (MCS) overall. In its evaluation of the MCS approaches used in the fishery, the team finds both strengths and some weaknesses, as described in the report. The team does not consider that a change in scoring leading to a condition is necessary regarding the management arrangements between 88.1 and 88.2 in this PI or elsewhere under P3. The legal framework in which the management system is couched does not appear to be inadequate and is, in the team’s view, competent to deliver outcomes in accordance with MSC Principles 1 and 2.

PI 3.1.4	1, 2	CCAMLR's current management rules do not allow allocation of catch (e.g., catch shares) and thus the Olympic Style fishery in the Ross Sea faces increasing issues of capacity, as acknowledged by CCAMLR over the last many years (see reports of the annual CCAMLR meetings in 2011, 2012, 2013, 2014, 2015). At the 2015 meeting of CCAMLR's Scientific Committee, it noted that "there was the potential for large overruns in SSRUs with small catch limits if all the vessels entered the fishery at once (para 3.177)." Further during this last fishing season (2014/15), some of the subareas in the Ross Sea (88.1 B, C and G) were closed within one week of the start of fishing, further emphasizing the risk of overruns (see. WG-FSA 2015, para 3.10). Acoura Team response: PI 3.1.4 considers the following: The management system provides economic and social incentives for sustainable fishing and does not operate with subsidies that contribute to unsustainable fishing. The concern raised relates to the Olympic nature of the fishery and the potential for overruns on catch limits. The assessment team concurs that the potential for overruns still exists especially where catch limits are low and notes in its report that the enforcement of catch limits is central to achieving outcomes consistent with MSC Principles 1 and 2. Subsidies are not in place to exacerbate this situation. However, the team considers that the potential for overruns in catch necessitates careful ongoing monitoring and management. Overall, the assessment team considers that while some incentives are in place that are consistent with achieving sustainable fisheries outcomes, incentives do not appear to have been considered explicitly in regular reviews of management policy. The second proposed review of CCAMLR performance provides a natural opportunity to do this. If considered appropriate by the CAMLR Commission, assessing incentives for not exceeding catch limits could be included in that review. No changes in scoring are considered necessary.

Comment	Nature of Comment	Justification Please attach additional pages if necessary.
☐ I wish to comment on the adequacy of the consultation process used to gather information about this fishery (e.g. related to the RBF process, selection of stakeholders consulted, etc.).		
Comment	**Nature of Comment**	**Justification** Please attach additional pages if necessary.
☒ I wish to comment on other portions of the report (e.g. background information, species biology, peer review reports and CAB responses, list of consultees, etc.).	4: Needing clarity around gear and vessel certification	The MSC certification for the Ross Sea Toothfish Longline Fishery is specifically for bottom set longline of Spanish or autolines (section 3.1, Unit of Certification table). The vessel Tronio has applied at each CCAMLR meeting to use Trot Lines – which is a different type of gear (see CCAMLR Report for applications by Spain for this vessel since 2012, including 2015). Trot-lines, which used baskets of hooks, have a lower rate of catching fish in a condition which is suitable for tagging (see SC-CAMLR 2011 Report, para 9.28). The certification should be clear on the use of gear and ensure that vessels only use that gear when fishing in 88.1 and 88.2. If this is not the case then either the certification should be rejected or a corrective action should be raised to ensure that the unit of certification is actually what has been applied for. Acoura Team response: Trot lines are sometimes used by Tronio – this is a variation of the Spanish system and this does catch less fish in a condition suitable for release. However, the requirements to release the same proportion of tagged fish in an appropriate and specified condition remain. Tronio has released the required numbers of fish in the required condition and so the use of Trot lines has not affected the contribution of this vessel to the overall tagging programme.
Comment	**Nature of Comment**	**Justification** Please attach additional pages if necessary.

☒ I wish to comment on other portions of the report (e.g. background information, species biology, peer review reports and CAB responses, list of consultees, etc.).	4: Issues around by-catch management	The different reporting rates of bycatch between different vessels has been noticed for several years. This was emphasized in the latest WG-FSA assessment (see 2015 WG-FSA report, para 8.2-8.8), which indicated that vessels reported by-catch rates were inconsistent with observer reported rates (with the later under-reporting 50%). This raises a serious question on bycatch management and reporting in the fishery. It also questions the decision to remove this as an assessment condition (5) in 2011 surveillance audit (pages 32 and 33 of draft report). Acoura Team response: CCAMLR have determined that member states have indeed been employing different reporting procedures for bycatch. We understand that this is now being standardised. The Client Group vessels have been recording all bycatch, which is now to be the standard. The client group data has been that used in this assessment.

Comment	**Nature of Comment**	**Justification** Please attach additional pages if necessary.
☒ I wish to comment on other portions of the report (e.g. background information, species biology, peer review reports and CAB responses, list of consultees, etc.).	4: Issues around tagging rates	The no-tagging of small fish is in contravention of conservation measures requiring that all fish released should be tagged. This issue was raised last year by Ukraine (2014 Commission report, para 7.22): *The Commission considered the Scientific Committee's advice to SCIC regarding the reported release of small untagged toothfish in exploratory fisheries (SC-CAMLR-XXXIII, paragraph 12.1 and Annex 7, paragraph 5.42). Some Members noted that this was already prohibited under existing conservation measures. The Commission requested that the Scientific Committee and its working groups further consider this issue in 2015 and provide advice on the extent of this practice and whether all small-sized toothfish should be tagged and released alive, with a view of clarifying conservation measures if required.* This issue was raised in stakeholder meetings but is not covered in the assessment. An analysis carried out by CCAMLR this year showed it was Norwegian vessels that had the largest release of small fish that had not been tagged. The Norwegian vessel Seljevaer had the lowest tagging rate per tonnes of toothfish in the fishery in 2014. Given that stock assessments are based entirely on the Ross Sea toothfish tagging program, it is essential that vessels comply with CCAMLR tagging rules. Acoura Team response: Tagging is carried out in proportion to catch and tagging requirements have been achieved. Above this, some vessels (notably Norwegian) have apparently also released (alive) small toothfish of little commercial value and with a high expectation of survival, based on a misunderstanding of CCAMLR requirements (specifically Footnote 4 of CM26-01 2009). Numbers are apparently in the order of 12-15 individuals per vessel (around 12 kg) – a very small fraction of the total catches (J Fenaughty pers. comm.). It is understood that this CM has now been clarified such that fish cannot be returned to the sea unless tagged (CM 41-01 para 2)
Comment	**Nature of Comment**	**Justification** Please attach additional pages if necessary.

☒ I wish to comment on other portions of the report (e.g. background information, species biology, peer review reports and CAB responses, list of consultees, etc.).	4: Dumping of Offal	CCAMLR Conservation Measures 41-09 and 41-10 (for 88.1 and 88.l2 respectively) ban the dumping of offal. As noted in the 2014 New Zealand Plenary Report on Toothfish: "Discarding in the CAMLR Convention area is illegal. However, observers and crew on some New Zealand vessels have reported indirect evidence of discarding by other (unknown) vessels, e.g. the presence of toothfish offal in sampled toothfish stomachs, and in the 2012 and 2013 seasons some vessels acknowledged illegal discard practices after being boarded and inspected by New Zealand fisheries officers from naval patrol vessels." It is unclear which vessels have been dumping offal but concern has been raised in stakeholder meetings to ensure all the vessels operating have sufficient hold capacity to retain offal. This non-compliance should be acknowledged and addressed by the CAB in the reassessment of toothfish. Acoura Team response: The CCAMLR requirements on the dumping of offal are principally as a seabird mitigation measure – and so of much less consequence for the Ross Sea than elsewhere in the CCAMLR area. Nevertheless, we note that discarding has been reported by members of the Client Group who will continue to record this and provide evidence to authorities of further incidences (J Fenaughty pers. comm.). Any incidences attributed to Client Group members will be addressed if and when identified.

Comment	**Nature of Comment**	**Justification** Please attach additional pages if necessary.
☒ I wish to provide general comments about the assessment of this fishery against the MSC Fisheries Standard.	1, 2, 3 and 4: overall disapproval	While ASOC applauds the efforts of the Ross Sea toothfish fishers to continue gathering more life history and ecosystem information about the Ross Sea toothfish, we strongly disagree with the overall assessment and scoring of this fishery, as indicated above. The major gaps in the life history and ecosystem knowledge are not adequately filled by the many models and assumptions under which the toothfish stock is managed. We highly recommend that the CAB reconsider the performance indicator scoring, based on our points above and reconsider the overall high score and positive assessment for the Ross Sea Toothfish Longline Fishery. Acoura Team response: The overall views of the assessment team, reflected above, are that whilst there are continuing gaps in the information base for the fishery, the development of the fishery continues to be sufficiently precautionary for these to be acceptable in relation to the requirements of the MSC standard. No changes in scoring are therefore considered necessary.

REFERENCES CITED

Ainley, D.G., J.T. Eastman and C.M. Brooks. In Review. Comments on “The Antarctic toothfish (*Dissostichus mawsoni*): biology, ecology and life history in the Ross Sea region,"

Ainley, D. G., M. A. Larue, I. Stirling, S. Stammerjohn, and D. B. Siniff. 2015. An apparent population decrease, or change in distribution, of Weddell seals along the Victoria Land coast. Marine Mammal Science, 31(4): 1338-1361.

Ainley, D. G., N. Nur, J. T. Eastman, G. Ballard, C. L. Parkinson, C. W. Evans & A. L. DeVries, 2013. Decadal trends in abundance, size and condition of Antarctic toothfish in McMurdo Sound, Antarctica, 1972–2011. Fish and Fisheries 14: 343–363.

Ainley, D.G. & G. Ballard. 2012. Trophic interactions and populations trends of killer whales (*Orcinus orca*) in the Southern Ross Sea. Aquatic Mammals 38: 153-160.

Ainley, D.G., G. Ballard & S. Olmastroni. 2009. An apparent decrease in the prevalence of “Ross Sea Killer Whales” in the Southern Ross Sea. Aquatic Mammals 35(3): 335-347.

Ainley, D.G. & D.B. Siniff, 2009. The importance of Antarctic toothfish as prey of Weddell Seals in the Ross Sea: A Review. Antarctic Science 21: 317-327.

Burns, J.M., S.J. Trumble, M.A. Castellini, and J.W. Testa. 1998. The diet of Weddell seals in McMurdo Sound, Antarctica as determined from scat collection and stable isotope analysis. Polar Biology 19: 272-282.

Eastman, J., 1985. *Pleuragramma antarcticum* (Pisces, Nototheniidae) as food for other fishes in McMurdo Sound, Antarctica. Polar Biology 4:155-160.

Eisert, R. 2003. Energy Metabolism of Weddell Seals (*Leptonychotes weddelli*) During the Lactation Period. PhD dissertation, Lincoln University, Christchurch, New Zealand.

Fenaughty, J. M., J. T. Eastman & B. D. Sidell, 2008. Biological implications of low condition factor ‘‘axe handle’’ specimens of the Antarctic toothfish, *Dissostichus mawsoni*, from the Ross Sea. Antarctic Science 20: 537–551.

Goetz, K. T. 2015. Movement, habitat, and foraging behavior of Weddell Seals (Leptonychotes weddellii) in the Western Ross Sea, Antarctica. PhD dissertation. University of California, Santa Cruz.

Hanchet, S. M., G. J. Rickard, J. M. Fenaughty, A. Dunn & M. J. Williams, 2008. A hypothetical life cycle for Antarctic toothfish *Dissostichus mawsoni* in Antarctic waters of CCAMLR Statistical Area 88. CCAMLR Science 15: 35–54.

Hanchet, S., A. Dunn, S. Parker. P. Horn. D. Stevens & S. Mormede, 2015. The Antarctic toothfish (*Dissostichus mawsoni*): biology, ecology, and life history in the Ross Sea region. Hydrobiologia DOI 10.1007/s10750-015-2435-6

LaRue, M. A., J. J. Rotella, R. A. Garrott, D. B. Siniff, D. G. Ainley, G. E. Stauffer, C. C. Porter, and P. J. Morin. 2011. Satellite imagery can be used to detect variation in abundance of Weddell seals (*Leptonychotes weddellii*) in Erebus Bay, Antarctica. Polar Biology 34: 1727-1737.

Lenky, C., R. Eisert, O. T. Oftedal & V. Metcalf, 2012. Proximate composition and energy density of nototheniid and myctophid fish in McMurdo Sound and the Ross Sea, Antarctica. Polar Biology 35: 717–724.

Lyver, P.O.; Barron, M.; Barton, K.J.; Ainley, D.G.; Pollard, A.; Gordon, S.; McNeill, S.; Ballard, G.; Wilson, P.R. (2014) Trends in the Breeding Population of Adélie Penguins in the Ross
Sea, 1981–2012: A Coincidence of Climate and Resource Extraction Effects. PLoS ONE 9(3): e91188.

Pinkerton, M.H., J.M. Bradford-Grieve & S.M. Hanchet. 2010. A balanced model fot eh food web of the Ross Sea, Antarctica. CCAMLR Science 17: 1-31.

Pitman, R.L. & P. Ensor. 2003. Three different forms of killer whales in Antarctic waters. Journal of Cetacean Research and Management 5: 131-139.

14 APPENDIX 4. SURVEILLANCE FREQUENCY

(REQUIRED FOR THE PCR ONLY)

Note: to avoid conflict with CCAMLR meetings, it is currently planned that surveillances take place in August in New Zealand and September in UK/Europe.

Table 5: Surveillance Score for the Fishery

Criteria	Surveillance Score	Insert Fishery Name & score below
1. Default Assessment Tree		
Yes	0	
No	2	
2. Number of Conditions		
Zero Conditions	0	
1-5 Conditions	1	
>5 Conditions	2	
3. Principle Level Scores		
≥ 85	0	
<85	2	
4. Conditions on outcome PIs?		
Yes	2	
No	0	

Table 6: MSC Fishery Surveillance levels

			Years after certification or re-certification			
Surveillance score	**Surveillance level**		**Year 1**	**Year 2**	**Year 3**	**Year 4**
2 or more	Normal surveillance		On-site surveillance audit	On-site surveillance audit	On-site surveillance audit	On-site surveillance audit & recertification visit
1	Remote surveillance	Option 1	Off-site surveillance audit	On-site surveillance audit	Off-site surveillance audit	On-site surveillance audit & recertification visit
		Option 2	On-site surveillance audit	Off-site surveillance audit	On-site surveillance audit	
0	Reduced surveillance		Review new information	On-site surveillance audit	Review new information	On-site surveillance audit & recertification visit

Table 7: Fishery Surveillance Plan

Score from CR Table C3	Surveillance Category	Year 1	Year 2	Year 3	Year 4
[e.g. 2 or more]	[e.g Normal Surveillance]	[e.g. On-site surveillance audit]	[e.g. On-site surveillance audit]	[e.g. On-site surveillance audit]	[e.g. On-site surveillance audit & recertification site visit]

15 APPENDIX 5. CLIENT AGREEMENT

(REQUIRED FOR PCR)

The report shall include confirmation from the CAB that the Client has accepted the PCR. This may be a statement from the CAB, or a signature or statement from the client.

(Reference: CR: 27.19.2)

16 APPENDIX 6 OBJECTIONS PROCESS

(REQUIRED FOR THE PCR IN ASSESSMENTS WHERE AN OBJECTION WAS RAISED AND ACCEPTED BY AN INDEPENDENT ADJUDICATOR)

The report shall include all written decisions arising from an objection.

17 APPENDIX 7 BIBLIOGRAPHIES

Appendix 7.1 References supporting the Ross Sea Antarctic Toothfish Fishery MSC Certification/Recertification

During the annual surveillance meeting for the Ross Sea toothfish MSC client group, Silvifish Resources Ltd as Client Group Coordinators committed to supplying a full list of relevant papers used for either the present certification or which will provide a basis to support recertification. Target date was agreed as 15th of January 2015 with references to be provided electronically and sent to Jo Akroyd for distribution to the eNGO community who had raised this issue.

Caveats

- Inclusion of a paper does not necessarily indicate agreement with the research carried out or the conclusions of the authors. In a number of cases supplementary papers by the same or other authors have provided different and/or contrary findings. However such papers are included to provide context to scientific conclusions used to support the certification/recertification.
- All attempts have been made to include all papers or relevant information used either for the initial certification, during annual surveillance meetings of the Ross Sea Toothfish certification, and which may provide a basis for the upcoming recertification. There may however be other information which will come to light and will be used for recertification. In such cases an updated list of any new references will be provided before 2015 meetings.

Author Index

(Norman, 1937; Gon & Heemstra, 1990; K.-H. Kock, 1992; A. J. Constable & de la Mare, 1996; Schulz
& Stattegger, 1997; D.J. Agnew, 2000; A. J. Constable *et al.*, 2000; A.J. Constable, 2002; Horn, 2002;
J.M. Fenaughty *et al.*, 2003; Horn *et al.*, 2003; Dam & Kooyman, 2004; P.J. *et al.*, 2004; S.L Ballara & O'Driscoll, 2005; M. Francis & Ó Maolagáin, 2005; Hanchet *et al.*, 2005; Marriott *et al.*, 2005; R.L
O'Driscoll, 2005; R.L. O'Driscoll *et al.*, 2005; Phillips *et al.*, 2005; A.F.Petrov, 2006; D.J. Agnew *et al.*, 2006; D. Ainley *et al.*, 2006; D. G. Ainley *et al.*, 2006; S. L. Ballara *et al.*, 2006; Dunn *et al.*, 2006; J. M.
Fenaughty, 2006; M. P. Francis, 2006; Hanchet, 2006; Hanchet *et al.*, 2006; P.J. *et al.*, 2006; Stevens,
2006; D. Ainley, 2007; Dunn, Ballara*, et al.*, 2007; Dunn, Hanchet*, et al.*, 2007; S.M. Hanchet *et al.*,
2007; S. M. Hanchet *et al.*, 2007; K. H. Kock *et al.*, 2007; Lodge *et al.*, 2007; McMillan *et al.*, 2007;
Mormede *et al.*, 2007; Naganobu, 2007; M. Pinkerton *et al.*, 2007; M. H. Pinkerton, A. Dunn*, et al.*,

2007; M. H. Pinkerton, S. M. Hanchet, *et al.*, 2007; Ponganis & Stockard, 2007; Smith *et al.*, 2007;
Southwell *et al.*, 2007; D. J. Agnew, 2008; Bury *et al.*, 2008; Delegation of New Zealand, 2008; Dunn
& Rasmussen, 2008; Fenaughty JM, 2008; Hanchet, Fu, *et al.*, 2008; Hanchet, Stevenson, *et al.*, 2008;
Kohen, 2008; M.H. Pinkerton, 2008; Middleton & Dunn, 2008; Mormede, 2008; Mormede *et al.*,
2008; M.H. Pinkerton *et al.*, 2008; B. Sharp *et al.*, 2008; D. G. Ainley & Siniff, 2009; A. Dunn *et al.*, 2009; A Dunn *et al.*, 2009; Hanchet *et al.*, 2009; Middleton & Dunn, 2009; M. Pinkerton *et al.*, 2009;
2010, 2010; D.M Tracey, 2010; Dunn *et al.*, 2010; M. P. Francis, 2010; Hilborn, 2010; Horn & Sutton,
2010b, 2010a; Middleton, 2010; Mormede & Dunn, 2010; Parker S., 2010; S. J. a. M. H. S. Parker,
2010; M.H. Pinkerton *et al.*, 2010; R.G. Cole and S.M. Hanchet S.J. Parker, 2010; R.G. Cole and S.M.
Hanchet S.J. Parker, 2010; B. R. Sharp, 2010b, 2010a; B. R. Sharp, S.J. Parker, M.H. Pinkerton, B.B.
Breen, V. Cummings, A. Dunn , S.M. Grant, S.M. Hanchet, H.J.R. Keys, S.J. Lockhart, P. O'B. Lyver, R.L. O'Driscoll, M.J.M. Williams, P.R. Wilson 2010; B. R. a. P. S. J. Sharp, 2010; Brooks *et al.*, 2011; Dunn *et al.*, 2011; J.M. Fenaughty & Brown, 2011; R. I. C. C. Francis, 2011; S. M. Hanchet *et al.*, 2011; S.M. Hanchet *et al.*, 2011; B. R. Sharp & Watters, 2011; D. G. Ainley & Ballard, 2012; D. G. Ainley *et al.*,
2012; Ashford *et al.*, 2012; Bowden *et al.*, 2012; Bruyn *et al.*, 2012; Dunn *et al.*, 2012; Hanchet, Mormede, Parker, & Dunn, 2012; Hanchet, Mormede, Parker, Dunn, *et al.*, 2012; Mormede & Dunn, 2012a, 2012c, 2012b; Mormede *et al.*, 2012; S. Parker, 2012; S. Parker, Fenaughty, *et al.*, 2012; S.
Parker, McMillan, *et al.*, 2012; S. Parker & Mormede, 2012; S. J. Parker & Marriott, 2012; M.H. Pinkerton & Bradford-Grieve, 2012; M.H. Pinkerton, Forman, *et al.*, 2012; M.H. Pinkerton, McMillan, *et al.*, 2012; M.H Pinkerton & Sharp, 2012; B. R. Sharp & Ollivier, 2012; Stevens *et al.*, 2012; M. L.
Stevenson *et al.*, 2012; Sutton *et al.*, 2012; Thompson *et al.*, 2012; D. o. N. Z. a. t. USA, 2012; Webber
& Parker, 2012; Yeon *et al.*, 2012; Zaytsev, 2012; N. Zealand, 2012; Eisert *et al.*, 2013; Hanchet,
Mormede, *et al.*, 2013; Hanchet, Sharp, *et al.*, 2013; Jo *et al.*, 2013; Mormede, 2013a, 2013b;
Mormede & Dunn, 2013; Mormede, Dunn, *et al.*, 2013b, 2013a; Mormede, Dunn, Parker, *et al.*,
2013; Mormede & Thanassekos, 2013; S. J. Parker, Dunn, *et al.*, 2013; S. J. Parker, Hanchet, Mormede, & Dunn, 2013; S. J. Parker, Hanchet, Mormede, Dunn, *et al.*, 2013; Secretariat, 2013; D. o. t. USA & Zealand, 2013; Yeon *et al.*, 2013; D. o. N. Zealand & USA, 2013a, 2013b; Norway and the United Kindgom; Delegations of New Zealand, 2014; Norway and the United Kindgom Delegations of
New Zealand, 2014; Hanchet & Parker, 2014; Hanchet *et al.*, 2014; Ladroit *et al.*, 2014; Mangel *et al.*,
2014; McClure & Reid, 2014; Mormede, Dunn, *et al.*, 2014a, 2014b; Mormede, Parker, *et al.*, 2014; Mormede, Pinkerton, *et al.*, 2014; S. J. Parker, Hoyle, *et al.*, 2014; S. J. Parker & Mormede, 2014; S. J.
Parker, Petrov, *et al.*, 2014; S. J. Parker, Webber, *et al.*, 2014; M.H. Pinkerton *et al.*, 2014; Robinson
& Reid, 2014; Secretariat, 2014; C. Secretariat, 2014; M. J. Stevenson *et al.*, 2014)

References

2010, WG-FSA Subgroup on VMEs. (2010) **Report on bottom fisheries and vulnerable marine ecosystems: draft template and workplan**. CCAMLR, Hobart, Australia.
WG-EMM-10/15.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: The WG-FSA Subgroup on VMEs was tasked with providing a draft template of a Report on Vulnerable Marine Ecosystems to WG-EMM and WG-FSA in 2010. This paper provides a draft template, including the workplan and discussion. It has been compiled by the Subgroup for consideration at WG-EMM in 2010. The structure aims to follow the logic of the fishery reports already provided by WG-FSA: (i) Status of the fisheries, (ii) Knowledge on the fish stocks, (iii) Methods, (iv) Assessments of status and future catch limits, (v) Other Issues, and (vi) Advice. These topics have been tailored to suit the issue of VMEs, resulting in the following structure to replicate that approach: (i) Details of Bottom Fisheries, (ii) Details of Vulnerable Marine Ecosystems, (iii)
Assessments of VME Impacts, (iv) Management Strategies to conserve VMEs, and (v) Management Advice. The long lists of tasks currently before the Scientific Committee and its working groups have been embedded within this structure in order to give them a greater context than as the lists from our reports. This should help each working group prioritise the future work and identify the key methods, parameters or field strategies that need to be undertaken. Discussions to date would suggest that the report be routinely update each year in WG-FSA but with input from WG-SAM on the development of assessment and evaluation methods, and from WG-EMM on consideration of the objectives for VMEs and their ecology would occur in WG-EMM. The assessments and advice would arise from WG-FSA. It is envisaged that, following comments by WG-EMM, a draft report will be generated as far as possible for consideration by WG-FSA later in the year.

A.F.Petrov. (2006) **A case of giant squid attack on Antarctic toothfish *Dissostichus mawsoni* norman, 1937 (perciformes, nototheniidae) caught on bottom-set longline in the ross sea**. CCAMLR, Hobart, Australia.
WG-FSA-06/P3 Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: In the beginning of February 2005, during the hauling of bottom-set longline in the Ross Sea (East Antarctic) from the depth of 1480 m to the surface a very large squid taken a large individual of Antarctic toothfish *D. mawsoni* (Norman, 1937) with a size of 160 cm and weight of 58 kg caught by a longline hook, was hauled up to the board of longliner VOLNA. Squid was very active and did not release its prey until under command of fish master it was beaten off by gaffs. Squid was not lifted aboard but it was registered with the use of photo-and video cameras. This allowed to determine its species belonging and size. On the opinion of the most competent specialist on squids in the Southern Hemisphere Yu.A. Philipova and our comparative observations this was giant squid *Mesonychoteuthis hamiltoni* 1925).

Agnew, D. J. (2008) **Analysis of Ross Sea tagging and recapture rates**. CCAMLR, Hobart, Australia.
WG-SAM-08/7.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: 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, forinclusion in the Ross Sea stock assessment.

Agnew, D.J. (2000) **The illegal and unregulated fishery for toothfish in the Southern Ocean, and the**
CCAMLR catch documentation scheme. *Marine Policy,* 24, Pages 361–374
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: Fishing for toothfish in Antarctic waters started in the 1980s. Large amounts of illegal and unregulated fishing were observed in the mid-1990s, reaching 4 times the regulated catch in 1997. The Commission for the Conservation of Antarctic Marine Living Resources has adopted a number of Conservation Measures to control this illegal fishing. The Catch Document Scheme, adopted in 1999, which aims to reduce unregulated fishing through trade-related measures, is described in detail.

Agnew, D.J. , J. Moir Clark, P.A. McCarthy, M. Unwin, M. Ward, L. Jones, G. Breedt, S. Du Plessis,
J. Van Heerdon & G. Moreno. (2006) **A study of Patagonian Toothfish (*Dissostichus eleginoides*) posttagging survivorship in Subarea 48.3**. *CCAMLR Science,* 13, 279□289.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: During the 2005 fishing season, experiments on the survivorship of toothfish following tagging were carried out on eight different vessels fishing in Subarea 48.3. Toothfish were kept in tanks with seawater replacement for at least 12 hours after tagging. On one vessel, fish with a variety of injuries were selected to see if this affected recovery. In the final analysis, 396 animals were included, with an overall survivorship of 90%. Smaller animals and animals in better initial condition had a higher survivorship than large animals and those in poor condition. The results suggest that experienced observers using animals in good condition would normally achieve a toothfish post-tagging survivorship of 95% or more. An assumption of 90% post-tagging survivorship is a conservative value which might be appropriate to use in population estimators until further survivorship studies have confirmed the 95% rate.

Ainley, D. (2007) **Insights from the study of the last intact neritic marine ecosystem**. CCAMLR, Hobart, Australia.
WG-EMM-07/P3 Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the
Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Frank, K.T. et al. (2007: Trends Ecol. Evol. 22, 236-242) provide interesting analysis, after compiling information from 19 subregions, on how the exploited shelf ecosystems of the North Atlantic are structured, either by predation (top down) or resource availability (bottom up), depending on their biodiversity and climate (cold vs warm). By the ecological ‘rules’ laid out, the Ross Sea should be structured by predation. Analysis has shown, however, that some portions of the Ross Sea follow the rules but others do not. This is apparent, though, only because the Ross Sea, unlike the remaining Southern Ocean and other portions of the World Ocean, remains at least for now, intact. If its whales, flightless seabirds, seals and large predatory fish had been severely reduced, as in the North Atlantic, bottom-up structuring likely would prevail.
Ainley, D., V. Toniolo, G. Ballard, K. Barton, J. Eastman, B. Karl, S. Focardi, G. Kooyma, P. Lyver, S. Olmastroni, B.S. Stewart, J.W. Testa & P. Wilson. (2006) **Managing ecosystem uncertainty: critical habitat and dietary overlap of top predators in the Ross Sea**. CCAMLR, Hobart, Australia.
WG-EMM-06/29 Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)

ABSTRACT: We summarize three types of data in order to increase appreciation among fishery managers of the close spatial and temporal ecological overlaps among top predators in the Ross Sea Shelf Ecosystem (RSShE). This includes data on diet, foraging behavior, and habitat use. Murphy (1995) demonstrated that space-time overlap is critical to predicting the degree to which a fishery might affect a food web. The fisheries that we contemplate are those for Antarctic toothfish and the Antarctic minke whale, though other species might also soon be exploited in the Ross Sea region. In addition to those two predators we also include other trophic competitors and (and in two cases predatory species): killer whale (type C), Weddell seal, Emperor penguin, Adélie penguin, and 4 species of flighted birds. Using data from satellite tags attached to top predators that occur at colonies and haul outs along the coast of Victoria Land from 1990 through 2004, we summarize the foraging ranges from these sites and the habitats used for foraging. We also summarize data on diet and overlaps in foraging behavior among these predators from analyses of scats and stomach contents and time-depth-recorders collected from 1976 through 2002. Finally, we present results of ship-based surveys of birds and cetaceans made from 1976 through 1981. Though many of those species have not yet been studied using satellite telemetry, their diets have been investigated. Most top predators in the Ross Sea feed at relatively great depths, perhaps because this affords them access to waters under sea ice, which persists in this region except for late summer. Three of them are able to exploit the entire water column of the shelf, with others foraging from near surface to mid-depths. The major geographic habitats used include waters that are or were part of the marginal ice zone that rings the Ross Sea Polynya during spring and summer when primary production is in full swing. Waters over shallow banks, especially in the western region, also appear to be important habitats. Even for colonies of these predators that are near the shelfbreak, their foraging efforts appear to be restricted to waters overlying the upper slope and shelf although deeper waters are well within range. In the RSShE, the main prey species eaten by most of the listed predators is the Antarctic silverfish, which is a major predator of ice krill. Based on frequency of occurrence in the diet, the prevalence of silverfish among diving predators averages 70% (range 4595%) and among near-to-surface predators averages 31% (range 4-53%). The other main prey species of RSShE top predators is ice krill. Antarctic krill replaces ice krill in the predators' diets over the Ross Sea continental slope and outer shelf waters. The key, and perhaps critical, foraging habitats of the seals and penguins from the colonies and haul-outs studied so far along the Victoria Land coast occur almost entirely within CCAMLR statistical area SSRU 88.1J and the southern third of 88.1H, one of the main SSRUs for harvests of Antarctic toothfish. We make recommendations for research needs related to top predators, including further assessments of population size and diet (including studies of fatty acid composition) from autumn through early spring when sea ice is most extensive, and simultaneous tracking of toothfish and cetaceans, especially the toothfish-eating killer whale.

Ainley, D.G, G. Ballard & K. M. Dugger. (2006) **Competition among penguins and cetaceans reveals trophic cascades in the western Ross Sea, Antarctica**. *Ecology,* 87, 2080-2093.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: An apparent trophic cascade that appears during summer in the western Ross Sea, Antarctica, explains why the Antarctic silverfish (Pleuragramma antarcticum) there becomes cannibalistic; its principal prey, crystal krill (Euphausia crystallorophias) becomes scarce; and the diatom community is minimally grazed compared to adjacent areas. The krill is the major grazer of diatoms. On the basis of fieldwork at Ross Island, we suggest that the cascade results from foraging by unusually numerous Adélie Penguins (Pygoscelis adeliae), minke whales (Balaenoptera bonaerensis), and fish-eating killer whales (Orcinus orca). These species and other top predators apparently deplete the krill and silverfish. In drawing our conclusions, we were aided by two "natural experiments." In one "experiment," large, grounded icebergs altered the seasonal pattern of change in regional sea-ice cover, but not the seasonal change in penguin diet and foraging behavior that was also detected during the

pre-iceberg era. In the other "experiment," a short-term polynya (opening in the ice) brought penguins and whales together in a confined area, this time altering both penguin diet and foraging behavior. We conclude that the foraging of penguins and whales, and not a formerly hypothesized seasonal decrease in sea-ice cover, explains (1) the annual switch in the penguins' prey from krill to silverfish, (2) the subsequent lengthening of penguin foraging trips, and (3) a marked decline of cetaceans in the area later in the season. Reduction in the middle-trophiclevel prey is expressed in the relaxed grazing pressure on phytoplankton.

Ainley, D.G. & G. Ballard. (2012) **Trophic interactions and population trends of killer whales (*Orcinus orca*) in the Southern Ross Sea**. *Aquatic Mammals,* 38, 153-160.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: Foraging events and related trends in numbers of Type-B and -C killer whales (*Orcinus orca*) are reported for the vicinity of Ross Island, Ross Sea, Antarctica, between 2002 and 2010. Updating an earlier report, the frequency of sightings and the number of individuals per sighting of Ross Sea killer whales (Type-C; RSKWs), a fishing-eating ecotype, has continued to decrease in a pattern coincident with a decrease in the number and size of an important prey: Antarctic toothfish (*Dissostichus mawsoni*). Increasingly rare, large fish are much more energetically dense and may also be socially important to the whales, a relationship with potential parallels to that known between well-
studied fish-eating killer whales and large Chinook salmon (*Oncorhynchus tshawytscha*) in the northeast Pacific. In contrast, the prevalence of the larger, mammal-eating Type-B killer whales has not changed in the southern Ross Sea study area. Predation events by Type-B killer whales involving Weddell seals (*Leptonychotes weddellii*), interest in large penguins, such as emperors (*Aptenodytes forsteri*), and lack of interest in small penguins, such as Adélies (*Pygoscelis adeliae*), are presented. In the case of both killer whale forms, the progressive seasonal breakup of fast ice in large bays bordering the Ross Sea likely provides reliable, enhanced foraging opportunities as prey are exposed one area at a time during summer. Given the apparent relationship between RSKW prevalence and the availability of large toothfish, we speculate that the current management strategy of Antarctic toothfish in the Ross Sea region threatens current population levels of RSKW

Ainley, D.G., N. Nur, J.T. Eastman, G. Ballard, C.I. Parkinson, C.W. Evans & A.L. DeVries. (2012) **Decadal trends in abundance, size and condition of Antarctic toothfish in McMurdo Sound, Antarctica, 1972-2011**. *Fish and Fisheries,* DOI: 10.1111/j.1467-2979.2012.00474.x.
MSC Reference for the re-certification of the Ross Sea Toothfish Fishery 2015
ABSTRACT: We report the analyses of a dataset spanning 39 years of near-annual fishing for *Dissostichus mawsoni* in McMurdo Sound, Antarctica, 1972-2011. Data on total length, condition and catch per unit effort (CPUE) were derived from the > 5500 fish caught, the large majority of which were measured, tagged and released. Contrary to expectation, the length frequency of the McMurdo Sound catch was dominated by fish in the upper two-thirds of the overall distribution exhibited in the industrial catch for the Ross Sea shelf. Fish length and condition increased from the early 1970s to the early 1990s and then decreased. Fish length positively correlated with Ross Sea ice extent in early spring, a relationship possibly caused by more ice encouraging larger fish to move farther south over the shelf and into the study area. Fish condition positively correlated with the amount of open water in the Ross Sea during the previous summer (Feb), perhaps reflecting greater availability of prey with the higher productivity that more open water brings. Decreas-ing fish size corresponds to the onset of the fishery, which targets the large individuals. CPUE was constant through 2001 and then decreased dramatically. We hypothesize that this decrease is related to the industrial fishery, which began in the 1996-97 austral summer, and concentrates effort over the icefree Ross Sea continental slope. As a result of limited prey choices and close coupling among mesopredators of the region, Antarctic toothfish included, the fishery appears to be dramatically altering the trophic structure of the Ross Sea.

Ainley, D.G. & D.B. Siniff. (2009) **The importance of Antarctic toothfish as prey of Weddell seals in the Ross Sea**. *Antarctic Science,* 21, 317-327.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: Uncertainty exists over the importance of Antarctic toothfish (*Dissostichus* mawsoni) as prey of top predators in the Ross Sea. In this paper we assess relative weight given to direct, observational evidence of prey taken, as opposed to indirect evidence from scat and biochemical analysis, and conclude that toothfish are important to Weddell seals (Leptonychotes weddellii). The seals eat only the flesh of large toothfish and therefore they are not detected in scat or stomach samples; biochemical samples have been taken from seal sub-populations where toothfish seldom occur. Using direct observations of non-breeding seals away from breeding haulouts in McMurdo Sound, 0.8–1.3 toothfish were taken per day. Based on these and other data, the non-breeding portion of the McMurdo Sound seal population, during spring and summer, consume about 52 tonnes of toothfish. Too many unknowns exist to estimate the non-trivial amount consumed by breeders. We discuss why reduced toothfish availability to Weddell seals, for energetic reasons, cannot be compensated by a switch to silverfish (Pleuragramma antarcticum) or squid. The Ross Sea toothfish fishery should be reduced including greater spatial management, with monitoring of Weddell seal populations by CCAMLR. Otherwise, probable cascades will lead to dramatic changes in the populations of charismatic megafauna.
Ashford, J., M. Dinniman, C. Brooks, A. Andrews, E. Hofmann, G. Cailliet, C. Jones & N. Ramanna. (2012) **Does large-scale ocean circulation structure life history connectivity in Antarctic toothfish (*Dissostichus mawsoni*)?** *Canadian Journal of Fisheries and Aquatic Sciences,* 69, 1-17.
MSC Reference for Ross Sea Toothfish annual surveillance in 2012
ABSTRACT: A multi-disciplinary approach incorporating otolith chemistry, age data and numerical
Lagrangian particle simulations indicated a single, self-recruiting population of Antarctic toothfish (*Dissostichus mawsoni*) in the Southeast Pacific Basin (SPB) and Ross Sea, with a life history structured by the large-scale circulation. Chemistry deposited prior to capture along otolith edges demonstrated strong environmental heterogeneity, yet the chemistry in otolith nuclei, deposited during early life, showed no differences. Age data showed only adult fish in catches on the PacificAntarctic Ridge in the SPB; and structuring of life stages consistent with transport pathways from the northern Ross Sea. Lagrangian particle simulations predicted that early life stages following the flow in the SPB would be transported to areas in the Ross Sea where juveniles are caught; whereas, the circulation would facilitate adult movement along the shelf slope and back into the SPB where spawning adults are caught. These results suggest that: successfully spawning fish spend only a part of their adult life history in the Ross Sea; areas in the eastern Ross Sea contribute disproportionately to the spawning population; and areas in the southwestern Ross Sea may supply fisheries in the southern Indian Ocean.

Ballara, S. L., A. Dunn & M. P. Francis. (2006) **Summary of Ross Sea skate tagging programme results**, pp. 10. CCAMLR, Hobart, Australia.
WG-FSA-06/32.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Over 9,000 skates have been tagged and released in the Ross Sea over a period of seven years, and 47 (0.5%) have been recaptured. The recapture of tagged *Amblyraja georgiana* after up to four years at liberty shows that some skates survive and recover from being hauled out of depths of around 1,000 m and tagged. In-water tagging greatly reduces the incidence of broken jaws in skates, and probably increases the survival of released animals. Unfortunately, this means that length at release can not be determined, so no useful data were gathered for estimating skate growth rates. *Amblyraja georgiana* moved very little, even after four years at liberty. There was no movement between SSRUs, and the maximum distance travelled was less than 70 km. The distance travelled did not increase with period at liberty for skates at liberty more than nine months. It appears that this

species makes only small-scale movements along depth contours.

Ballara, S.L & R.L. O'Driscoll. (2005) **A review of rattail (*Macrourus* spp) and skate bycatch, and analysis of standardised CPUE, for the exploratory fishery in the Ross Sea (CCAMLR Subareas 88.1 & 88.2) from 1997/98 to 2004/05**, pp. 33. CCAMLR, Hobart, Australia.

WG-FSA-05/24.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)

ABSTRACT: A standardised CPUE analysis was used to determine factors affecting bycatch rates of rattails (*Macrourus* spp.) and skates in the exploratory fishery for toothfish in the Ross Sea (CCAMLR Subareas 88.1 & 88.2). The analysis was based on fine-scale haul-by-haul (C2) data and observer data from all vessels in the fishery from 1997/98 to 2004/05. The major factors influencing rattail bycatch were vessel, area, and depth. Catch rates of rattails were highest along the shelf edge (SSRUs 88.1E, 88.1I, 88.1K and 88.2E) in depths from 600 to 1000 m, and there was an order of magnitude difference in rattail catch rates between different vessels. Examination of vessel characteristics showed that catch rates of rattails were lower with the Spanish line system than with the autoline system. Russian and Korean vessels had extremely low catch rates compared to other vessels. Standardised CPUE of rattails has shown a general increasing trend since 1998/99, with a peak in 2002/03.

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

Bowden, D.A., S.M. Hanchet & P.M. Marriott. (2012) **Demersal fish communities in the Ross Sea region of Antarctica: comparisons between video and trawl survey methods**, pp. 21. CCAMLR, Hobart, Australia.

WG-FSA-12/51.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)

ABSTRACT: Reliable estimates of demersal fish community composition and population densities are essential for understanding the ecological effects of fisheries. Such estimates are conventionally derived from research trawl surveys but video techniques afford an alternative, or complementary, approach. Using data collected during a survey of demersal fish communities in the Ross Sea region of Antarctica, we compared measures of community composition, population density, and biomass derived from three sampling methods; a large demersal fish trawl, a beam trawl, and a towed camera system. Twenty-three sites spanning the continental shelf, northern continental slope, abyssal plain, and two seamounts were sampled using the towed camera and at least one of the trawl types, allowing direct comparisons between sampling methods. Patterns of species turnover between sites were similar across all methods. Estimates of fish population densities from the towed camera and beam trawl data were also comparable but those from the demersal trawl were consistently lower than for the other methods. *Macrourus* spp. grenadiers were ca. eight times less abundant in the demersal trawl than the video data but more large individuals were sampled by the trawl than the video and biomass estimates were similar. We hypothesise that this pattern could result from size-specific depth preferences in *Macrourus* spp. and conclude that video and trawl methods provide complementary information and if used together could be effective in routine assessments of demersal fish populations.

Brooks, C.M., A.H. Andrews, J.R. Ashford, N. Ramanna, C.D. Jones, C.C. Lundstrom & G.M. Cailliet. (2011) **Age estimation and lead-radium dating of Antarctic toothfish**

(*Dissostichus mawsoni*) in the Ross Sea. *Polar Biology,* 34, 329-338.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: Antarctic toothfish (*Dissostichus mawsoni*) are the target of an important commercial fishery in the Southern Ocean, yet age data used for management have not been comprehensively tested for accuracy. In this study, Antarctic toothfish were aged using counts of otolith growth zones based on criteria established for Patagonian toothfish, *D. eleginoides*, a closely related species. To validate these ages, the radioactive disequilibrium of lead-210 and radium-226 in otolith cores was measured and used as an independent chronometer to accurately deter-mine age across the range of fish caught in large numbers by the fishery. Growth-zone counts indicated Antarctic toothfish live to at least 39 years of age, and were in close agreement with the chronometer, validating the age estimation criteria and the accuracy of age estimates. Von Bertalanffy growth function parameters indicated Antarctic toothfish were relatively slow-growing (k = 0.111), espe-cially in relation to their maximum size (L? = 158.9 cm).

Bruyn, P. J. N. de, Cheryl A. Tosh & Aleks Terauds. (2012) **Killer whale ecotypes: is there a global model?** *Biological Reviews,* 88, 62-80.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: Killer whales, Orcinus orca, are top predators occupying key ecological roles in a variety of ecosystems and are one of the most widely distributed mammals on the planet. In consequence, there has been significant interest in understanding their basic biology and ecology. Long-term studies of Northern Hemisphere killer whales, particularly in the eastern North Pacific (ENP), have identified three ecologically distinct communities or ecotypes in that region. The success of these prominent ENP studies has led to similar efforts at clarifying the role of killer whale ecology in other regions, including Antarctica. In the Southern Hemisphere, killer whales present a range of behavioural, social and morphological characteristics to biologists, who often interpret this as evidence to categorize individuals or groups, and draw general ecological conclusions about these super-predators. Morphologically distinct forms (Type A, B, C, and D) occur in the Southern Ocean and studies of these different forms are often presented in conjunction with evidence for specialised ecology and behaviours. Here we review current knowledge of killer whale ecology and ecotyping globally and present a synthesis of existing knowledge. In particular, we highlight the complexity of killer whale ecology in the Southern Hemisphere and examine this in the context of comparatively well-studied Northern Hemisphere populations. We suggest that assigning erroneous or prefatory ecotypic status in the Southern Hemisphere could be detrimental to subsequent killer whale studies, because unsubstantiated characteristics may be assumed as a result of such classification. On this basis, we also recommend that ecotypic status classification for Southern Ocean killer whale morphotypes be reserved until more evidence-based ecological and taxonomic data are obtained.

Bury, S.J., M.H. Pinkerton, D.R. Thompson, S. Hanchet, J. Brown & L. Vorster. (2008) **Trophic study of Ross Sea Antarctic toothfish (*Dissostichus mawsoni*) using carbon and nitrogen stagle isotopes**, pp.
41. CCAMLR, Hobart, Australia.
WG-EMM-08/27.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: 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 δ15N and δ13C. Positive relationships between length and δ15N indicate that, very generally, larger fish consume prey of a higher trophic level than smaller fish. There were substantial residual within-species variations in δ15N and δ13C. *Dissostichus mawsoni* exhibited a range of 7 ‰ (9-16 ‰) in δ15N, which is equivalent to two trophic steps. All fish, except Antimora rostrata (2.7 ‰ range) showed a δ15N 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 δ15N and δ13C 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 δ13C signature was more depleted (indicating a pelagic signature) than the octopods, which were all benthic feeders. Large variations in δ13C for each species (around 3 ‰ for each species) indicated a variation in source of carbon within individual species. Species with enriched δ13C 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* δ15N and δ13C 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 13C values compared to the Ross Sea Slope, most
likely due to warmer temperatures to the north. Since this increased δ13C 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.
Constable, A. J. & W. K. de la Mare. (1996) **A generalised model for evaluating yield and the longterm status of fish stocks under conditions of uncertainty**. *CCAMLR Science,* 3, 31□54.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: This paper presents a general fish stock projection model for assessing the long-term annual yield which satisfies objectives for the maintenance of the spawning stock biomass in accordance with CCAMLR criteria. These specify a bound on the probability that the spawning biomass will become depleted to below some specified level over a specified period and set a further constraint on the long-term status of the stock relative to the pre-exploitation biomass. The model provides a flexible method for assessing the influence of different patterns of growth, natural mortality, spawning and fishing on estimates of yield and yield per recruit. It can also be used to evaluate stochastic stock trajectories under a specified catch regime. The model uses an adaptive Runge-Kutta algorithm to calculate stock trajectories and catch rates over a specified simulation period. The procedure numerically integrates a set of differential equations which incorporate functions that specify growth, mortality, age-dependent selectivity and seasonal patterns in fishing mortality. Results from the model are compared with existing analyses from the krill yield model. The model can include a known catch history and thus allow assessments of yield to be made for existing fisheries. An example is presented for the Patagonian toothfish, *Dissostichus eleginoides*, around South Georgia Island.

Constable, A. J., W. K. de la Mare, D.J. Agnew, I Everson & Denzil Miller. (2000) **Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)**.

ICES Journal of Marine Science, 57, 778□791.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: We aim to identify the important steps in the evolution of the ecosystem approach to management under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). The first section provides the background to CCAMLR, including the formulation of the convention and its objectives, its operation, and the historical trends in fisheries. Later sections describe (i) the reasons why a precautionary approach to setting catch limits evolved, (ii) how the precautionary approach takes account of ecosystem objectives and provides for the orderly development of new fisheries, and (iii) how the use of ecosystem indicators in the setting of catch limits and for monitoring the effects of fishing is being evaluated. The final section describes the general framework being used to develop a feedback-management system that incorporates objectives, target species assessments and ecosystem assessments. The CCAMLR experience provides two important lessons. First, conservation objectives can only be achieved by implementing management measures, even when very little is known. Second, methods were found for achieving scientific consensus despite the uncertainties surrounding estimates of parameters and the behaviour of the system. CCAMLR is yet to face the real test in its ecosystem approach, the development of the krill fishery. Before this occurs, appropriate management procedures have to be developed to avoid localized effects on the ecosystem and to provide effective feedbacks on the effects of fishing through its monitoring programme.

Constable, A.J. (2002) **Evaluation of the effects of illegal, unregulated, and unreported (IUU) fishing on the legal catch of fisheries for *Dissostichus Eleginoides***, pp. 13. CCAMLR, Hobart, Australia.
WG-FSA-02/69.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: CCAMLR currently establishes catch limits each year for Patagonian toothfish, *Dissostichus eleginoides*, that can be sustained over the generation time of the species, maintaining the population at a productive level with only a small chance of become depleted. The increasing levels of illegal, unregulated and unreported (IUU) fishing for toothfish in the CCAMLR area threatens the success of CCAMLR achieving ecologically sustainable fisheries as well as threatening the status of populations of this species. As a result of IUU fishing, the catch limits set by CCAMLR are being reduced each year to compensate for the effects of historical levels of IUU catches. To date, the rate of reduction of the legal catch limits does not seem to be commensurate with the rising levels of IUU catches. This paper explores the consequences of different rates of IUU fishing to the legally-binding TACs set by CCAMLR. The scenarios explored are with IUU annual catch at 0.33x, 1x, 2x and 4x a legal catch limit derived from an assessment based on the 2001 WG-FSA assessments, which is approximately 3 000 tonnes. The IUU catches are applied with the legal catch limit being adjusted each year after the IUU catch and the legal catch were combined in the catch history and a new long-term sustainable annual catch was estimated using the GYM and applied as the legal catch limit for the following year, assuming no future IUU fishing. If there was no IUU fishing, the long-term sustainable annual yield is set according to the escapement part of the decision rule. With fishing at levels greater than the long-term sustainable yield because of IUU fishing then the threat of depletion is increased and the legal catch limit needs to be reduced following each year that the total catch is above the sustainable levels. The closure of the legal fishery occurs when the spawning stock has been almost depleted to 20% of the pre-exploitation median biomass with a high probability of being depleted during the future projection period. Thus, low levels of IUU fishing may be tolerated, but only in the short term, while the spawning stock is above the target status of abundance. A long-term sustainable fishery requires that IUU fishing be at least reduced to levels that are much less than the long-term sustainable annual yield estimated using the CCAMLR assessment process. Continued IUU fishing at the rates reported by CCAMLR in 2001 will result in a closure of the legal fisheries in the Indian Ocean within the next 12 years because it is in excess of the estimated long-term

sustainable annual catch level. The rate of reduction of the legal TAC is low because the effects of IUU fishing are averaged out in the assessment process over 35 years, assuming no more IUU fishing takes place following the assessment. The consequence of IUU fishing is a precipitous decline in the legal TAC once IUU fishing has mined the stock to a point that there is a high probability of the stock becoming depleted during the future projection period. Consequently, action to control IUU fishing would be too late if it was delayed until there was a significant reduction in the long-term annual yield obtained in the assessment process.

D.M Tracey, M.E. Carter and S.J. Parker (2010) **Evaluation of VME taxa classification by scientific observers from New Zealand vessels in the Ross Sea Antarctic toothfish longline fishery during the 2009/10 season**.
TASO-10/10.Used for Ross Sea Toothfish MSC 2011
ABSTRACT: Conservation Measure 22-07 (2008) requires vessels fishing in the Ross Sea (and most areas south of 60 °S) to collect and monitor longline bycatch for VME taxa, and implement a moveon rule if required. To ensure effective monitoring, an evaluation of VME taxa classification by Scientific Observers from four vessels in the Ross Sea Antarctic toothfish longline fishery during the 2009-10 season was conducted. Scientific Observers classified invertebrate bycatch using a revised and expanded VME taxa classification guide, and retained 1109 samples from 1272 longline segments for subsequent classification by parataxonomists and/or taxonomists, from which 4555 specimens were identified. Improvements made to the classification guide, along with specific training, benefitted the accuracy of data collection. Comparison of the observer's classification versus the taxonomist's classification showed that for most groups, the observer classifications were reasonably precise (88% accuracy). Some problems in distinguishing demosponges and hexactinellid sponges, sponges from ascidians, and stylasterid hydrocorals from gorgonian corals remains. Scientific Observers rarely classified non-VME taxa as VME taxa (23 of 1008 samples). In the
Echinodermata group, brittle stars (a non-VME taxon) were sometimes recorded as snake stars (a VME taxon). Briefings prior to sailing and additional training materials can address most remaining issues.

Dam, Robert P. Van & Gerald L. Kooyman. (2004) **Latitudinal distribution of penguins, seals and whales observed during a late autumn transect through the Ross Sea**. *Antarctic Science,* 16, 313318.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: During a cruise to the Ross Ice Shelf we counted all penguins and marine mammals seen whilst underway. Our objective was to determine the abundance and distribution of these animals along our cruise line. From 14 May until 11 June the sun was below the horizon. Our observations were from the 18 m high bridge. Most watches were in the dark, aided by the bridge spotlights. A total of 79 emperor penguins, 920 Adélie penguins, and 27 marine mammals were counted. We conclude that the Ross Sea, in which wildlife flourishes during the summer, is depauperate in winter. The low numbers of marine mammals may be due partially to their tendency to remain below the surface most of the time. However, Adélie penguins, a visual hunter which rests on sea ice at night, appear to prefer pack ice edges where there is a few hours of daylight and civil twilight for pursuit of prey. Non-breeding emperor penguins also rest on sea ice at night. All but four were observed north of the Ross Sea. Unlike more northerly colonies where females lay their egg and disperse in May female departure in the Ross Sea appears to be later and, we were unable to determine their winter foraging area.

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

WG-FSA-08/62.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: 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.

Delegations of New Zealand, Norway and the United Kindgom. (2014) **Proposal for a longline survey of toothfish in the northern Ross Sea region (SSRUs 88.2 A and B)**, pp. 16. CCAMLR, Hobart,
Australia.
WG-FSA-14/61.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We propose a multi-year and multi-member research plan using standardised longline gear to sample the toothfish populations in the northern areas (61°- 66° S) of SSRUs 88.2A-B. The purpose of the research as requested by the Scientific Committee (SC-CAMLR XXXII, paragraph 3.76) is to characterise the local toothfish populations found there to better understand stock structure, movement patterns and improve estimation of population characteristics by Ross Sea spatial population models. Additional outcomes of the research relate to mapping the bathymetry of the fishable area, documenting relative abundance of Patagonian and Antarctic toothfish, tagging toothfish for biomass estimation and for stock linkage studies, and collecting information on distribution, relative abundance, and life history of bycatch species.
Delegations of New Zealand, Norway and the United Kindgom;. (2014) **Medium-term research plan for the Ross Sea toothfish fishery**, pp. 27. CCAMLR, Hobart, Australia.
WG-FSA-14/60.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The aim of this paper is to review the management of the Ross Sea toothfish fishery and to identify key research objectives for the fishery over the next 3-5 years in relation to Article II of the Convention. The paper focuses primarily on Antarctic toothfish, as catches of Patagonian toothfish are negligible, and covers Subarea 88.1 and Subarea 88.2 SSRUs 88.2A and B. We begin by briefly summarising the management and operation of the fishery up to and including the 2012/13 fishing year. This includes the 3-year experiment from 2005/06 to 2007/08, the further development of the CCAMLR tagging programme and associated requirements, and other changes to the management of the fishery. We then identify uncertainties in our current knowledge that 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 which can be addressed over the short to medium term. However, the need to further develop Management Strategy Evaluation and Management Procedures for the toothfish fishery in the medium-long term is also recognised. The purpose of this paper is to begin the discussion on medium-term research objectives for the Ross Sea fishery and the development of a medium-term research plan which could be adopted by the Scientific Committee.

Dunn, A, S.J. Parker & S. Mormede. (2010) **Development of methods for evaluating the management of benthic impacts from longline fishing using spatially explicit production models, including model validation**, pp. 24. CCAMLR, Hobart, Australia.
WG-FSA-10/29.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: An important management objective for CCAMLR in the high seas region of the Antarctic is to develop appropriate methods of monitoring and managing impacts of bottom fisheries on vulnerable marine ecosystems (VMEs). We describe a spatially explicit production model that can be used to investigate a range of scenarios for simulating the effect and management of benthic impacts from longline fishing effort. Further, we update this paper with a set of simulations using a range of simple and extreme case studies to validate the underlying model and code. In general, the model simulations were carried out under a range of productivity assumptions, impact, and spatial scale, with and without management by areal closures. The management action simulated considered a range of areal closure radii and bycatch trigger thresholds. We conclude that spatially explicit production models can provide a useful tool for the investigation of impacts of fishing effort on benthic organisms. They have the advantage that they are relatively simple to construct, run, and interpret. In most cases, the results of the simulations suggested that management action of areal closures in the Ross Sea region are likely to result in an improved outcome relative to scenarios where there was no management action, but that the magnitude of simulated impacts under the plausible models was often very small. We also note that further work on these simulations are required - including investigating how changes in the distribution of future fishing may influence estimated impacts or how different assumptions of the underlying distributions of benthic organisms may influence recovery or management effectiveness. However, as the magnitude of these impacts in the scenarios tested were small, we recommend that research be focused, at least in the short term, to provide the observational or experimental data necessary to constrain important model parameters, to reduce uncertainty and provide more plausible scenarios.

Dunn, A & S. Rasmussen. (2008) **Development of a spatially explicit age-structured statistical catchat-age population dynamics model for modelling movement of Antarctic toothfish in the Ross Sea**, pp. 31. CCAMLR, Hobart, Australia.
WG-SAM-08/14.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: 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 & Hanchet 2007) would need to be evaluated within a simulation-experiment in order to address current assessment model uncertainties.

Dunn, A, S. Rasmussen & S M Hanchet. (2009) **Development of spatially explicit age-structured population dynamics operation models for Antarctic toothfish in the Ross Sea**, pp. 44. CCAMLR, Hobart, Australia.
WG-SAM-09/18.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: We present developments towards spatially explicit age-structured population dynamics operating models for Antarctic toothfish in the Ross Sea. The operating models consider both a coarse-scale and fine-scale spatial resolution and consider scenarios where abundance can be present over the entire Ross Sea region or constrained to areas where the fishery has operated. The models represent developments towards plausible operating model constructs that may be used for evaluating assessment biases or other factors to quantify risk and uncertainties for management of the Ross Sea Antarctic toothfish fishery. Further, we outline steps towards using the model as an estimation model to estimate movement and spatial distribution parameters as an aid in evaluating the operating models. The models are implemented in the generalised Bayesian population dynamics model, the Spatial Population Model (SPM). The SPM program allows implementation of an aggregate movement model for use with large numbers of areas as a discrete time-step statespace model that represents a cohort-based population age structure in a spatially explicit manner. Models can be 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. The operating models considered were single sex age-structured models that categorised fish as immature, mature, or spawning. Observations can include spatially explicit commercial catch proportions-at-age, proportions mature, and tag-release and tag-recapture observations. Estimates of parameters when the operating models were used as estimation models with observations from the Ross Sea Antarctic toothfish fishery appeared to broadly reflect the hypothesised spatial distribution of Antarctic toothfish, suggesting that younger fish were found predominantly in the southern shelf areas and adult fish distributed along the slope and northern areas of the Ross Sea. Fits to the commercial catch proportions-at-age observations were generally good in most models, although fits to the plus group of the proportions-at-age catch data were less than ideal. Model estimates of proportions-mature appeared to be sensible, with a clear pattern that the proportions mature were a function of location and age. Tag release and recapture data were less well fitted by the models due, in part, to the conflict with assumptions of known abundance in the model and the abundance information inherent in the tag-recapture observations.

Dunn, A., S L Ballara & S M Hanchet. (2007) **An updated descriptive analysis of the toothfish (*Dissostichus spp.*) tagging programme in Subareas 88.1 & 88.2 up to 2006□07**, pp. 25. CCAMLR, Hobart, Australia.
WG-FSA-07/40.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: The descriptive analyses of the toothfish tagging programme carried out in Subareas 88.1 and 88.2 since 2001 are updated, including data for the 2007 season for all vessels. This paper provides an update of the preliminary tag-release and tag-recapture data that were presented at the July 2007 meeting of WG-SAM by including revised data and data from non-New Zealand vessels that fished in 2007.
Overall, a total of 15 088 Antarctic toothfish have been reported as released and 458 recaptured, and 911 Patagonian toothfish released and 43 recaptured since 2001. The number of tags recaptured in the Ross Sea in 2007 by New Zealand vessels was the highest annual recapture to date and double the number caught in 2006, although the nature of these recaptures suggests that assumptions of homogeneous mixing may need to be investigated. For the first time, long distance movements of Antarctic toothfish were observed from toothfish tagged by fishing vessels. Six fish moved 400-600 km from the slope fisheries in SSRUs 88.1H, 88.1I, and 88.1K to grounds off Terra Nova Bay and Ross Island in SSRU 88.1J. There was also some evidence that more fish are recaptured after a longer time at liberty on the slope than in the North. In addition, a Patagonian toothfish tagged near Macquarie Island was recaptured in the north of the Ross Sea, after 4 years at liberty.
Analysis of tag recapture rates suggested some evidence that rates between New Zealand and nonNew Zealand vessels were different, and further, that the rate that tags were recaptured from vessels of different nations were different. The reason for these differences is unclear, but may related to different survival rates of fish tagged by different vessels, different detection rates of tagged fish on different vessels, and/or incomplete spatial mixing of the fish tagged by different vessels in different local regions. Further investigation is required

Dunn, A., S M Hanchet, S.L. Ballara & M.P. Francis. (2007) **Preliminary investigations of an assessment model for skates and rays in the Ross Sea**, pp. 35. CCAMLR, Hobart, Australia.
WG-SAM-07/04.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: This report presents the data and preliminary results from developmental model for Antarctic skates in SSRUs 88.1H, 88.1I, 88.1J, & 88.1K of the Ross Sea. The developmental model attempted to create a catch history of all skates and rays in the Ross Sea, and integrate these data with the available observational data (including tag-recapture data) into a single integrated stock assessment model. We conclude that aspects of the catch history were very uncertain, including the species composition, the weight and number of skates caught, the proportion discarded, and the survival of those tagged or discarded. The size composition of the commercial catch was also very uncertain because of the low numbers sampled each year. Most aspects of the tagging data were also uncertain including the actual numbers of skates released, the initial mortality of tagged skate, the tag loss rate, and the numbers of skates scanned for tags. While updated summaries of the numbers of skate tag releases and recaptures have been reported, these data are still preliminary, and further work is required. Lastly, there is great uncertainty over the biological parameters including age and growth, natural mortality, steepness, and size and age at maturity.
The applicability of a general model, such as presented here, to a multi-species catch has not been investigated. While is it plausible that a general model may be adequate if the productivity parameters of the different species of skates and rays are similar, we conclude that additional research is required to investigate the usefulness of such models. We also make a number of suggestions for areas where better data are required. These include

recommending work that would improve species identification, increasing the detection rate of tagged skates, increasing the number of skates measured and sexed, validating estimates of age and growth, revising the skate tagging protocols, and undertaking more extensive skate survivorship experiments.

Dunn, A., S.M. Hanchet & J. Devine. (2009) **Descriptive analysis of the toothfish (*Dissostichus* spp.) tagging program in Subareas 88.1 and 88.2 for the years 2000/01 to 2008/09.**, pp. 28. CCAMLR, Hobart, Australia.
WG-FSA-09/38.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The descriptive analyses of the toothfish tagging programme carried out in Subareas 88.1 and 88.2 since 2001 are updated, including data for the 2009 season for all vessels. Overall, a total of 21 351 Antarctic toothfish have been reported as released and 854 recaptured, and 1 133 Patagonian toothfish released and 57 recaptured since 2001. The number of Antarctic toothfish tags recaptured in the Ross Sea in 2009 by all vessels was about 50% of that recaptured in each of 2007 and 2008. Similar recapture rates (tags per tonne) to 2007 and 2008 were obtained from fishing in SSRUs 88.1H and 88.1I, but much lower rates were obtained from fishing in SSRUs 88.1C and 88.1K. The reason for this is unclear. For the first time, long distance movements of Antarctic toothfish between the North and slope were observed from toothfish tagged by fishing vessels. Two fish moved from SSRU 88.1H to 88.1C, whilst three fish moved from SSRU 88.1B to SSRUs 88.1H and 88.1I. In addition several fish moved distances of 400-600 km (Figure 5), with movements between the slope fisheries in SSRUs 88.1H, 88.1I, and 88.1K to grounds off Terra Nova Bay and Ross Island in SSRU 88.1J and vice versa. Other than these longer distance movements, most fish have moved short distances, typically less than 100 km. There was also some evidence that more fish are recaptured after a longer time at liberty on the slope than in the North.

Dunn, A., P L Horn & S M Hanchet. (2006) **Revised estimates of the biological parameters for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea**, pp. 14. CCAMLR, Hobart, Australia.
WG-FSA-SAM-06/08.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This report updates the estimates of the biological parameters for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea (Subareas 88.1 and SSRUs 88.2A-B). We present revised estimates of the von Bertalanffy growth curves, length weight relationship, and natural mortality based on CCAMLR observer data collected from commercial fishing operations in the Ross Sea. In addition, we review meta-data for plausible estimates of the steepness parameter of the stockrecruitment relationship and recruitment variability of Antarctic toothfish.

Dunn, A., G.J. Rickard, S.M. Hanchet & S.J. Parker. (2012) **Models of larvae dispersion of Antarctic toothfish (*Dissostichus mawsoni*)**, pp. 13. CCAMLR, Hobart, Australia.
WG-FSA-12/48.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Antarctic toothfish (*Dissostichus mawsoni*) have a circumpolar distribution, and have been found associated with bathymetric features shallower than 2250 m and typically deeper than 500 m from the Antarctic continent north to approximately 57° S. Efforts to understand early life history and stock structure in the Ross Sea have parallels for populations in other regions of the Antarctic, and hypotheses about how stock structure is maintained may apply to each population.
We provide an update of the circumpolar models of larval dispersion for *D. mawsoni* developed by Hanchet et al. (2008) using the HiGEM circumpolar oceanographic model documented by Rickard et al. (2010). We used a finer resolution of simulated locations in the

northern areas of Subarea 88.1 & 88.2 to further investigate the possible larval dispersal from spatially discrete spawning grounds in these Subareas. Further, we derive plausible spawning locations from Scientific Observer sampling of *D. mawsoni* in other ocean sectors to identify starting locations for modelling the potential egg and larval dispersal around Antarctica using the HadGEM (Rickard et al. 2010) oceanographic model. The results are currently too preliminary to make conclusions about possible stock structure within these sectors.
Information on the depth of transport and the timing and velocity of any directed swimming will assist in improving these simulations.

Dunn, A., M.H. Smith, D.J. Agnew & S. Mormede. (2011) **Estimates of the tag loss rates for single and double tagged toothfish (*Dissostichus mawsoni*) fishery in the Ross Sea**, pp. 13. CCAMLR, Hobart, Australia.
WG-SAM-11/18.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the
Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: The rate at which tags are lost from tagged toothfish is an important parameter in modelling of the Antarctic toothfish (*Dissostichus mawsoni*) populations in Subarea 88.1 and 88.2. The toothfish stocks in these areas have been assessed using data from tag-release and recapture experiments within a CASAL integrated stock assessment model, using tag loss rates derived by Dunn et al. (2005). We update their estimates and calculate tag loss rates for both single and double tagged fish for use within the CASAL stock assessment models from the available data. Revised estimates of the rate at which individual tags are lost from tagged toothfish in Subareas 88.1 and 88.2 from a sample of 969 double tagged and subsequently recaptured fish suggested that the loss rate was about 3.5% (95% C.I.s 0.020-0.054) of individual tags were lost almost immediately, and then there was an ongoing rate of about 0.039 (95% C.I.s 0.027-0.052) tags per year. For double tagged fish this corresponds to 99.5% of double tagged fish having at least one tag remaining after one year at liberty; 98.9% after two years at liberty; declining to 94.6% after six years; and to 88.4% after ten years. Comparison of the different loss rate models suggested that there was evidence of
immediate failure of tags ($\alpha = 0.035$) and an ongoing constant rate of failure ($\lambda = 0.039$ y-1), but no evidence of a change in the failure rate over time. It is plausible that there could be a catastrophic failure of tags or some other systematic change in the tag loss rate after some long period at liberty, but there was no evidence of such failure in these data for periods of up to six years at liberty. The loss rate for double tags had been incorrectly derived and applied in the assessment models of Dunn & Hanchet (2009a, 2009b), with the loss rates slightly over-estimated for double tagged fish in the first four years and under-estimated after that. However, the tag loss rate and the double tag approximation rates calculated in this study suggest that the change in value of the tag loss rate parameter combined with the incorrect double tag model had very little impact on the assessment estimates of biomass in the assessment models. The equivalent tag loss rate that can be used to provide a close approximation of the true tag loss rate in the Subarea 88.1 and 88.2 assessment
models is either $\lambda = 0.0071$ y-1 (where we exclude recapture events that occur after four years) or $\lambda = 0.0084$ y-1 (where we exclude recapture events that occur after six years). Simulations showed that the impact on the assessment of ignoring tag recapture data after a six year period was to introduce negligible bias of less than 0.5% with less than 1% change in the overall estimated variance (mean squared error). Similarly, a simulation experiment that excluded earlier years of release data from the assessment models also suggested that the removal of early data had little impact on the assessment models. Estimates of bias were negligible (<0.5%) and the increased variability (as measured by mean squared error) was less than 3% even if all tag release and recapture data before 2005 were removed.

Eisert, R., M.H. Pinkerton, S.D. Newsome & O.T. Oftedal. (2013) **A Critical re-examination**

of the evidence for a possible dependence of Weddell Seals (*Leptonychotes weddellii*) on Antarctic toothfish *(Dissostichus mawsoni*) in the Ross Sea, Antarctica, pp. 30. CCAMLR, Hobart, Australia.
WG-EMM-13/28.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: There is presently debate over the degree to which the fishery for Antarctic toothfish (*Dissostichus mawsoni*; 'toothfish') in the Ross Sea may affect the ecological viability of top predators such as Weddell seals (*Leptonychotes weddellii*), but available evidence remains inconclusive as a result of both methodological limitations and knowledge gaps. We present new stable isotope data on Weddell seal prey, consider the assumptions underlying application of stable isotope methodology to Weddell seals, and estimate the potential contribution of toothfish to the diet of Weddell seals using an isotope mixing model. As a new approach, we also estimate Weddell seal food requirements by considering nutritional quality of potential prey species including toothfish in the context of updated estimates of Weddell seal energy requirements. The energy density of potential prey items (fish and invertebrates) covers a four-fold range. Nutritional analysis of Ross Sea prey suggests that toothfish may represent a unique high-energy food resource for Weddell seals that possibly cannot be adequately replaced by other prey, in particular during periods of high energy demand such as late-stage lactation and the post-breeding recovery of body weight and condition. The assumed dominance of Antarctic silverfish (*Pleuragramma antarcticum*) in Weddell seal diets should be re-examined given the known biases of methods used to derive diet estimates. While large (>30 g) silverfish occurring at high densities are a valuable nutritional resource, smaller size classes are unlikely to be adequate to meet the estimated energy requirements of adult Weddell seals. Our ability to conclusively determine possible dependence of Weddell seal populations on toothfish, and hence possible impacts of toothfish removal by fisheries, is primarily hindered by (a) insufficient information on Weddell seal diet, due to inadequate temporal coverage and biased methodology, and (b) uncertainty regarding Weddell seal abundance and spatial foraging patterns in the Ross Sea region.

Fenaughty, J. M. (2006) **Geographical differences in the condition, reproductive development, sex ratio, and length distribution of Antarctic Toothfish (*Dissostichus mawsoni*) from the Ross Sea, Antarctica (CCAMLR Statistical Subarea 88.1)**. *CCAMLR Science,* 13, 27□45.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: A number of morphological and reproductive measurements made seasonally on
Antarctic toothfish *Dissostichus mawsoni* from mid-December to early April during the 2000-01 to 2004-05 fishing seasons aboard the autoliner *San Aotea II* have been analysed. Results of this study indicate measurable differences in a number of indices from toothfish found on the Ross shelf proper, as distinct from those sampled on the more isolated seamounts and features to the north. These are length modal distribution, sex ratio, fish body condition factor, and reproductive development. *D. mawsoni* samples from the northern part of the Ross Sea showed that this component of the population had a unimodal length distribution at a consistent peak over all sampling seasons in comparison with the southern group in which the distribution was multimodal, showed a consistent and significant higher ratio of males to females, was in poorer condition, and was more advanced in reproductive development.

Fenaughty, J.M. & J. Brown. (2011) **CCAMLR Measures regulating the tagging of *Dissostichus* species, metrics used to assess vessel tagging performance, the potential for some anomalous results, and general recommendations on tagging; a view from the hauling room.**, pp. 28. CCAMLR, Hobart, Australia.
WG-FSA-11/50.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at

the Fish
Stock Assessment Working Group of CCAMLR)
ABSTRACT: The background to the current CCAMLR toothfish tagging programme is reviewed and recent performance measures implemented by CCAMLR to control and monitor the tagging of toothfish (*Dissostichus* species) in exploratory fisheries carried out within the Convention Area are described. Following the first season of implementation we describe several circumstances which will cause anomalies in the tag overlap statistic used to monitor tagging performance. These relate to differences in the length distribution of *Dissostichus* species within the assessed management division (ASD) or changes in the tagging rate within sub areas of the assessed ASD. The current level of two tonnes of *Dissostichus* catch triggering the requirement to achieve a tag overlap statistic of 60% or more for upcoming season as specified in Annex 41-01/C is evaluated by means of simple simulations. The results of this analysis indicate that at low levels of tagging, equating to between 2 and 10 t of *Dissostichus* catch, there is a strong likelihood that a breach of the Measure would occur. We make recommendations from a user perspective on other aspects of toothfish tagging such as crew participation in the process, tag colour, training, and clarification of the controlling measures. We also recommend that the CCAMLR tagging protocol be updated and translated.

Fenaughty, J.M., D.W. Stevens & S.M. Hanchet. (2003) **Diet of the Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea, Antarctica (Subarea 88.1)**. *CCAMLR Science,* 10, 113–123.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: The diet of Antarctic toothfish (*Dissostichus mawsoni*) captured by bottom longline in the Ross Sea during the 2001 and 2002 fi shing seasons was analysed (3 937 and 5 426 stomachs examined respectively). Fish sampled in 2001 were caught at depths of 317 to 2 154 m and ranged from 58 to 190 cm in total length (TL). Fish sampled in 2002 were caught at depths of 815 to 1 623 m and ranged from 62 to 197 cm TL. A high proportion of stomachs were empty (34% in 2001 and 49% in 2002) and the remaining stomachs often contained prey in advanced stages of digestion, making prey identification difficult. Fish were the most important prey category (%F = 86 in 2001 and %F = 77 in 2002), in particular icefish (family Channichthyidae) and Whitson's rattail (*Macrourus whitsoni*). Squid, bait and prawns followed in importance in the diet.

Fenaughty JM, Eastman JT, Sidell BD (2008) (2008) **Biological implications of low condition factor 'axe handle' specimens of the Antarctic toothfish, *Dissostichus* mawsoni, from the Ross Sea. Antarct Sci 20: 537–551**. *Antarct Science*
20, 537–551.
MSC Reference for Ross Sea Toothfish annual surveillance in 2011
ABSTRACT: Abstract: We evaluated the condition factor (K), an index of weight per unit length, in a sample of 49 761 longline-caught specimens of Antarctic toothfish, *Dissostichus mawsoni*, from the Ross Sea. Our sample consisted of specimens from northern (60-70°S) and southern (70-78°S) regions. Fifty percent of the northern sample and 4.9% of the southern sample were large individuals with a low condition factor (K^{ah} = 1.0182) and displaying an "axe handle (ah)" morphology with a notably thinner trunk. In the northern sample 55.4% of the males and 43.2% of the females were less than Kah. In the southern region 5.3% of the males and 4.5% of the females were less than Kah. The axe handle morphology is attributable to the metabolic loss of muscular and subcutaneous lipid stores, and probably proteins, from white muscle. Our discussion considers energy metabolism as related to migration, feeding and reproduction. We suggest that migration, a life history trait of the phyletically basal notothenioid clades *Pseudaphritis* and *Eleginops*, persists in *D. mawsoni*. The spawning migration from the southern shelf to ridges and seamounts in the north may reflect fidelity to historic spawning grounds. As evidenced by the axe handle specimens neutral buoyancy of large *D. mawsoni* may be ephemeral, fluctuating over the

course of adult life.

Francis, M.P. (2006) **Review of biological parameters for Ross Sea skates**, pp. 18. CCAMLR, Hobart,
Australia.
WG-FSA-06/31.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Biological parameters were reviewed and updated for the two main species of skates taken as bycatch in the Ross Sea toothfish fishery: *Amblyraja georgiana* and *Bathyraja* cf. *eatonii*. Differences in length-weight relationships among regions raise doubt about the conspecificity of *A. georgiana* from the Ross Sea and South Georgia, and of *B*. cf. *eatonii* from the Ross Sea and Heard Island and the MacDonald Islands. The taxonomy needs to be resolved before biological parameters derived from populations outside the Ross Sea can be applied to Ross Sea skates. Length-weight regression relationships for male and female *A. georgiana* and *B*. cf. *eatonii* from the Ross Sea are provided. Male and female relationships differ significantly for both species. Male *A. georgiana* attain 50% maturity at 92 cm total length (TL). The length at maturity of females is not well determined but is probably in the range 95-100 cm TL.
Length at maturity of B. cf. eatonii is poorly determined, but is about 90-100 cm TL for males and 100-110 cm TL for females. The best available, but unvalidated, growth curve for *A. georgiana* for both sexes combined is: TLt =101.31(− e • 0.308 [t+1.30]). The best estimate of longevity in *A. georgiana* is 14 years. However this may be a considerable underestimate, and true longevity may exceed 20 years. Age at sexual maturity for *A. georgiana* is estimated to be about 6-7 years for males and 8-13 years for females. The most plausible range for the natural mortality rate, M, for *A.*
georgiana is probably 0.15-0.25. No growth curve, longevity estimate or age at maturity estimate is available for *B*. cf. *eatonii*.

Francis, M.P. (2010) **Revised biological parameters for the Antarctic skates *Amblyraja georgiana* and *Bathyraja* cf. *eatonii* from the Ross Sea**, pp. 14. CCAMLR, Hobart, Australia.
WG-FSA-10/27.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Revised weight-length and length-length regressions are provided for *Amblyraja georgiana* and *Bathyraja* cf. *eatonii*. Significant differences between males and females occurred for all comparisons except for B. cf. eatonii length-length regressions. Some observer maturity staging data were unreliable, as indicated by comparison with lab staging, and the presence of very large skates scored as immature. For *A. georgiana*, this resulted in flatter maturity ogives for observer data than lab data, and different estimates of median length at maturity. The lab estimates were based on small datasets that did not cover the maturation range adequately, so using them instead of the observer estimates is not necessarily a good option. Logistic regressions differed significantly between the sexes for both datasets, but observer data suggested that females matured at a larger size than males, whereas lab data suggested the reverse. The differences between sexes may therefore be spurious, and an artifact of insufficient and inaccurate data. Until better data are available, length at maturity should be regarded as the same for both sexes. The median lengths at maturity estimated for both sexes combined were similar for both data sources: 65.9 cm for lab data and 66.5 cm for observer data, suggesting a reasonable overall value of 66 cm PL. There are still insufficient reliable data to estimate the median length at maturity of *B*. cf. *eatonii*, but it is probably around 65-75 cm for males and 70-80 cm for females. Reasonable point estimates are therefore 70 cm for males and 75 cm for females.

Francis, MP. & Caoimhghin Ó Maolagáin. (2005) **Age and growth of the Antarctic Skate (*Amblyraja georgiana*) in the Ross Sea**. *CCAMLR Science,* 12, 183□194.

MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: X-rays of vertebral half-centra, and x-rays and transmitted white light examination of caudal thorns, were used to estimate the ages of the Antarctic skate (*Amblyraja georgiana*) from the Ross Sea. Caudal thorns viewed with transmitted white light provided the clearest growth bands, but reading precision was low, producing uncertain age estimates. Furthermore, annual deposition of thorn bands has not been validated. The maximum estimated age was 14 years, but this should be regarded as a conservative estimate of longevity because of the possibility that thorn growth ceases in large individuals. There was no obvious difference in growth between the sexes, so the von Bertalanffy Lt□□e□□ , where Lt is the pelvic length (PL) in centimetres at age t years. Applying this growth curve to the estimated lengths at maturity for males and females 70.8 1□0.308 1.10t□ curve for both sexes provides the best available representation of growth in the species: □□(64 and 66-69 cm PL respectively) produced estimated ages at maturity of 6-7 years for males and 8-11 years for females. These estimates are near the middle to upper end of the range of ages at maturity for skates worldwide. The results of this study are preliminary and should be used with caution. Further work is needed to determine whether the thorn ageing technique presented here produces reproducible and reliable age estimates.

Francis, R.I.C.C. (2011) **Data weighting in statistical fisheries stock assessment models**. *Canadian Journal of Fisheries and Aquatic Sciences,* 68, 1124-1138.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: The conclusions drawn from fisheries stock assessment models can depend strongly on the relative weights assigned to different data sets. However, there is no consensus amongst practitioners as to the best approach to data weighting. From a discussion of some key questions concerning data weighting in stock assessment models, I draw three guiding principles: (i) do not let other data stop the model from fitting abundance data well; (ii) when weighting age or length composition data, allow for correlations; and (iii) do not down-weight abundance data because they may be unrepresentative. I propose an approach to data weighting based on these principles. Two factors that complicate this approach are that some decisions are inevitably subjective (which underlines the need for expert knowledge in stock assessment), and some technical problems are unresolved.
Gon, O. & P.C. Heemstra. (1990) **Fishes of the Southern Ocean**, pp. 462. J.L.B. Institute of Ichthyology, Grahamstown.
for Ross Sea Toothfish
ABSTRACT: A comprehensive account of the fishes of the circum-Atlantic Southern Ocean, compiled by 32 scientists from 11 countries. In addition to systematic accounts of 272 fish species in 49 families, the book includes chapters on the origin, evolution, systematics, biology, conservation and exploitation of Antarctic fishes. There is an illustrated key to families, as well as a key to each genus and species. Each species account includes a diagnosis and distribution map, and notes on distribution, breeding and feeding.

Hanchet, S M, S. Mormede & A. Dunn. (2013) **A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997–98 to 2012–13**, pp. 36. CCAMLR, Hobart, Australia.
WG-FSA-13/48.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This report summarises the timing, depth, and location of fishing together with the biological aspects and catch of Antarctic toothfish for the period 1997-98 to 2012-13. In 2012-13, all the Ross Sea slope SSRUs were clear of ice and catches were evenly distributed across the three SSRUs. As in recent years, the remaining catches came mainly from SSRUs 88.1C, 88.1J, and 88.2H. Unstandardised Antarctic toothfish CPUE in the Ross Sea and Subarea 88.2 fisheries have fluctuated over the past 10 years with no trend. A standardised CPUE analysis in the Ross Sea fishery showed an increase to 2008 followed by a slight decline to 2013. Standardised CPUE indices in Subarea 88.2 showed a general

decline from 2003 to 2013 in SSRU 882H, but a general increase from 2006 to 2013 in SSRUs 88.2C-G. However, these indices were very uncertain due primarily to the lack of a consistent set of vessels over time and may not be indexing abundance. Length frequency distributions of Antarctic toothfish in the Ross Sea fishery have continued to be reasonably stable in the North and to have a strong mode of smaller fish on the Slope. Mean ages and ages of larger fish increased in the first few years of the fishery in each area but have declined since 2005. The trend on the Slope appears to be confounded by the trend of some vessels fishing shallower there in the last four years. There is some evidence for a similar reduction in mean age in SSRU 88.2H, but the data are very uncertain due to the paucity of otolith readings and it is recommended that the age data are given low weighting in the 2013 assessment and that otolith readings for this area are given a high priority. There has been a marked change in sex ratio in the North of the Ross Sea fishery, with an increase in the proportion of males since 2001, but with little change in the rest of Subarea 88.1 or 88.2.
Hanchet, S M, B. Sharp & S. Parker. (2013) **Priority research surveys to address uncertainties in the assessment of toothfish in Subareas 88.1 and 88.2**, pp. 8. CCAMLR, Hobart, Australia.
WG-FSA-13/55.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We have identified key uncertainties in the stock assessment of Antarctic toothfish in Subareas 88.1 ad 88.2 which could be addressed using specific research surveys and other dedicated voyages. Given the continued uncertainty arising from the relative paucity of abundance data, age and length composition data and gonad data for toothfish in some geographic areas and seasons, and from lack of sufficient data to understand toothfish movements and stock structure, we believe that research of this kind should be given a high priority by the Scientific Committee. We recommend the Scientific Committee invite members to submit proposals to address these uncertainties, and consider mechanisms by which coordinated research plans involving multiple Members could be generated either by the Scientific Committee or in its working groups.

Hanchet, S. M. (2006) **Species profile for Antarctic toothfish (*Dissostichus mawsoni*)**, pp. 22. CCAMLR, Hobart, Australia.
WG-FSA-06/26.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: A toothfish species profile, covering aspects of the biology, fisheries and stock assessment of both toothfish species was completed by Everson (2002). Aspects of the biology of *D. mawsoni* were summarised by Hanchet et al. (2003), whilst more recent research has been reported in background documents to WG-FSA. The aim of the current work was to collate and summarise existing biological data on *D. mawsoni*. The report focuses primarily on data collected from the Ross Sea fishery because this is where most of the work has been carried out, but data from the other areas and fisheries have been included when available. It is intended that this report form the basis of a species profile of *D. mawsoni* as requested at the 2005 CCAMLR meeting (SCCAMLR XXIV).

Hanchet, S. M., S. Mormede & A. Dunn. (2009) **Distribution and abundance of Antarctic toothfish in the Ross Sea**, pp. 25. CCAMLR, Hobart, Australia.
WG-EMM-09/40.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the
Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: This report is a synthesis of mostly existing information which has been compiled for the purposes of addressing items on the FEMA 2 agenda. It summarises the management of the fishery, catch and effort, size distribution, and tagging data collected from the Antarctic toothfish fishery up to the 2007/08 fishing year. It focuses in particular on Antarctic continental shelf of the Ross Sea itself, because this is the area where any ecosystem effects related to predators of toothfish are most likely to occur. Of the total catch from the fishery to date of almost 19 000 t, about 20% has been taken from the northern

grounds, 70% from the continental slope, and 10% from the continental shelf of the Ross Sea. The shelf catch has been taken from three quite localised fishing grounds of deep water (mainly > 800 m) off Terra Nova Bay, Ross Island, and in the south of 88.1L (adjacent to the Ross Ice Shelf). The catch rates from the exploratory longline fishery typically show high temporal and spatial variability, even between consecutive sets within the main fishing grounds. There are no reliable estimates of Antarctic toothfish abundance on the shelf at the current time. In preparing this paper we have identified some data sources which could potentially be used to estimate the abundance of toothfish on the Ross Sea shelf. However, CPUE is inherently variable both within and between seasons on the various fishing grounds and different vessels have fished different grounds in different years making interpretation difficult. Tag-recapture data from the Terra Nova Bay fishing ground would also be difficult to interpret because of the movement of tagged fish. There is also other information on the distribution of Antarctic toothfish from the area derived from other research surveys and from studies focusing on other species. US Scientists at McMurdo Sound have collected Antarctic toothfish since 1971 using vertical set lines. Their sampling has shown significant within and between season variability in catch rates. Very few Antarctic toothfish have been caught in the Ross Sea by other research sampling. Indirect observations from cameras mounted on seals shows that Antarctic toothfish at McMurdo Sound can occupy the entire water column, but the spatial and temporal extent of its midwater distribution and the proportion of the population which occurs off the bottom are unknown.

Hanchet, S. M., S. Mormede, S.J. Parker & A. Dunn. (2011) **Proposal for a CCAMLR sponsored research survey to monitor abundance of pre-recruit Antarctic toothfish in the southern Ross Sea**, pp. 20. CCAMLR, Hobart, Australia.
WG-SAM-11/16.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: The exploratory fishery for *Dissostichus* spp. has now been operating for 14 years in Subarea 88.1 and for nine years in Subarea 88.2. Associated research has led to an assessment of the fisheries potential yield, but a source of ongoing uncertainty in the stock assessment concerns recruitment dynamics. Although pre-recruit Antarctic toothfish fish are caught in various locations during fishing operations, different vessels catch different length classes in different locations and in different years, making it impossible to develop a consistent time series that would monitor trends in recruitment over time from the fishery. At its 2010 meeting, the Scientific Committee agreed that a time series of recruitments from a well designed survey could be a useful input into a stock assessment model and requested members develop a pre-recruit survey design. This paper develops a proposal for a CCAMLR sponsored research survey in response to the Scientific Committee request. We consider here the objectives of the survey, the target fish age and length classes to be monitored, appropriate survey strata size and location, the number of sets in each stratum required to achieve target c.v.s, and associated sampling methodologies. Further, we propose that the first survey be a pilot, with two main objectives:
(i) To establish the feasibility of developing a time series of longline surveys to monitor 80-100 cm TL toothfish in parts of SSRUs 881.J and 881.L in the southern Ross Sea using standardised gear in a standardised manner; and
(ii) To carry out experimental depth stratified fishing in 500-600 m depth adjacent to the survey boundaries to establish the most appropriate depth strata for future surveys. We are submitting this proposal to WG-SAM for further evaluation as requested by the Scientific Committee (SC-CAMLRXXIX, para 3.185).
We are particularly interested in ways to improve the survey design, as well as additional work that could be undertaken to demonstrate the use of the results of such a survey in the provision of advice to the Scientific Committee.

Hanchet, S. M., M. L. Stevenson & A. Dunn. (2006) **A characterisation of the toothfish fishery in Subareas 88.1 & 88.2 from 1997□98 to 2005□2006**, pp. 25. CCAMLR, Hobart,

Australia.
WG-FSA-06/29.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The exploratory fishery for Antarctic toothfish (*D. mawsoni*) has been operating for nine years in Subarea 88.1 and for five years in Subarea 88.2 with a large amount of data collected on toothfish and the associated bycatch. All SSRUs in the two subareas except for 881D and 882C have now been fished. The 2006 *D. mawsoni* catch was the second highest on record with a total of 3388 t against a combined catch limit of 3451 t. The subarea catch limit was almost reached in both Subarea 88.1 and 88.2. 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. Concentration of effort within a smaller spatial area also increased the recovery of tags by over 50% (Dunn & Hanchet 2006). Interesting patterns are beginning to emerge concerning the size distribution of fish from the different areas in Subareas 88.1 and 88.2. The occurrence of large adult fish from relatively shallow waters on the Ross Sea Shelf as well as the occurrence of small juveniles in much deeper water on the continental slope in Subarea 88.2 suggests that depth alone does not explain all the variation in toothfish length in the areas. Further sampling from along the continental slope of the continent is needed to determine the extent of these small fish.

Hanchet, S. M., M. L. Stevenson & A. Dunn. (2007) **A characterisation of the toothfish fishery in Subareas 88.1 & 88.2 from 1997□98 to 2006□2007**, pp. 20. CCAMLR, Hobart, Australia.
WG-FSA-07/28.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish
Stock Assessment Working Group of CCAMLR)
ABSTRACT: The exploratory fishery for Antarctic toothfish (*D. mawsoni*) has been operating for ten years in Subarea 88.1 and for five years in Subarea 88.2. This report summarises the large amount of data collected on toothfish and the associated bycatch by all vessels participating in the fishery. All SSRUs in the two subareas except for 881D and 882C have now been fished. The 2007 *D. mawsoni* catch was the second highest on record with a total of 3431 t against a combined catch limit of 3579 t. 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, and two catch limits exceeded in the 2007 season. Although there was a large overrun of the catch limit in the North region, the overall catch limit for Subarea 88.1 was only exceeded by 2%. The catch limit was under caught in Subarea 88.2. The concentration of effort within smaller spatial areas in Subarea 88.1 has undoubtedly contributed to the large increase in tag recoveries over the past two seasons (Dunn et al. 2007). The length frequency data from the Ross Sea fishery have been very consistent over the past 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.

Hanchet, S. M., M. L. Stevenson, N. L. Phillips & A. Dunn. (2005) **A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997□98 to 2004□05**, pp. 27. CCAMLR, Hobart, Australia.
WG-FSA-05/29.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)

ABSTRACT: The exploratory fishery for *Dissostichus* spp. has now been operating for 14 years in Subarea 88.1 and for 9 years in Subarea 88.2. This report summarises the timing, depth, and location of fishing together with the catch of *Dissostichus* spp and bycatch species by year for the period 1997-98 to 2009-10. During the 2009-10 fishing year most of the catch in Subarea 88.1 came from the slope SSRUs 881H and 881I, with a reduced catch from 881K due to ice conditions. The catch limit in the north was all taken from 881C, whilst the catch limit from the shelf was taken mainly from 881J. Most catch from Subarea 88.2 was taken from SSRU 882E, with little fishing occurring in the other SSRUs, and the catch limit was under caught by 250 t. Unstandardised catch per set and catch per hook have varied considerably over time in each of the fisheries showing no trend in the main fisheries in Subarea 88.1 and SSRU 88.2E, but a slight decline in SSRU 882CDFG over the last two years.
We carried out a more detailed characterisation of Patagonian toothfish catches for the first time. A total of 124 t of Patagonian toothfish has been reported from the fishery, with catches mainly coming from the northwest of the Ross Sea region (SSRUs 881A and 881B). Some observers appear to have problems distinguishing the two toothfish species, and many small (<100 cm TL) toothfish which have been reported as Antarctic toothfish should in fact be Patagonian toothfish. We recommend that observers be made aware of this issue, and that the species identification be independently checked through examination of a subsample of otoliths from these small fish.
A major source of uncertainty in the current stock assessment concerns the recruitment dynamics. It has been suggested that a pre-recruit longline survey be developed to collect data to better estimate these parameters. We recommend WG-FSA consider whether such a survey would be worthwhile and identify several fishing grounds on the Ross Sea shelf where such a survey could be carried out.

Hanchet, S.M., D. Fu & A. Dunn. (2008) **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.** . CCAMLR, Hobart, Australia.
WG-FSA 08/32.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: 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, para 11.53). The bycatch 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 t (cv = 29%) to 41 823 t (cv = 28%) depending on assumptions. Applying estimates of gamma (γ) = 0.01439 and 0.01814 gave indicative estimates of yield in range 386-602 t and 487-759 t respectively. These indicative yield estimates provide tentative support for the bycatch limit of 374 t currently in place for *M. whitsoni* on the Ross Sea slope (SSRUs 88.1H-L and

88.2A-B).

Hanchet, S.M., S. Mormede, S. Parker & A Dunn. (2012) **Proposal to continue the time series of research surveys to monitor abundance of pre-recruit Antarctic toothfish in the southern Ross Sea in 2013**, pp. 8. CCAMLR, Hobart, Australia.
WG-SAM-12/28.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: At its 2011 meeting, the Scientific Committee agreed that a time series of relative recruitments from a well-designed survey could be a useful input into the Ross Sea stock assessment model and endorsed a proposal to carry out this work once the fishery had closed at the end of the 2011/12 season. The first survey was successfully completed in February 2012 and the results presented to the 2012 meeting of WG-SAM (Hanchet al. 2012). In this paper we provide a proposal to continue this time series. The objectives of this second survey of the time series are as follows:
(i) To carry out the second of a time series of longline surveys to monitor pre-recruit (<110 cm TL) toothfish in the southern Ross Sea (strata A12-C12) using standardised gear in a standardised manner; and
(ii) To define additional experimental stations in adjacent areas to identify areas of high pre-recruitabundance which could be included as additional strata in future annual surveys.

Hanchet, S.M., S. Mormede, S. Parker, A. Dunn & H.-S. Jo. (2012) **Results of a CCAMLR-sponsored research survey to monitor abundance of pre-recruit Antarctic toothfish in the southern Ross Sea, February 2012**, pp. 22. CCAMLR, Hobart, Australia.
WG-FSA-12/41.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: At its 2011 meeting, the Scientific Committee agreed that a time series of relative recruitments from a well-designed survey could be a useful input into the Ross Sea stock assessment model and endorsed a proposal to carry out this work once the fishery had closed at the end of the 2011/12 season. The survey had two main objectives: (i) To establish the feasibility of developing a time series of longline surveys to monitor pre-recruit (<100 cm TL) toothfish in the south of SSRUs 881.J and 881.L in the southern Ross Sea using standardised gear in a standardised manner; and (ii) To carry out experimental depth-stratified fishing in 400-600 m depth adjacent to the survey boundaries to establish the most appropriate depth strata for future annual surveys. The survey demonstrated it is possible to carry out a longline survey of pre-recruit toothfish from a commercial fishing vessel in Ross Sea using standardised gear in a standardised manner. Based on a total of 45 sets in the three core strata (A12-C12) the survey biomass estimate had an overall c.v. of 9%, which met the target c.v. of 10%. The survey caught mainly 70-110 cm TL, 5-10 year old, Antarctic toothfish. It provided new data on the depth distribution of pre-recruit fish in this area. Catch rates of pre-recruit toothfish were highest between 500 and 900 m and very low shallower than 450 m. The size distribution of toothfish was very similar between the four main strata suggesting no depth preference between 400 and 900 m. It is recommended that future surveys in this area should focus on depths of 500-900 m. The survey also demonstrated the feasibility of collecting samples for wider ecosystem monitoring. Although the main aim of the 2012 survey was to monitor pre-recruit toothfish, the survey provided the opportunity to compare survey catch rates in 2012 with historical commercial catch rates by *San Aotea II* and its sister ship *Janas* in 1999, 2001, and 2004. The results of this analysis suggest that there has been no significant change in catch rates in the southern Ross Sea over the past decade.

Hanchet, S.M., S. Mormede, S.J. Parker & A. Dunn. (2011) **Revised proposal for a CCAMLR sponsored research survey to monitor abundance of pre-recruit Antarctic toothfish in the southern Ross Sea.** CCAMLR, Hobart, Australia.
WG-FSA-11/47.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented

at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: At its 2010 meeting, the Scientific Committee agreed that a time series of recruitments from a well-designed survey in the Ross Sea could be a useful input into the stock assessment model and requested members develop a pre-recruit survey design. A preliminary proposal for a pre-recruit survey was presented to the 2011 meeting of WG-SAM. In this paper we provide an update of the preliminary proposal by taking into account the comments of WG-SAM. It provides the scientific rationale and background for the research proposal for a longline survey of pre-recruit toothfish in the southern Ross Sea, which has been submitted as a paper to the Scientific Committee. We consider here the objectives of the survey, the target fish age and length classes to be monitored, appropriate survey strata size and location, the number of sets in each stratum required to achieve target c.v.s, and associated sampling methodologies. As a result of this review, we propose that the first survey be a pilot, with two main objectives:
(i) To establish the feasibility of developing a time series of longline surveys to monitor prerecruit (<100 cm TL) toothfish in the south of SSRUs 881.J and 881.L in the southern Ross Sea using standardised gear in a standardised manner; and
(ii) To carry out experimental depth-stratified fishing in 400-600 m depth adjacent to the survey boundaries to establish the most appropriate depth strata for future annual surveys.

Hanchet, S.M. & S.J. Parker. (2014) **Towards the development of an assessment of stock abundance for Subarea 88.2 SSRUs 88.2C–G** pp. 16. CCAMLR, Hobart, Australia.
WG-FSA-14/59.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This paper frames a discussion for improving the assessment of toothfish abundance for SSRUs 88.2C-G. We initially provide a characterisation of the fishery and a summary of available tagging and length frequency data. Although 880 tagged fish have been released in this region, only 2 tagged fish have been recaptured. It is likely that the lack of recaptures of tagged fish in this region has been caused primarily by the poor spatial overlap of released tagged fish with subsequent fishing effort.
By drawing on the success of tagging programmes in other CCAMLR fisheries, we develop an approach for improving the spatial overlap of the location of tagged fish and subsequent fishing effort. We identify four main grounds previously fished in SSRUs 88.2C-G. We recommend that in the short term (the next 2-3 years) it be made mandatory for vessels to complete all of their sets inside one or more of these fishing grounds as a condition of fishing in the slope region (SSRUs 88.2C-G). This condition could be relaxed in future years once sufficient tags have been recaptured to carry out an assessment of the stock in this region. We also recommend that the tagging rate in this region be increased to at least 3 tags per tonne in the short term. In addition to improving estimates of abundance a higher tagging rate and more recaptures will also increase information on fish movement within the Amundsen Sea slope which will help reduce uncertainty about the stock identity of toothfish caught in this area.

Hanchet, S.M., S.J. Parker & S. Mormede. (2014) **Proposal to continue the time series of CCAMLRsponsored research surveys to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea in 2015**, pp. 10. CCAMLR, Hobart, Australia.
WG-SAM-14/25.Used for Ross Sea Toothfish MSC 2014 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: This paper is presented for consideration by CCAMLR and may contain unpublished data, analyses, and/or conclusions subject to change. Data in this paper shall not be cited or used for purposes other than the work of the CCAMLR Commission, Scientific Committee or their subsidiary bodies without the permission of the originators and/or owners of the data. 1 By indicating that the paper is to be considered for publication in CCAMLR Science the authors have agreed that the paper can be considered by the Editorial panel of the journal and that if the paper is accepted for peer review it is the

responsibility of the authors to ensure that permission to publish data and cite working group papers has been received.

Hanchet, S.M., G. Rickard, J. M. Fenaughty, A. Dunn & M. Williams. (2007) **A hypothetical life cycle for Antarctic toothfish *Dissostichus mawsoni* in Antarctic waters of CCAMLR Statistical Area 88**, pp.
25. CCAMLR, Hobart, Australia.
WG-FSA-07/35.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Aspects of the reproduction, size distribution, and movements of Antarctic toothfish *Dissostichus mawsoni* in CCAMLR Statistical Areas 88.1 & 88.2 were reviewed. Based on the presumed location and timing of spawning, and the probable early life history characteristics of toothfish, we investigated models that mimic the drift of eggs and larvae over a 6-24 month period using an oceanic circulation model linked to the high resolution global environmental model (HiGEM). The location of toothfish larvae after an 18-24 month period suggested by the models agreed moderately well with the distribution of the smallest toothfish taken in the toothfish fishery.
Our present hypothesis is that *D. mawsoni* in CCAMLR Statistical Subareas 88.1 and 88.2 spawn to the north of the Antarctic continental slope, mainly on the ridges and banks of the Pacific-Antarctic Ridge. The spawning appears to take place during winter and spring, and may extend over a period of several months. Depending on the exact location of spawning, eggs and larvae become entrained by the Ross Sea gyres, and may either move west settling out around the Balleny Islands and adjacent Antarctic continental shelf, south onto the Ross Sea shelf, or eastwards with the eastern Ross Sea gyre settling out along the continental slope and shelf to the east of the Ross Sea in Subarea 88.2. As the juveniles grow in size they move west back towards the Ross Sea shelf and then move out into deeper water (greater than 600m). The fish gradually move northwards as they mature, feeding in the slope region in depths of 1000-1500 m, where they gain condition before moving north onto the Pacific-Antarctic ridge to start the cycle again. Spawning fish may remain in the northern area for up to 2-3 years. They then move southwards back onto the shelf and slope where productivity is higher and food is more plentiful where they regain condition before spawning. We recommend research surveys be carefully planned to test some of these hypotheses.

Hanchet, S.M., M.L. Stevenson, C. Jones, P.M. Marriott, P.J. McMillan, R.L. O'Driscoll, D.W. Stevens, A.L. Stewart & B.A. Wood. (2008) **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.** CCAMLR, Hobart, Australia.
WG-FSA-08/31.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: 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.

Hilborn, Ray. (2010) **Pretty Good Yield and exploited fishes**. *Marine Policy* 34, 193-196.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013

ABSTRACT: While much of traditional fisheries theory has concentrated on maximum or optimum yield, the reality of fisheries management is that biomass yield is only one of the several indicators of fisheries performance, and desired outcomes generally only need to provide something near the maximum possible yield. A range of policies are explored to find those that produce "Pretty Good Yield" defined as sustainable yield at least 80% of the maximum sustainable yield. Such yields are generally obtained over a broad range of stock sizes (20-50% of unfished stock abundance), and this range is not sensitive to the population's basic life history parameters such as natural mortality rate, somatic growth rate, or age at maturity. The most important biological parameter determining this range is the intensity of recruitment compensation. Meta-analysis shows compensation is usually strong and there is reasonably little yield lost at what are now widely accepted definitions of overfishing or risk for most stocks. Similarly, maintaining stocks at 50% of unfished stock abundance for ecological or economic reasons results in little expected loss of yield.

Horn, P.L. (2002) **Age and growth of Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*) in waters from the subantarctic to the Ross Sea, Antarctica**. *Fisheries Research,* 56, 275-287.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: The margins of otoliths of Patagonian toothfish (*Dissostichus eleginoides*) from several samples collected throughout the year were classified as either opaque or translucent. The margins were generally opaque in summer and translucent in winter. Thus, this species appears to deposit one translucent zone in its otoliths each year, and counts of these zones are probably a valid method to determine fish age. Comparisons of readings of *D. eleginoides* otoliths by workers from various institutions indicated a reasonable between-reader consistency, but still suggested that the otoliths were difficult to read. Von Bertalanffy growth parameters were calculated from the author's readings only, separately by sex, for *D. eleginoides* caught from waters south of New Zealand to the Ross Sea, Antarctica, by longline and trawl fisheries. *D. eleginoides* appear to be moderately fast growing, at least to about age 10, and reasonably long-lived, reaching at least 50 years. Females grow at a faster rate and reach a larger size than males, but both sexes exhibit comparable maximum ages. Von Bertalanffy growth parameters were also calculated, separately by sex, for Antarctic toothfish (*Dissostichus mawsoni*) caught by the longline fishery in the northern Ross Sea. Otoliths of this species were interpreted similarly to those of *D. eleginoides*, but this method of ageing *D. mawsoni* is invalidated. *D. mawsoni* appears to be moderately fast growing, at least to about age 10, and can live for at least 35 years. This species probably grows at a slightly faster rate, and reaches a larger size than *D. eleginoides*.

Horn, P.L. & C.P. Sutton. (2010a) **A preliminary assessment of age and growth of Antarctic silverfish (*Pleuragramma antarcticum*) in the Ross Sea, Antarctica.** . CCAMLR, Hobart, Australia.
WG-FSA-10/20.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Antarctic silverfish (*Pleuragramma antarcticum*) were sampled during a trawl survey in the Ross Sea, Antarctica. Biological data, including fish length, weight, sex, gonad maturity, liver weight and diet analysis were collected from 311 specimens. Standard length and weight were well correlated (r2 = 0.99). Counts of growth zones in 304 thin-sectioned otoliths were used to estimate ages and von Bertalanffy growth parameters. The species is relatively slow-growing with a moderate longevity; the maximum estimated age was 14.3 years. Von Bertalanffy parameters derived for both sexes combined are: L□, 22.1 cm SL; K, 0.167 y-1; t0, -0.4 years. Parameter estimates were also derived for the sexes separately. Female Antarctic silverfish appear to reach a larger size than males, but none of the estimated von Bertalanffy parameters were statistically significantly different between sexes. All parameter estimates are preliminary as the ageing method is unvalidated and about two-thirds of the sampled fish could not be sexed.

Precision estimates and age bias plots indicated that there was good within-reader and betweenreader agreement, so the otolith sections appear able to be consistently interpreted. The standard lengths of the sampled Antarctic silverfish ranged from 4.6 cm to 22.9 cm. Pronounced modes in the length-frequency distribution occurred at 7.1-7.5 cm, 10.6-11.0 cm, and 15.1-15.5 cm. The agefrequency distribution exhibited a mode from age 6 to 9 years.

Horn, P.L. & C.P. Sutton. (2010b) **A preliminary assessment of age and growth of eel cod (*Muraenolepis sp.*) and violet cod (*Antimora rostrata*) in the Ross Sea, Antarctica** CCAMLR, Hobart,
Australia.
WG-FSA-10/19.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Samples of an eel cod (*Muraenolepis* sp.) and violet cod (*Antimora rostrata*) were obtained from the bycatch of the longline fishery for toothfish (*Dissostichus mawsoni* and *D. eleginoides*) in the Ross Sea, Antarctica. Counts of zones visible in sectioned otoliths were used to estimate growth parameters for these species. The estimates must be considered preliminary because they are unvalidated, the otoliths are quite difficult to interpret, and the sampled fish do not represent the full length or sex distributions of the populations (i.e., small fish and males were absent).
The *Muraenolepis* samples were not identified to species. However, they were obtained from a relatively confined areal and depth range, so probably comprise a single species. They are relatively short-lived, with a maximum estimated age of 9.5 years. Von Bertalanffy parameters derived from female and unsexed fish only are: L□, 42.8 cm TL; K, 0.408 y-1; t0, -0.1 years. Violet cod are relatively long-lived, with a maximum estimated age of 41.5 years. Von Bertalanffy parameters derived from female and unsexed fish only are: L□, 78.4 cm TL; K, 0.053 y-1; t0, 0.1 years.

Horn, P.L., C.P. Sutton & A.L DeVries. (2003) **Evidence to support the annual formation of growth zones in otoliths of Antarctic toothfish (*Dissostichus mawsoni*)**. *CCAMLR Science,* 10, 125□138.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013
ABSTRACT: Antarctic toothfi sh (*Dissostichus mawsoni*) from the Ross Sea (CCAMLR Subarea 88.1) have been aged assuming that one translucent zone is formed annually in the otoliths of this species. However, no evidence to validate this assumption has previously been presented. In the current work, otoliths from four distinct juvenile length-frequency modes were examined, and the translucent zones counted. Zone counts were consistent within modes, and increased by one in each consecutive mode. This indicates that the modes represented year classes and that one translucent zone is formed annually in otoliths of juvenile *D. mawsoni*. Mean fi sh lengths at ages 0.5, 1.5, 2.5 and 3.5 years were estimated to be 14, 28, 37 and 46 cm total length (TL) respectively. These estimates agree with growth curves calculated previously from a sample of data that was large but lacked any fi sh younger than 3.5 years. Counting translucent zones in the otoliths of *D. mawsoni* appears to be a valid method for determining the age of this species. In addition, sagittal otoliths were examined from *D. mawsoni* that had been injected with oxytetracycline some years before recapture. The six recaptured fish were all large (129-145 cm TL at tagging) and had been at liberty from 1 to 7 years. The number of zones between the fluorescent oxytetracycline line and the otolith margin indicates that one translucent zone is formed annually in otoliths of post-mature *D. mawsoni*.

Jo, H.-S., I. Yeon, C. Lim, S M Hanchet, D.W. Lee & C.-K. Kang. (2013) **Fatty acid and stable isotope analyses to infer diet of Antarctic toothfish caught in the southern Ross Sea**. *CCAMLR Science,* 20, 21-36.
MSC Reference for Ross Sea Toothfish annual surveillance in 2013

ABSTRACT: To infer important prey resources for Antarctic toothfish (*Dissostichus mawsoni*) in the southern Ross Sea, their lipid composition was determined and compared to lipid profiles of fish and invertebrate species taken as by-catch in the fishery or collected from the stomachs of toothfish. Stable carbon and nitrogen isotope ratios were also determined to further identify feeding relationships between these species. The aim of this study was to establish the feasibility of tracking the main dietary items of Antarctic toothfish by comparing results of biomarker analysis and conventional diet analysis. Samples were collected during a longline survey of pre-recruit toothfish in February 2012. Results of fatty acid (FA) and stable isotope analyses from this study provide evidence that a combination of these two techniques can delineate the main prey items of Antarctic toothfish and trophic structure of the toothfish-related fish food web in the southern Ross Sea ecosystem. Similarities in total FA compositions and the FA profiles in muscle tissue of Antarctic toothfish, and *Pleuragramma antarcticum*, *Pogonophryne barsukovi*, *Dacodraco hunteri* and *Trematomus loennbergii* indicated a trophic connection between toothfish and these fish species.
Mean δ15N values of Antarctic toothfish were higher than those of *P. antarcticum*, *P. barsukovi* and *T. loennbergii*, indicating a higher trophic position of the toothfish. In contrast, similar δ15N values between Antarctic toothfish and icefish (*D. hunteri*) suggested that they occupy the same trophic position. Overall results of this survey are consistent with the frequency and percentage occurrence of prey in Antarctic toothfish stomachs. Further sample collection and biomarker analyses for more pelagic and benthic biota are needed to better understand the entire food-web structure in the southern Ross Sea.

Kock, K.-H. (1992) *Antarctic fish and fisheries*. Cambridge University Press.
ABSTRACT: Antarctic finfish have been exploited for more than two decades and many stocks now appear to be overfished. This is the first detailed account of this fishery, and will help us better understand how to manage it. The book begins by giving a comprehensive description of Antarctic fish biology and ecology, the thorough understanding of which is a prerequisite to sound management of the fishery. Subsequent sections consider the course of finfish exploitation and the present state of exploited fish stocks in the Southern Ocean. The author concludes by proposing more effective management methods for the fish resources of the Southern Ocean in light of the Convention on the Conservation of Antarctic Marine Living Resources.

Kock, K.H., K. Reid, J. Croxall & S. Nicol. (2007) **Fisheries in the Southern Ocean: an ecosystem approach**. *Philosophical Transactions of The Royal Society B-Biological Sciences,* 29, 2333-2349.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is bound by its Article II, 3 to follow an ecosystem approach to management. This approach has been extended to the application of a precautionary approach in the late 1980s. In our review, we deal primarily with the science-related aspects of CCAMLR and its development towards an ecosystem approach to the management of the living resources of the Southern Ocean. To assist the Commission in meeting its objectives, as set out in Article II, 3, the Scientific Committee established the CCAMLR Ecosystem Monitoring Programme to detect possible effects of krill fishing on the performance of top-level predators, such as albatrosses, penguins, petrels and fur seals. Fisheries in the Southern Ocean followed the fate of other fisheries worldwide in which target species were depleted to low level one after the other. Currently, two types of fisheries are open: the longline fisheries on Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*Dissostichus* mawsoni) and the trawl fisheries on mackerel icefish (Champsocephalus gunnari). Both fisheries are managed in a single-species context, however, with conservation measures in place to protect bycatch species, such as rattails (Macrouridae) and skates and rays (Rajidae). Two major problems still exist in fisheries in the Southern Ocean: the by-catch of birds in longline fisheries

primarily in the Indian Ocean and the high level of IUU fishing again in the Indian Ocean. Both, the by-catch of birds and high IUU catches undermine the credibility of CCAMLR to safeguard the marine living resources in the Southern Ocean.

Kohen, M., J. Berguno, I. Everson, N. Gilbert, E. Marschoff, F. Meere, M. Richardson, R. Sanchez and K.Sainsbury. (2008) **CCAMLR performance review panel report**
ABSTRACT: none

Ladroit, Y., R. O'Driscoll & S. Mormede. (2014) **Using acoustic echo counting to estimate grenadier abundance in the Ross Sea (SSRU88.1I)**, pp. 25. CCAMLR, Hobart, Australia.
WG-FSA-14/62.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Grenadiers (*Macrourus* spp.) are the main bycatch species in the exploratory longline fishery for toothfish in the Ross Sea. Previous studies concluded that acoustics methods could be used to index the relative abundance of grenadiers and be useful for exploring spatial distribution. Automated acoustic methods were developed to estimate grenadier distribution and abundance based on echo counting. These methods can be applied to large volumes of relatively low quality, opportunistically collected acoustic data. Trials using data from SSRU 88.1I showed positive correlations between acoustic targets and longline catches of grenadiers and toothfish. Single targets were most abundant within 250 m of the bottom at seabed depths of 700-1000 m, and revealed consistent spatial patterns, with higher numbers of targets on the eastern side of the Iselin Bank. The acoustic target strength distribution of single targets was similar to that predicted based on the expected size range of grenadiers. Variability in spatial coverage between years meant that it was not possible to obtain a consistent time-series of relative abundance estimates for grenadiers from acoustic data collected opportunistically by New Zealand vessels in SSRU 88.1I. The next step will be to apply to these methods to a wider set of data across the Ross Sea region.
Recommendation:
We recommend that other nations routinely collect acoustic data in the Ross Sea fishery and make this available for analysis. Collection of acoustic data from a larger pool of vessels would increase the available information, so that more consistent spatial coverage of grenadier distribution might be achieved.

Lodge, M.W., D. Anderson, T. Løbach, G. Munro, K. Sainsbury & A. Willock. (2007) **Recommended Best Practices for Regional Fisheries Management Organizations: Report of an independent panel to develop a model for improved governance by Regional Fisheries Management Organizations.** Chatam House, London, 160 pp.
ABSTRACT: The idea of preparing a comprehensive suite of recommended best practices for regional fisheries management organizations (RFMOs) was fi rst proposed as one of the recommendations of the ministerially-led Task Force on Illegal, Unreported and Unregulated Fishing on the High Seas (the High Seas Task Force). Although the purpose of the Task Force's work was to devise a set of practical proposals for tackling the immediate problem of illegal, unreported and unregulated (IUU) fishing, it very quickly realized that if international actions aimed at curbing IUU fishing were to achieve their full effect, it would be essential also to improve the effectiveness with which the present system of high seas governance is implemented. A key aspect of this would be to promote and encourage progressive reform of RFMOs so as to ensure that they are fully equipped to carry out the role envisaged for them by international fishery instruments such as the UN Fish Stocks Agreement and the FAO (UN Food and Agriculture Organization) Code of Conduct for Responsible Fisheries. Although a relatively recent phenomenon (the first such regional organizations began to appear in the 1950s), RFMOs are generally acknowledged to play a critical role in the global system of fisheries governance. In recent years, there has been an increasing recognition of the need for RFMOs to improve their performance in accordance with the demands of

strengthened international fishery instruments aimed at better conservation and management of fishery resources. Calls for better performance have come from, inter alia, the 2006 United Nations Fish Stocks Review Conference, the FAO Committee on Fisheries, the 2005 St John's Conference on the Governance of High Seas Fisheries and the High Seas Task Force. The most recent (December 2006) UN General Assembly resolution on sustainable fisheries urged RFMOs to strengthen their mandates and to modernize their measures for and approaches to fisheries management; it called upon States to make further efforts to strengthen and enhance cooperation among existing and developing RFMOs.1 The same resolution also called upon States to develop and apply best practice guidelines to RFMOs and to undertake performance reviews of them, based on transparent criteria. This publication is intended to assist and inform States and RFMOs in their efforts to improve RFMO performance by setting out what the Panel collectively views as current 'best practice' in the implementation of international fishery instruments and by clearly delineating the priorities and goals that RFMOs should pursue if they are to meet the core challenges of global fisheries management.

M.H. Pinkerton, A. Dunn and S.M. Hanchet 2008. (2008) **Trophic overlap of Weddell seals (*Leptonychotes weddelli*) and Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea, Antarctica.** . CCAMLR, Hobart, Australia.
WG-EMM 08/43.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: 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, animalmounted 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.

Mangel, M., J. Brodziak & G.M. Watters. (2014) **Steepness for Antarctic toothfish**

(*Dissostichus mawsoni*) based on life history, pp. 30. CCAMLR, Hobart, Australia.
WG-FSA-14/32.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Although steepness is typically considered a convenient re-parametrization of a stockrecruitment relationship, it is deeply rooted in the biology of each species. Furthermore, specifying steepness and other life-history parameters such as natural mortality and growth rates fixes reference points that are commonly used in fisheries management. Thus, one cannot pick an arbitrary value of steepness in a stock assessment. We take the first step towards a consistent treatment of steepness for Antarctic toothfish by showing how to compute a frequency distribution of steepness based on life-history parameters. We also highlight what the next steps should be both theoretical and empirical - for improving estimates of steepness and their use in stock assessments.

Marriott, P.M., M.J. Manning & P.L. Horn. (2005) **Age estimation and maturity of the ridge-scaled macrourid, *Macrourus whitsoni*, from the Ross Sea**, pp. 19. CCAMLR, Hobart, Australia.
WG-FSA-05/20.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Juveniles of the macrourid rattail *Macrourus whitsoni* were collected by the NIWA research vessel *Tangaroa* during the BioRoss survey of the Western Ross Sea and Balleny Islands, with the purpose of analyzing the otoliths to generate more accurate age estimates for this species. Intensive analysis of otoliths from small specimens greatly increased confidence in the interpretation of the zone structure displayed in the early growth rings. The findings supported the interpretation protocols used in previous work on this species. Von Bertalanffy growth curves were generated and compared to previous results finding no significant differences between the years. Von Bertalanffy parameters for the pooled dataset with unsexed juveniles are L∞ 76.12, K 0.065 and 0 t -0.159 for males and L∞ 92.03, K 0.055 and 0t 0.159 for females. Revised es mates of the mean total lengthat-maturity (38.8cm, 46.4cm) and mean age-at-maturity (10.6 years, 13.6 years) are presented for males and females respectively, using a reduced probit model.

McClure, E. & K. Reid. (2014) **A review of by-catch in CCAMLR exploratory toothfish fisheries**, pp.
34. CCAMLR, Hobart, Australia.
WG-FSA-14/16.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Mitigating the adverse affects of commercial fishing on the environment is an integral responsibility of fisheries globally. Efforts to reduce bycatch, to exploit previously unfavourable species and to carry out research on associated organisms have increased with time but charismatic megafauna tend to gain priority, despite their numbers being relatively low compared to fish bycatch species. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is widely recognized for its thorough and effective management of Southern Ocean toothfish fisheries, especially in eliminating incidental seabird mortality, but comparatively little research has been applied to the thousands of fish caught as bycatch annually. Fish bycatch mitigation controls in toothfish fisheries have seen a relatively recent evolution through CCAMLR's conservation measures but their effectiveness has not been thoroughly investigated. This study explores trends in fish bycatch of exploratory fisheries for toothfish within the CCAMRL Convention Area, from 2006-2013, relating observations to CCAMLR's conservation measures. We found a significant reduction in bycatch landings by weight and number of individuals across years, despite no significant reduction in fishing effort probably linked to changes in landings of skates. Bycatch by weight formed 6.7% of total catch per year, however the number of individuals landed was at times double that of toothfish. Gear type comparisons indicate that autolines catch a greater diversity of bycatch species than Spanish lines and trotlines.

McMillan, P.J., P. Marriott, S.M. Hanchet, J.M. Fenaughty, E. Mackay & H. Sui. (2007) **Field identification guide to the main fishes caught in the Ross Sea longline fishery**, pp. 35. CCAMLR, Hobart, Australia.
WG-FSA-07/41.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: A preliminary field identification guide to the main fishes caught by toothfish longline boats fishing in the Ross Sea was prepared under the New Zealand Ministry of Fisheries Project ANT2005-02 and was used by Ministry of Fisheries observers and fishers during the 2006-07 season. That guide was revised in 2007 following comments and suggestions from the users and now covers 27 taxa. Mostly it provides information for identification to species but for liparids (snailfishes), zoarcids (eelpouts) and bathydraconids (dragonfishes) identification is at family level and for Muraenolepis (eel cods), and Pogonophryne (plunderfishes) identification is to genus. Identification to species for some fishes is difficult because of uncertain taxonomic status, e.g., Pogonophryne, or scarcity of field characters, e.g., liparids. Some species likely to be seen only in stomach contents of other fishes are included. Future revisions could be made as taxonomic issues are resolved, and more species are recorded from the Ross Sea. Data and images are stored on a relational database to facilitate revision and easy information retrieval.

Middleton, D.A.J. (2010) **Stability of trip selections for the assessment of Antarctic toothfish in the Ross Sea**. CCAMLR, Hobart, Australia.
WG-FSA-10/26.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: A dataset for the 2009 assessment of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea was selected on the basis of data quality metrics for individual trips. Initial informative datasets were selected comprising trips with high (above median) rates of recovery of previously released tags, and/or where tags released on the trip were subsequently recaptured at a high rate. These trips were used to define a range for various data quality metrics considered to be informative with respect to tagging data. Other trips with data quality metric values within these ranges were added to the dataset. A retrospective analysis of this data selection method was undertaken to evaluate whether trip selection was stable over time. The 2009 dataset was reduced by omitting data from the two most recent years, and the data selection method applied to these 2007 and 2008 datasets. Results from this three year period indicate that additional, historical trips may be added to the data set as new tagging data become available. However, once selected, trips are also selected in subsequent years. This analysis indicates that the tagging data selection methodology developed for the 2009 assessment yields generally stable selections over time. The retrospective analysis period is, however, short, and stability of trip selection in future years as further data are added will also be of interest.

Middleton, D.A.J. & A Dunn. (2009) **Identification of data quality metrics for tagging data selection**, pp. 14. CCAMLR, Hobart, Australia.
WG-SAM-09/19.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: The suite of data quality metrics introduced by Middleton & Dunn (2008) is examined to identify those metrics that are most informative with respect to the identification of good tagging data. Trips considered to have “known” good tagging data are identified, based on above-median rates of recapture of tags released by the trip, and above-median tag recapture rates by the trip. A bootstrap analysis indicates that the range of data quality metrics associated with known good tagging data is sensitive to the set of trips considered to have good data. However, a restricted set of data quality metrics may be most powerful in distinguishing the trips considered to have good tagging data. These include metrics for taxonomic resolution in the observer data, goodness of fit of catch data to Benford’s Law, and the variation in toothfish catch rates. This reduced set of data quality metrics could be helpful in the identification of trips which have similar data quality to the known “good data”

trips, but where, due to heterogeneity in the stock and in the spatial and temporal distribution of fishing effort, it is not possible to establish this directly from tag recaptures.

Middleton, D.A.J. & A. Dunn. (2008) **Development of a methodology for data quality assessment.**, pp. 32. CCAMLR, Hobart, Australia.
WG-SAM-08/13.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the
Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: 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.

Mormede, S. (2008) **Year of the Skate sampling protocol: learning from the 2007-08 season sampling protocol on NZ vessels**. CCAMLR, Hobart, Australia.
WG-FSA-08/49.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: 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 bycatch 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.

Mormede, S. (2013a) **Further development of pairwise tag detection performance index and its application to the stock assessment of toothfish in the Ross Sea fishery**, pp. 10. CCAMLR, Hobart,
Australia.
WG-SAM-13/34.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the
Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: Tag release and recapture data are used in integrated age-structured stock assessments of Antarctic toothfish

(*Dissostichus mawsoni*) in Subareas 88.1 and 88.2 to determine abundance and sustainable yields.
The assessment model assumes that all vessels have equal tag detection rates; as a consequence including observations from vessels with low detection rates (and/or low tagging survival rates) could lead to an over-estimate of the stock biomass. In this paper we develop further an index of vessel-specific tag detection performance for the Ross Sea fishery using a case-control methodology which controls for the inter-annual spatial and temporal variability of commercial fishing operations from which tags are released and recaptured. We then develop selection criteria, which can be used to determine the subset of vessels for which there is confidence in their tag-recapture data. Finally, we apply these selection criteria to the tag data available at the time of the 2011 stock assessment to determine the effect of this selection method on the tag data available and also illustrate its effect on the results of that assessment.
For each vessel in the fishery, every fishing haul from the nominated 'case' vessel was matched to one or more 'control' hauls from other vessels fishing in the same time and location (i.e. in the same fishing season and within a specified distance). The index was calculated as the scaled number of tags recaptured by the case hauls relative to the number of tags recaptured by the matched control hauls. By iterating over all events for all vessels, we generated a relative index of tag detection rate for each vessel, with a value of one representing the average performance across all vessels. The tag data from vessels for which the confidence interval was greater than zero and extended at or above one were selected for inclusion in the stock assessment. When applying this decision rule, 75% of all tags released and 83% of tags recaptured were selected for inclusion in the analysis. In comparison, when the 2011 stock assessment was carried out using a different data selection algorithm, more than 90% of all tags released and recaptured were selected for inclusion. We recommend this approach be used as a data selection method for the stock assessment of toothfish in the Ross Sea region. The application of such indices could be extended to other regions where tag data is used in stock assessment, and developed for other data types such as catch per unit effort when used to inform stock assessment.

Mormede, S. (2013b) **Pairwise tag performance: testing the sensitivity of the tag detection index and the mortality of tagged fish index**, pp. 9. CCAMLR, Hobart, Australia.
WG-FSA-13/50.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: Vessel-specific indices of tag detection rates and tagging mortality rates were developed in 2012 and further developed in 2013, using a methodology which controls for the spatial and temporal variability of fishing operations by pairing each individual tag release or recapture event with all other fishing events which occurred in the same time and place (i.e. within a specific distance and in the same fishing season). The method showed that when the confounding effects of variable fishing location and time were controlled there were nonetheless significant differences between vessels with respect to the tag detection index in the Ross Sea region. Here we present the results of simulations which indicate that the index of tagging mortality rate obtained using this method is not as useful as is the index of tag detection rate. We recommend that in the absence of a better index of tagging mortality, the tag detection index be used to select data for use in the 2013 toothfish stock assessments for the Ross Sea and Subarea 88.2 fisheries, with respect to both tag releases and tag recaptures. This recommendation is in accordance with that of most of the participants at WG-SAM 2013 (paragraph 4.7).

Mormede, S. & A Dunn. (2010) **Characterisation of skate catches in the Ross Sea Region**, pp. 23. CCAMLR, Hobart, Australia.
WG-FSA-10/25.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The toothfish fishery in the Ross Sea region (CCAMLR Subareas 881 and 882)

has been operating since the 1996-97 fishing season. The fishery has increased to an annual Antarctic toothfish (*Dissostichus mawsoni*) catch of about 3000 t. Skates form a small proportion of the total catch (typically 2% or less). In this paper we summarise the current available fisheries and biological information for skates in the Ross Sea Region, including the data collected in the two "Year of the Skate" fishing seasons in 2008/09 and 2009/10. The composition of the skate catch by species is uncertain; it is estimated that about 33 000 starry skates were landed, and 55 000 released in the Ross Sea region by all vessels to the end of the 2009-10 fishing season, and about 4300 Eaton cf. skates were landed and 4600 released in the same region over the same period of time. There were also differences in the distribution of the two species, starry skates generally being found deeper and more to the west than Eaton cf. skates in the Ross Sea region. Scaled length frequencies showed no change in distribution between 2003 and 2008 for landed starry skates, whilst tagged starry skates had a lower proportion of large individuals than landed starry skates. Eaton cf. skates had a different length frequency, with a narrower distribution centred around a larger average size than starry skates. This larger distribution is consistent with other studies suggesting Eaton cf. skates might grow to larger sizes than starry skates.
During the "Years of the Skate", a total of about 3300 starry skates and 700 Eaton cf. skates were tagged and 13 starry skates and 3 Eaton cf. skates were recaptured and successfully linked to a tag event. In total there have now been a total of 179 tags recaptured but only 128 have been successfully linked. There was no evidence of growth retardation linked with the capture and tagging event. Tag loss rates of T-bar tags were similar to those calculated for toothfish.
The "Years of the Skate" have been instrumental in collecting further data on skates, in particular length and tagging data. The quality of the tagging database has also improved since it has been centrally managed by CCAMLR. It has shown the value of collecting large amounts of data in specific years rather than small amounts of data in many years. An updated risk assessment of the skate population in the Ross Sea region should be carried out.

Mormede, S. & A. Dunn. (2012a) **The development of spatially and temporally controlled measures of survival and tag-detection for the CCAMLR tagging program**, pp. 14. CCAMLR, Hobart, Australia.
WG-SAM-12/30.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: A reliable commercial tagging program is critical to the successful assessment and management by CCAMLR of a number of toothfish fisheries in Antarctica. The evaluation of the tagging programme relies on two key aspects
(i) that the tagged fish have a good chance of survival and
(ii) (ii) that the tagged fish are reliably detected when recaptured.
Previous attempts to evaluate individual vessel tagging performance in relation to these two aspects has been thus far inconclusive because of confounding factors such as time and location of tagging and subsequent fishing effort, as well as size of fish tagged. We propose that, by controlling for the spatial and temporal confounding factors using a case-control study design, we can derive meaningful indices of relative tagging performance of groups of fishing effort (e.g. vessel, vesseltrip). We developed indices to compare (i) the tag detection rate of recaptured fish and (ii) the tagging survival of released fish. This method was applied to the toothfish tagging data in CCAMLR Subareas 88.1 and 88.2. Initial results show that the indices developed can provide evidence of significant differences in tagging performance between different groups of fishing effort. Preliminary investigation showed these indices are robust to the choice of the control group and the area included in the analysis. Subject to further checks, this method could be used to investigate the relative tagging performance of different components of the CCAMLR tagging program across all fisheries, and more generally the relative performance of spatially and temporally heterogeneous data sets.

Mormede, S. & A. Dunn. (2012b) **Quantifying vessel performance in the CCAMLR tagging program: spatially and temporally controlled measures of relative mortality and tag-detection rates**, pp. 17. CCAMLR, Hobart, Australia.
WG-FSA-12/47.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: A reliable commercial tagging program is critical to the successful management by CCAMLR of a number of toothfish fisheries in Antarctica, but the evaluation of tagging performance has been thus far inconclusive because the confounding effect of factors such as time and location of tagging, and size of fish tagged, makes meaningful comparisons between vessels difficult. We propose that, by controlling for the spatial and temporal confounding factors using a case-control study design, we can derive meaningful indices of relative performance of groups of fishing effort (e.g. vessel, trip, etc). We developed indices of
(i) the mortality (or loss of all tags) of released fish and
(ii) (ii) the detection rate of recaptured fish. This method was applied to the tagging data in CCAMLR Subareas 88.1 and 88.2.
Results show that the indices developed can provide evidence of significant differences in performance between the different vessels or groups of fishing effort. Further investigation showed these indices are robust to the choice of the control group and the area included in the analysis, as well as variations to the 'space window' within which control hauls were selected and paired with each case haul. This method is a good candidate to investigate the relative performance of the CCAMLR tagging program across all fisheries, and more generally the relative performance of spatially and temporally heterogeneous data sets.

Mormede, S. & A. Dunn. (2012c) **Using outputs from spatial population models of Antarctic toothfish in the Ross Sea region to investigate potential biases in the single population model**, pp.
7. CCAMLR, Hobart, Australia.
WG-FSA-12/45.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We present a method to evaluate potential biases and uncertainty in the tagging assumptions of the stock assessment for Antarctic toothfish in the Ross Sea region using spatially explicit operating models. The method allows investigation of potential biases and uncertainty in the assumptions of spatial distribution and fish mixing used in the standard stock assessments for the Ross Sea region (and potentially other CCAMLR areas). We use the generalised Bayesian population dynamics model, the Spatial Population Model (SPM), to develop spatially explicit movement models of the Antarctic toothfish in the Ross Sea region as operating models in simulation experiments. Simulated observations from these models were then used in a single area stock assessment model derived from the stock assessment model of Antarctic toothfish in the Ross Sea region. Results from preliminary case studies suggest that the standard single area stock assessment model for the Ross Sea was relatedly unbiased when we simulated from an operating model derived from the bestfitting coarse-scale model that restricted fish to areas inside the historical footprint of the fishery. However, the results when using a similar model that allowed for fish to be present in areas outside the area historically accessed by the fishery suggested the standard stock assessment may be biased low. While we note that these results are preliminary and further analyses should be carried out, we consider that simulation experiments using spatially explicit models can provide a useful tool to evaluate potential bias and uncertainty in our understanding of the stock assessment in the CCAMLR region. We recommend the further development of this method at future meetings.

Mormede, S. & A. Dunn. (2013) **Investigation of potential biases in the assessment of Antarctic toothfish in the Ross Sea fishery using outputs from a spatially explicit operating model**, pp. 9. CCAMLR, Hobart, Australia.

WG-SAM-13/36.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: Toothfish stock assessment results are strongly influenced by tag-release and tagrecapture data, and rely on the assumption that tagged and untagged fish have constant probabilities of recapture regardless of the spatial distribution of releases or subsequent fishing effort for recaptures. Conceptually this assumption implies either that tagged and untagged fish mix equally in the population, or that fishing effort for recaptures is distributed in proportion to the underlying abundance. Neither of these conditions are likely to occur in practice, and violation of this assumption may lead to bias. In this paper we investigate such potential biases in the assessment of Antarctic toothfish in the Ross Sea fishery using simulated outputs from spatially explicit operating models. Two spatially explicit operating models were developed: each was comprised of 189 discrete cells, with a cell size of about 25,000 km2. The first model was restricted to those locations of the Ross Sea region that have been fished (restricted model), and the second model extended to encompass all areas (unrestricted model). Simulated observations were generated from these models, and used as inputs into a simplified non-spatial stock model based on the 2011 Ross Sea toothfish stock assessment. Results suggested that the assessment model was biased low by 17% or 43% assuming movements defined by the restricted and unrestricted models respectively. The bias was thought to reflect the underlying distributions of tag-releases and subsequent fishing effort, and the limited mixing of fish between areas - more than half of tags have been released (and subsequently recaptured) from SSRUs 88.1H and 88.1I, while a large proportion of the fish are in remaining SSRUs where fewer tags were released and with lower fishing effort. This effect is accentuated in the unrestricted model, where about half of the fish are distributed in areas that had not been subject to fishing effort. We note that the extent of bias will depend on both the proportion of fish in unfished areas and movement rates between fished and unfished areas, but that misspecification of other parameters in the assessment models (for example tag mortality rates and tag detection rates) or alternate spatial hypotheses may also introduce biases that we have not considered in this paper. While additional analyses need to be undertaken to confirm or improve the spatial models used here and alternative movement hypotheses should be tested, we consider that these simulation experiments provide a useful tool to evaluate potential bias and uncertainty in our understanding of the assessment in the Ross Sea toothfish stock and potentially similar tag-based assessments elsewhere in the CCAMLR Area. They are also useful in investigate the likely consequences of management strategies for stock assessments, including changes in fishing effort or tagging distributions. They can also be used to investigate the potential effects of alternative biological hypotheses for less well defined parameters, for example maturity and natural mortality rates.

Mormede, S., A. Dunn, J. Fenaughty, M. Francis, S. Hanchet, R. O'Driscoll & N. Smith. (2007) **Preparing for the year of the skate: proposed information collection and tagging protocol for skates**, pp. 13. CCAMLR, Hobart, Australia.
WG-FSA-07/39.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: 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, CCAMLR-SAM-WG 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 bycatch 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

could be piloted in the 2007-08 season by all or a subset of vessels fishing in the Ross Sea. The results from the pilot study may be useful to inform modifications to data collection systems that would be required in 2008-09, for the "Year of the Skate". Note that we do not consider other information requirements such as determining biological parameters.

Mormede, S., A. Dunn & S.M. Hanchet. (2013a) **Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 88.2C–H for the years 2002–03 to 2012–13**, pp. 26. CCAMLR, Hobart, Australia.
WG-FSA-13/52.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This paper presents the Bayesian sex and age structured population stock assessment of
Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 covering SSRUs 88.2C, D, E, F, G, and H (SSRUs 88.2C-H). We examined several models including the 2013 implementation of the 2011 base case (R1), using the revised data selection method (R2), using a logistic selectivity for the northern fishery (R3), down-weighting the age data (R4), and having annual age length keys in the north (R5).
The stock assessment has strongly conflicting data: age frequency data push the biomass high, data from tags released in 2010, 2011 and 2012 suggest a much lower biomass, and data from tags released from 2004 to 2009 suggest an intermediate biomass. The two models (R1 and R2) which estimate a higher biomass are those where the age data were more influential. However, these age data are not reliable because a single age length key has been applied. When annual age-length keys are applied there was a strong shift towards younger ages (R5) and lower biomass. The remaining two models (R4 and R5) suggest a substantially lower biomass than previously estimated, mainly due to the signal in the last three years of tag data. These are the data in which we have the highest degree of confidence for this fishery, due to improvements in tagging protocols and data collection. We believe that there is sufficient conflicting information, and uncertainty in the age data, to warrant a decision to adopt the model which down-weights the age data in favour of the tag data as the base case. We therefore recommend that model R4 is used for providing management advice. In this model, the initial stock biomass is estimated at 6590 t (95% confidence interval 4800 - 9190 t), stock status is at 65%Bo (CI 52%-75%) and the yield based on the CCAMLR Decision Rules is 266 t. We also recommend that further ageing is carried out by fishing members involved in the fishery to allow annual full age length keys for all fisheries for future assessments.

Mormede, S., A. Dunn & S.M. Hanchet. (2013b) **Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea for the years 1997-98 to 2012-13**, pp. 36. CCAMLR, Hobart,
Australia.
WG-FSA-13/51.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish
Stock Assessment Working Group of CCAMLR)
ABSTRACT: We provide an update of the Bayesian sex and age structured population stock assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region (Subareas 88.1 and SSRUs 88.2A-B), using revised catch, catch-at-age, and tag-recapture data for the 20122013 seasons. Several models were examined including an update of the 2011 base case (R1), a model using the revised data selection method, new maturity ogive, and new data weighting method (R2), and a model which used a logistic selectivity for the fishery in the North. We recommend model R2 be used to provide catch limits for the stock because this model reflects the best science and methodologies available. Retrospective analysis and MPD profiles suggest that the tag recapture data from the last few years tend to push the model toward a higher biomass, in particular the data from the 2012 tagged fish. We expect this is due to higher catches in SSRU88.1K which has a comparably high

biomass but a shorter catch history (therefore fewer tags available for recapture) than the other slope SSRUs 88.1H and I. Fish released or recaptured in SSRU K have also consistently shown higher rates of movement between SSRUs and lower rates of recapture in the location of release, perhaps indicative of a more mobile population in this location. In contrast the updated data selection algorithm resulted in less tag data being selected for input into the stock assessment, which tended to push the model toward lower biomass. The updated maturity ogive a slightly positive effect, and the new data weighting had no effect on model biomass.
Sensitivity runs showed that cryptic biomass is not an issue for this stock assessment, and that the data from the sub-adult survey series is expected to be helpful in estimating year class strengths in the future.
Overall, model fits to the data were adequate, and, as in previous assessments, the tag-release and recapture data provided the most information on stock size. Monte-Carlo Markov Chain (MCMC) diagnostics suggested little evidence of non-convergence in the key biomass parameters, although there was some evidence of non-convergence in the annual shift parameters for the shelf fishery. MCMC estimates of initial (equilibrium) spawning stock abundance (B0) for the 2013 reference model were estimated as 68 790 t (95% credible intervals 59 540-78 470); and current (B2013) biomass was estimated as 74.8% B0 (95% C.I.s 71-78). The estimated yield, using the CCAMLR decision rules, was 3044 t.

Mormede, S., A. Dunn & S.M. Hanchet. (2014a) **Investigating emigration in stock assessment models of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 882 SSRUs 882C-H**, pp. 15. CCAMLR, Hobart, Australia.
WG-FSA-14/56.Used for Ross Sea Toothfish MSC 2014 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: In 2013, the Scientific Committee of CCAMLR could not achieve consensus on a stock status for Antarctic toothfish in Subarea 88.2 SSRUs 88.2C-H and identified several areas for further work. This was presented to WG-SAM in 2014, and found that the models were unable to fit patterns in the recaptures of tagged fish seen in the SSRU 88.2H fishery. The patterns showed a sharp decay rate of a cohort of tagged fish with few being recaptured after more than 3 years at liberty, a steepening of the decay rate over time, and a trend for increasing proportions of tagged fish caught over time. To help understand the population dynamics which could explain the observed patterns in the tag recapture data we carried out a series of simple simulations in R. This suggested that the observed pattern for that tagging data in SSRU 88.2H was only reproduced in scenarios that included both immigration and emigration, rates combined with moderate to high exploitation Within a single area model, emigration can be mimicked by treating it either as a constant biomass of removals or as an additional mortality rate. Both of these approaches were unsuccessful in achieving an adequate fit to the tag data. Clearly, the steep decline in the recapture rates of a cohort of tagged fish through time cannot be explained solely by emigration (a process that includes both tagged and untagged fish), but requires a significant amount of immigration each year to explain the remaining data. Models that include more than one area may be required to model both immigration into SSRU 88.2H and the subsequent emigration back to SSRUs 88.2C-G.

Mormede, S., A. Dunn & S.M. Hanchet. (2014b) **Preliminary investigations into a two-area stock assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Amundsen Sea Region**, pp.
12. CCAMLR, Hobart, Australia.
WG-FSA-14/57.Used for Ross Sea Toothfish MSC 2014 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: In 2013, the Scientific Committee of CCAMLR could not achieve consensus on a stock status for Antarctic toothfish in the Amundsen Sea Region (ASR - Subarea 88.2 SSRUs 88.2C-H) and identified several areas for further work. This work was carried out and

presented to WG-SAM in 2014, who noted that the assessments were unable to fit the patterns in the recaptures of tagged fish seen in SSRU 88.2H. As a consequence, WG-SAM requested further runs be carried out with emigration estimated in the model. However, the models that mimicked emigration in a single area assessment model failed to provide adequate fits to the observed tag recapture data (Mormede et al. 2014b). As an alternative approach, we present the preliminary development of a two-area stock assessment model. A two-area model is a method for allowing explicit modelling of movement (migration) of fish into an assessment model, allowing the modelling of the populations in the southern ASR (88.2C-G) and the northern ASR (88.2H), as well as modelling the movement of fish between these two areas.
The inclusion of two-areas and migrations into the assessment model has both provided a more plausible explanation of the population structure as well as enabling a better account of the observed patterns in the tag recapture data. However, in this preliminary model some difficulties still remain. While the local biomass in the north and the migration to and from the northern ASR were able to be discerned, the biomass in the southern ASR and the associated proportion of that biomass migrating northward could not be resolved. This was because the parameters that represent the initial biomass in the southern ASR and the proportion of that biomass moving north were highly correlated, with little data to inform estimation of biomass in the southern ASR. As a result, estimates of the biomass and current stock status of the population from these models remains highly uncertain.

Mormede, S., A. Dunn, S. Parker & S.M. Hanchet. (2012) **Further development of coarse- and medium-scale spatially explicit population dynamics operating models for Antarctic toothfish in the Ross Sea region**, pp. 45. CCAMLR, Hobart, Australia.
WG-FSA-12/44.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We present developments towards spatially explicit age-structured population dynamics operating models for Antarctic toothfish in the Ross Sea. The operating models consider both a coarse-scale and medium-scale spatial resolution and consider scenarios where abundance can be present over the entire Ross Sea region or restricted to areas where the fishery has operated. The models are implemented in the generalised Bayesian population dynamics model, the Spatial Population Model (SPM). The SPM program allows implementation of an aggregate movement model for use with large numbers of areas as a discrete time-step state-space model that represents a cohort-based population age structure in a spatially explicit manner. Models can be 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. The operating models considered were single sex age-structured models that categorised fish as immature, mature, pre-spawning, spawning, or post-spawning. Observations include spatially explicit commercial catch proportions-at-age, proportions mature and proportions spawning (based on GSI data), CPUE, and tag-release and tag-recapture observations. Estimates of parameters when the operating models were used as estimation models with observations from the Ross Sea Antarctic toothfish fishery appeared to broadly reflect the hypothesised spatial distribution of Antarctic toothfish, suggesting that younger fish were found predominantly in the southern shelf areas, mature fish on the slope and spawning fish in the northern areas of the Ross Sea region. Fits to the commercial catch proportions-at-age observations were generally good in most models, although fits to the plus group of the proportions-at-age catch data were less than ideal. Model estimates of proportions-mature appeared to be sensible, with a clear pattern that the proportions mature were a function of location and age. Tag release and recapture data were less well fitted by the models due, in part, to the conflict with assumptions of known abundance in the model and the abundance information inherent in the tag-recapture observations. Whilst these models are an improvement on earlier versions, further work is required to improve these residual patterns and to better match the observations.

Mormede, S., A. Dunn, S. Parker & S.M. hanchet. (2013) **A spatially explicit population dynamics operating model for Antarctic toothfish in the habitable depths of the Ross Sea region**, pp. 9. CCAMLR, Hobart, Australia.
WG-FSA-13/53.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We present a spatially explicit age-structured population dynamics operating model for Antarctic toothfish in the Ross Sea region, for a medium scale spatial resolution (189 spatial cells) covering the Ross Sea region. In this model run we spatially restrict the stock to cells where at least 5% of the depth is deemed suitable as habitat for toothfish (120 cells - semi-restricted model), and compare with previous models where the stock was either restricted to the fished cells only (65 cells - restricted model) or allowed to occupy the entire Ross Sea region including depths outside of those normally considered suitable habitat for toothfish (unrestricted model). The semi-restricted model provides a plausible distribution hypothesis in-between the two extreme bounding hypotheses represented by the previously presented restricted and unrestricted models (Mormede et al. 2013).
The most plausible model is the one that restricts toothfish distribution to depths which are known to provide suitable toothfish habitat. This is unsurprising because the model utilises fisherydependent data and has no information about the distribution of toothfish in areas where no fishing has occurred, such that the unrestricted model estimates fish movements into cells outside of the fished area including those with implausible depths for toothfish. Further data collection would be useful to improve the parameterisation of the model, in particular making collection of gonad weight measurements routine on all fishing vessels, surveying likely spawning grounds during winter, and obtaining fishery or survey data from areas not fished to date.

Mormede, S., S.J. Parker & P. Grimes. (2008) **Investigating length at maturity of Antarctic toothfish (*Dissostichus mawsoni*) based on scientific observers' data.** CCAMLR, Hobart, Australia.
WG-FSA-08/48.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: 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 137cm. 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 137cm. 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 populationwide 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 Lm50 be carried out both within the outside of the model. Lm50 only be quoted as area-specific unless derived from a spatially-explicit model.

Mormede, S., S.J. Parker, S.M. Hanchet, A. Dunn & S. Gregory. (2014) **Results of the third CCAMLR sponsored research survey to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea, February 2014 and development of the time series**, pp. 23. CCAMLR, Hobart, Australia.
WG-FSA-14/51.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: At its 2011 meeting, the Scientific Committee agreed that a time series of relative abundance from a well-designed survey could be a useful input into the Ross Sea stock assessment model. The first survey was completed in February 2012, and the second survey in February 2013. In this paper we provide results of the third survey in the time series. The objectives of this third survey were: (1) To carry out a longline survey to monitor subadult toothfish in the southern Ross Sea (strata A-C) using standardised gear in a standardised manner; and (2) To sample additional experimental stations in an adjacent area to identify areas of high subadult abundance which could be included as strata in future annual surveys.
The 2014 survey was successful in completing all the planned stations. Standardised catch rates for the core strata showed a slight decline across the three surveys but this decline was not significantly different. Age frequency data from the surveys have shown the progression of a cohort from age 7 in 2012 to age 9 in 2014. These results suggest that the surveys are indexing local abundance and will provide a reliable means of monitoring recruitment and estimating recruitment variability. In contrast, standardised commercial catch rates in the core area have been highly variable throughout the history of fishing in the survey area and the age data do not show modal class progression suggesting they are not useful for monitoring recruitment. Stations in the experimental stratum near Ross Island had high catch rates and much larger fish than in the other strata, and warrant future monitoring

due to their unique nature. We recommend the survey be continued to provide information on year class strength and an index of local abundance to be incorporated in the stock assessment.

Mormede, S., M. Pinkerton, A. Dunn, S.M. Hanchet & S.J. Parker. (2014) **Development of a spatiallyexplicit minimum realistic model for Antarctic toothfish (*Dissostichus mawsoni*) and its main prey (Macrouridae and Channichthyidae) in the Ross Sea**, pp. 17. CCAMLR, Hobart, Australia.
WG-EMM-14/51.Used for Ross Sea Toothfish MSC 2014 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: To explore the potential effects of the toothfish fishery on the population dynamics of Antarctic toothfish and its main prey, grenadiers (Macrouridae) and icefish (Channichthyidae), we develop a spatially explicit model using a predator-prey suitability model for the Ross Sea Region. We model the age-based population dynamics of toothfish, grenadier, and icefish, and include natural mortality (M1) and predation mortality (M2), in addition to fishing mortality (F) on all three species. The model suggests that the predation release caused by the fishery effect on toothfish abundance is greater than the direct fishing mortality on both prey species and that icefish is expected to show a larger increase in biomass through time than grenadiers. It also suggests that a prey-suitability function is more likely than a Holling type II function to describe the predatory relationships in the model. We use the model to compare the predicted population changes with available abundance data for each species to develop hypotheses of the nature of the interaction. Whilst this model is in a development stage, it provides a useful tool for evaluating potential impacts of the fishery on key prey species, and for assessing and designing monitoring tools for fish species associated with the toothfish fishery. We recommend targeted sampling of toothfish for diet analysis, and the monitoring of icefish and grenadier populations in SSRUs 88.1H and 88.1K through the development of age frequencies (length measurements and aging).
Mormede, S. & S. Thanassekos. (2013) **Steps carried out to check the data inputs to the stock assessment of the Ross Sea region of Antarctica**, pp. 5. CCAMLR, Hobart, Australia.
WG-FSA-13/56.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We detail the procedure followed to check the Ross Sea CCAMLR fisheries data prior to using them in a stock assessment of Antarctic toothfish (*Dissostichus* mawsoni). The R codes used in this procedure have been made available to the Secretariat.

Naganobu, M., 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, K. Ito. (2007) **Interactions Between Oceanography, Krill And Baleen Whales In The Ross Sea And Adjacent Waters, Antarctica In 2004/05**. CCAMLR, Hobart, Australia.
WG-EMM-07/07.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: A joint survey of the R/V *Kaiyo Maru* and the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was carried out to study the interactions between oceanographic conditions, and the distribution of krill as prey and baleen whales as predators in the Ross Sea and its adjacent waters, Antarctica, in austral summer of 2004/05. Results indicated close interactions between the thermal conditions, krill and baleen whale distributions. The oceanography of the surface layer was summarized as an oceanographic environmental index that integrated the mean temperature from 0 to 200 m in depth (ITEM-200). Distribution of ITEM-200 was used as background information for comparing with distribution patterns of each species. Antarctic krill (Euphausia superb) mainly distributed in the Antarctic Surface Water (ASW) area (ITEM-200 = 0 to 1°C) and

extended in the Shelf Water (SW) area (less than ITEM-200 = -1°C). Ice krill (Euphausia crystallorophias) clearly distributed in SW but not ASW. Humpback whales (Megaptera novaeangliae) mainly distributed in the Antarctic Circumpolar Current (ACC) waters with high density around ITEM-200 = 0°C near the Southern Boundary of ACC and their distribution slightly extended in ASW. Antarctic minke whales (Balaenoptera bonaerensis) mainly distributed in ASW and SW with a high density around ITEM-200 = -1°C in the continental shelf slope frontal zone. The interaction between distributions of krill and baleen whales with ITEM-200 could yield quantitative information to identify the boundary of distributions of Antarctic krill and ice krill for biomass estimations using acoustic data in the surveys. Finally we summarized a conceptual model of interaction between oceanography relating water mass and circulation pattern of the oceanic surface layer with ITEM200, as well as the distribution and abundance of krill and baleen whales.

Norman, J. R. (1937) **B. A. N. Z. Antarctic Research Expedition. 1929-1931. Reports -- Series B**. 51-88 pp.
ABSTRACT: None

O'Driscoll, R.L. (2005) **Risk categorization for *Macrourus whitsoni* and *Amblyraja georgiana* in the Ross Sea**, pp. 11. CCAMLR, Hobart, Australia.
WG-FSA-05/21.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This report presents risk categorization tables for *Macrourus whitsoni* and *Amblyraja georgiana*, which are the major bycatch species in the exploratory fishery for toothfish in the Ross Sea. *Amblyraja georgiana* were categorized as risk status 3 - species that are exploited as bycatch, and have a limited reproductive potential, and/or other life history characteristics that make them especially vulnerable to overfishing. The risk to *A. georgiana* is mitigated due to a CCAMLR programme to cut all skates from longlines whilst still in the water and release them. *Macrourus whitsoni* were categorized as between risk status 2 and 3 - although life history characteristics may make this species vulnerable to overfishing, catch rates in the toothfish fishery have not declined, juveniles are not selected by the fishery, and comparison of longline and trawl catch rates with other Antarctic areas suggest that population in the Ross Sea may be relatively large.

O'Driscoll, R.L., S.M. Hanchet & B.A. Wood. (2005) **Approaches to monitoring and assessing the abundance of rattails (*Macrourus* spp) and skates in the Ross Sea**, pp. 24. CCAMLR, Hobart,
Australia.
WG-FSA-05/22.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This report presents results from a desktop study to consider approaches to monitoring and assessing rattails and skates, which are major bycatch species in the exploratory fishery for toothfish in the Ross Sea. We review standardised CPUE analysis, quantitative research longline surveys, experimental manipulation of fishing effort, catch-curve analysis, tagging programmes, bottom trawl surveys, and acoustic surveys. We recommend that a random bottom trawl survey would be the best approach towards obtaining abundance estimates for rattails and skates in the Ross Sea. The major advantage of this approach is that preliminary stock assessments could be carried out for both species groups after only one successful trawl survey. Simulations have indicated that only 35-40 trawls would be required in the depth range 600-1500 m to obtain a precise estimate of bycatch abundance in the area of highest
densities (SSRUs 881E, G, H, I, J, and K). A trawl survey could also be used in conjunction with other methods of monitoring abundance, e.g., skates caught during the trawl survey could be tagged and released, rattails could be aged for catch-curve analysis. The main limitations of this approach is the variable ice cover in the Ross Sea, which may restrict

access to some areas, the rough bottom topography, and concerns about the environmental impact of bottom trawling on benthic communities. Tag-recapture experiments for skates and experimental manipulation of fishing effort are alternative methods which show some promise for monitoring abundance

P.J., Smith, A. McKenzie & L. Tubbs. (2006) **Preliminary analyses of an ectoparasite (*Eubrachiella antarctica*) as a marker for stock discrimination of Antarctic toothfish in the Ross Sea.** . CCAMLR, Hobart, Australia.
WG-FSA-06/28.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This project evaluated the prevalence and intensity of an ectoparasite *Eubrachiella antarctica* as a marker for stock discrimination of Antarctic toothfish in the Ross Sea. New Zealand Ministry of Fisheries Observers on four toothfish longline vessels recorded the number of *E.*
antarctica on the fins and in the buccal cavity of 621 large *D. mawsoni* (mostly 120-150 cm). Up to five *D. mawsoni* per set were examined for parasites in Small Scale Research Units (SSRUs) 88.1C, 88.2E and 88.2F; and two fish per set in SSRUs 88.1H - 88.1J. Up to 15 *E. antarctica*, one from each of the first fifteen sets in each SSRU, were dissected out and stored in ethanol for laboratory identification. All of the preserved copepod parasites were identified as female or male *E. antarctica*. *D. mawsoni* from 88.1H had a higher prevalence of *E. antarctica* compared to *D. mawsoni* from
88.1C, 88.1I, and 88.1J (and to 88.2E) and higher intensity compared to *D. mawsoni* from 88.1C,
88.1I, and 88.1J. However, neither intensity nor prevalence were significantly different between 88.1H and 88.2F. These area differences do not appear to be sampling artefacts produced by differences in host length structure, sex ratio, seasonality, or observer experience, but represent a regional difference in prevalence and intensity of *E. antarctica* on *D. mawsoni*. The small-scale regional differences suggested by the parasite marker are inconsistent with the genetic and tagging studies which suggest homogeneity at small spatial scales. Genetic, tagging, and parasite studies measure different biological parameters and results from these independent studies provide a picture of toothfish movement over different time scales. The stability of this regional difference in prevalence and intensity of *E. antarctica* needs to be tested with large scale sampling in future years.

P.J., Smith, S.M. McVeagh & P.M. Gaffney. (2004) **Genetic analysis of Antarctic toothfish samples from the southern ocean to explore potential stock boundaries.** . CCAMLR, Hobart, Australia.
WG-FSA 04/32.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Two molecular methods, mitochondrial DNA and introns, were used to determine genetic relationships among Antarctic toothfish, *Dissostichus mawsoni,* samples from three CCAMLR areas 48.1, 88.1, and 58.4.2. *D. mawsoni* appeared to be characterized by low diversity; no genetic variation was detected with restriction enzyme digests of nine sub regions of the mitochondrial genome. Polymorphisms were found in four out of seven introns digested with the restriction enzymes, but there was no population differentiation among the three sea areas. While direct sequencing of cytochrome b (665 base pair) showed virtually no variation, sequences for ~600 bp of the left domain of the control region showed nucleotide variation with some haplotypes restricted to sea areas. The weak genetic differentiation is supported by oceanic gyres, which may act as juvenile retention systems, and by limited movement of adult tagged fish. It is recommended that the Ross Sea *D. mawsoni* be treated as a separate stock unit.

Parker, S. (2012) **Viability criteria for tagging toothfish**, pp. 10. CCAMLR, Hobart, Australia.

WG-SAM-12/27.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: CCAMLR Conservation measures currently require vessels to tag only toothfish with a high probability of survival, but no objective criteria are provided for this evaluation. Achieving this requires an objective evaluation of the probability of survival of each fish to be tagged, which in turn requires objective criteria that link observable characteristics to survival. This paper proposes criteria based on assessments of injuries and vitality used on other species and includes several options for implementation in CCAMLR tagging programmes.

Parker S., B. Wood, S.M. Hanchet and A. Dunn (2010) **A bathymetric data framework for conservation in the Ross Sea region**. CCAMLR, Hobart, Australia.
WG-SAM-10/18.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: Bathymetric data are currently used inter alia to define management boundaries, implement conservation measures, allocate catch among areas, estimate spatial impacts due to fishing, and inform ecosystem-based management through bioregionalisation. Several data sources for bathymetric data exist, and these sources improve with time through additional data collection and improved analytical methods. We developed an algorithm to summarize bathymetric point data (x,y,z) for the Ross Sea region to provide a transparent and citable method to derive standard summary statistics for use by CCAMLR. This is especially important because of the multinational use of such data. The method is applicable to the entire Southern Ocean, but is currently applied only to the Ross Sea region. We have obtained publically available bathymetric data, created a spatial database, and have developed scripts for defining polygons of user-specified bathymetric areas, calculating the areas of those polygons, and displaying them as contour maps. As data sources improve, this process can update the summary statistics as needed in a comparable and transparent manner.

Parker, S., J. Fenaughty, E. Appleyard & C. Heinecken. (2012) **Recommendations for CCAMLR tagging procedures**, pp. 11. CCAMLR, Hobart, Australia.
WG-SAM-12/31.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: With the recognition that CCAMLR tagging programmes are used for abundance estimation of toothfish and skates, tagging operations need to be appropriately supported through documentation, training, and supplies. This paper reviews how tagging programme information could be effectively organised, provides a template training module for observers and vessel crew, and makes recommendations to update tagging protocols and to create a tagging checklist for use at the tagging station.

Parker, S., P.J. McMillan & P. Marriott. (2012) **Characterisation of *Muraenolepis* species by-catch in the CCAMLR Convention Area**, pp. 23. CCAMLR, Hobart, Australia.
WG-FSA-12/50.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: *Muraenolepis* species are caught in low numbers with bottom longline and trawl gears throughout the CCAMLR Convention Area. There are seven known species in the genus, but more work on the taxonomy of the group is needed and the number of species is uncertain. The few
biological studies published suggest a relatively fast growing, semelparous, life history with a maximum age of 11 years. The estimate of K from the growth function for specimens assumed to be
M. evseenkoi is much higher than for other Antarctic species. Individuals selected by longline gear are almost exclusively female, and a localised area of high catch rates occurs on Iselin Bank on Ross Sea slope. However, effects of fishing on this bycatch species depend on other factors, such as productivity, distribution pattern, and total biomass. Further

directed sampling to determine species composition, life history attributes, reproductive strategy, and sex-specific distribution, and any trends in biomass is needed from the Ross Sea area and throughout the Convention Area.

Parker, S. & S. Mormede. (2012) **Drawing on international experience to improve performance of CCAMLR tagging programs**, pp. 12. CCAMLR, Hobart, Australia.
WG-SAM-12/26.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: Mark-recapture methodologies are commonly used to inform the management of fisheries. In addition to answering targeted research questions, tagging programmes are typically used to describe movement patterns relative to stock unit identification or to support spatial disaggregation of stock assessment areas, and in some instances to derive population abundance estimates. This paper is intended as a discussion tool to identify and prioritize tagging-related issues for further research drawing on the experience tagging programmes internationally. To the extent that CCAMLR tagging programmes are unique, an evaluation of potential programme biases and corresponding information needs is presented. The paper focusses on the design and implementation of toothfish tagging programmes, but many of the potential issues apply equally to other tagged species such as skates.

Parker, S.J. and M.H. Smith (2010) **Is toothfish catch correlated with the catch of vulnerable benthic invertebrate taxa?** . CCAMLR, Hobart, Australia.
WG-EMM-10/27.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the
Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Accurate estimation of the true impact of bottom fishing on vulnerable marine ecosystems (VMEs) requires knowledge of the distribution of those communities relative to the fishing footprint. If high target fish catch rates are associated with habitats where VMEs are found, impacts from fishing would be higher than if VMEs are distributed randomly with respect to fishing locations. This study used the catch of the six most common vulnerable invertebrate taxa reported by observers on New Zealand vessels during the 2009/10 Ross Sea longline fisheries to correlate toothfish catch rates and benthic invertebrate catch rates at a longline segment level. Analysis of the data available showed no evidence that the presence of any of six VME taxa was related to Antarctic toothfish catch at the scale of a longline segment, approximately 1.2 km. This supports conclusions of previous work finding no relationship between total VME taxa weight and toothfish catch at the scale of a longline set, up to 10km. Our data were too limited for a robust comparison among fishing areas. Further studies at intermediate scales (10-100 km) would be useful to determine if both toothfish and individual VME taxa have regionally concentrated distributions showing a high degree of spatial overlap.

Parker, S.J., A. Dunn, S. Mormede & S.M. Hanchet. (2013) **Descriptive analysis of the toothfish (*Dissostichus* spp.) tagging programme in Subareas 88.1 & 88.2 for the years 2000–01 to 2012–13**, pp. 35. CCAMLR, Hobart, Australia.
WG-FSA-13/49.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We provide an update of the descriptive analyses of the toothfish tagging programme in
Subareas 88.1 and 88.2, including summaries of data for the 2013 season. Overall, a total of 37 047 Antarctic toothfish have been reported as released and 1903 recaptured, and 1155 Patagonian toothfish released and 95 recaptured since 2001. In recent years, most vessels have achieved or exceeded the required tagging rate of one toothfish per tonne of catch in the Ross Sea region. Tag recapture data showed that most fish are recorded as being recaptured only a short distance from their point of release, typically less than 100 km.

However, several long distance movements of tagged Antarctic toothfish between slope and north regions have been observed. Of those that have changed areas (i.e. between Shelf, Slope, North) in the Ross Sea region, 44 have moved from the Shelf to the Slope, 31 have moved from the Slope to the Shelf, 13 from the Slope to the North, and 5 from the North to the Slope (although 4 of those are suspected of being poor tag links based on growth rates and ancillary linking data). Three recaptured fish moved between the Ross Sea region and Subarea 88.2; One moving from the Ross Sea (SSRU 88.1K - shelf) to 88.2H (north), and two moving from Subarea 88.2 to the Ross Sea slope (SSRU 88.1H), one from 88.2H - north, and 1 from 88.2F - slope). The total number of recaptures in 2012 was lower than in 2010 and 2011, but the total number of recaptures in 2013 was very similar 2010 and 2011 and about double that in 2009. The reason for the low number of recaptures in 2009 and 2012 is likely a consequence of interannual changes in the main location of fishing effort arising from ice conditions in those years.

Parker, S.J., S.M. Hanchet, S. Mormede & A. Dunn. (2013) **Proposal to continue the time series of CCAMLR-sponsored research surveys to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea in 2014**, pp. 10. CCAMLR, Hobart, Australia.
WG-SAM-13/33.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: A research proposal to continue the southern Ross Sea subadult toothfish survey is presented. The survey will focus on estimating relative abundance in the core strata (A, B, C) in SSRUs 88.1 J and 88.1L, and will conduct exploratory sets in a newly defined stratum I in southern SSRU 88.1 M. Survey timing and methods will remain the same as in previous years, although the number of sets is proposed to be reduced by 5 sets to a total of 60 sets.

Parker, S.J., S.M. Hanchet, S. Mormede, A. Dunn & R. Sarralde. (2013) **Results of a CCAMLR sponsored research survey to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea, February 2013**, pp. 31. CCAMLR, Hobart, Australia.
WG-SAM-13/32.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: At its 2011 meeting, the Scientific Committee agreed that a time series of relative abundance from a well-designed survey could be a useful input into the Ross Sea stock assessment model. The first survey was completed in February (Hanchet al. 2012a). In this paper we provide the results of the second survey in the time series.
The objectives of this second survey were:
(i) To carry out a longline survey to monitor subadult toothfish in the southern Ross Sea (strata A-C) using standardised gear in a standardised manner; and
(ii) To sample additional experimental stations in adjacent areas to identify areas of high subadultabundance which could be included as strata in future annual surveys.

Parker, S.J., S.D. Hoyle, J.M. Fenaughty & A. Kohout. (2014) **Methodology for automated spatial sea ice summaries in the Southern Ocean**, pp. 20. CCAMLR, Hobart, Australia.
WG-FSA-14/54.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Sea ice is recognised as a core driver of both ecosystem dynamics and fishery performance in the Southern Ocean. Sea ice can limit access to fishing grounds, for both commercial fishing and scientific research. Although satellite data are available and have been used for ecosystem monitoring purposes and to inform research plans by CCAMLR, no quantitative summaries relative to fishing access are in use by CCAMLR. We develop a method to spatially and temporally summarise satellite-derived sea ice concentration data in the Southern Ocean, and relate it to data on commercial fishing vessel operations around the Antarctic continental margin. A spatial view is used to characterise the spatial dynamics

of sea ice in a target location for a specified period, and a temporal view is used to characterise the inter-annual patterns within a target area. Both can be viewed relative to ice conditions during historical fishing events. The distribution of local ice concentration at the time of each fishing event relative to the weighted ice concentrations within the fishery footprint was used to develop the relationship between sea ice concentration and fishing. Although more than 85% of fishing events occurred in areas with less than 20% sea ice, a threshold of 40-60% sea ice indicated the transition from fished to non-fished conditions. We present a summary of conditions in SSRUs 88.2C-G as a case study to identify and characterise areas with reliable access for the collection of fishery data.

Parker, S.J. & P. Marriott. (2012) **Indexing maturation of Antarctic toothfish (*Dissostichus mawsoni)* in the Ross Sea region**, pp. 21. CCAMLR, Hobart, Australia.
WG-FSA-12/40.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The longline fisheries for Antarctic toothfish (*Dissostichus mawsoni*) in subareas 88.1 and 88.2 have provided more than a decade of observations to aid in understanding the life history and ecology of toothfish. Updated spawning ogives for males and females support the currently used values. Using histological samples, a summer GSI threshold of 1% appears to be a good indicator of vitellogenic fish developing to spawn in the upcoming season. Evidence is accumulating that almost all Antarctic toothfish in the northern SSRUs have spawned in the previous season and are preparing to spawn in the upcoming season. Observations of post-spawning fish on the slope indicate that some females either spawn on the slope or return to the slope in early spring. The absence of high condition fish in the north indicate that any northward migration occurs in late autumn or winter. Determination of fish movement during the winter period requires winter sample collection from the northern area.

Parker, S.J. & S. Mormede. (2014) **Seamount-specific biomass estimates from SSRU 88.2H in the Amundsen Sea derived from mark-recapture data**, pp. 17. CCAMLR, Hobart, Australia.
WG-FSA-14/58.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Mark-recapture data for Antarctic toothfish from individual seamount features in SSRU 88.2H were analysed to estimate biomass trends on isolated seamounts. Biomass estimates were also calculated for SSRU 88.2H as a whole. The analyses indicate that:
•□□Fish seldom move among seamounts within the complex, and residence time on particular seamounts declines rapidly over 1-4 years.
•□□Fishing has occurred on almost every seamount in every year and usually in proportion to the level of tagging on the seamount in the previous year.
•□□Trends in local biomass estimates for individual seamounts and SSRU 88.2H overall showed a decline in biomass through time with a slight increase in biomass since 2012.
•□□The pattern in recapture rates of annual cohorts of tagged fish through time in SSRU 88.2H indicates a decrease in the percentage of the population tagged due to the annual immigration of untagged fish, along with catch and emigration of tagged and untagged fish resulting in a decreasing trend in biomass overall.
•□□Annual immigration also results in a progressive inflation of biomass estimates from markrecapture data, and therefore biomass estimates are most accurate after 1 year at liberty, but still overestimated due to immigration.

Parker, S.J., A.F. Petrov, C.P. Sutton & E.N. Kuznetsova. (2014) **Comparison of age readings by two otolith preparation techniques and readers**, pp. 10. CCAMLR, Hobart, Australia.
WG-FSA-14/53.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: During the 2012 CCAMLR toothfish ageing workshop, otoliths from 31 Antarctic

toothfish were exchanged between Russia and New Zealand ageing programmes to compare consistency in ages estimated by different readers and using different methods. Both “break and burn” and “bake and embed” techniques were used to prepare otoliths and each were read by an experienced reader from each program. The resulting four-way comparison enabled differences in preparation method to be distinguished from differences in interpretation of otolith banding patterns. Results suggest broad agreement in ages determined by each reader and with each method. However, there were enough inconsistencies in preparation technique and in interpretation of the break and burn preparation method to warrant further coordination and comparisons before merging data. Bake and embed preparations were consistently interpreted by both readers. This experiment highlights the importance of monitoring and comparing ageing protocols within and between fish ageing programmes. The criteria for determining similar age interpretation used here (mean paired age difference statistically equal to zero, overall CV less than 10%, and slope of regression across ages equal to 1) were useful diagnostics in interpreting age comparisons.

Parker, S.J., D.N. Webber & R. Arnold. (2014) **Deployment and recovery of an archival tag on an Antarctic toothfish in the Ross Sea**, pp. 16. CCAMLR, Hobart, Australia.
WG-FSA-14/64.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Data from electronic archival tags are often used to characterise movement and migration patterns in fishes. Understanding these movement patterns is one of the key information needs for the assessment and management of Antarctic toothfish. We deployed 4 pop-off satellite archival tags on large toothfish on the Ross Sea slope in January 2013 and report on the first recovery of an Antarctic toothfish tagged with an archival tag. The fish was recaptured in the fishery the following season (December 24, 2013), providing 335 days of data archived at 10 min intervals. Summaries of raw data show strong and contrasting patterns throughout the time series in several variables recorded and several periods with distinct behavioural profiles, suggesting significant activity throughout the winter period. With the lack of any daylight signal resulting from constant light or darkness, along with living below the photic zone and under ice, positioning using light-based geolocation is not possible. Current efforts focus on developing a Bayesian modelling approach to fit the most likely movements of the tagged fish during its time at liberty, based on the environmental variables recorded by the tag compared with spatial environmental data on depth, temperature and magnetic field strength.

Phillips, N L, A. Dunn & S M Hanchet. (2005) **Stratification of catch-at-length data using tree based regression. An example using Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea**, pp. 15. CCAMLR, Hobart, Australia.
WG-FSA-SAM-05/8.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This paper presents a new approach to the stratification of catch-at-length data of Antarctic toothfish (*D. mawsoni*) in the Ross Sea.
Tree based regression techniques were used to stratify the sampled catch based on the median length of Antarctic toothfish for each set using the observer length frequency data. The median lengths were weighted within the regression by the inverse of the variance, rather than giving equal weights to all tows. Two variables (depth and SSRU) were used by the tree regression model to determine the strata. The resulting stratification effectively split the fishery into 4 regions, consisting of shallow inshore regions where predominantly smaller fish were found, to deeper offshore regions where only larger fish were found. The paper presents the new estimates of Antarctic toothfish catch-at-length and catch-at-age from the Ross Sea up to the end of the 2003-04 fishing season.
Pinkerton, M., J.M. Bradford-Grieve & S M Hanchet. (2009) **A balanced model of the food web of the Ross Sea, Antarctica**, pp. 33. CCAMLR, Hobart, Australia.

09/42.Used for Ross Sea Toothfish MSC 2013 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: We present a quantitative food web of the Ross Sea as a step towards investigating ecosystem effects of the fishery for Antarctic toothfish (*Dissostichus mawsoni*). The model consolidates quantitative information on trophic links across all the major biota of the Ross Sea and tests for data consistency. The model has 38 trophic groups and is balanced in terms of annual flows of organic carbon in an average, recent year (1990-2000). The focus of the model is on the role of Antarctic toothfish in the food web, which means that the model has greater taxonomic resolution towards the top of the food web than the base. A survey of the available literature and both published and unpublished data provided an initial set of parameters describing the annual average abundance, 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. This set of parameters was not self consistent, and a method is described to adjust the initial parameter set to give a balanced model taking into account the estimates of parameter uncertainty and the large range of magnitude (>6 orders of magnitude) in trophic flows between groups. Parameters for biomass, production rate, growth efficiency, diet fractions, and other transfers of biomass between groups were adjusted simultaneously. We found that changes to the initial set of parameters needed to obtain balance were reasonably small for most groups and most parameters. The mean absolute change for all key parameters (biomass, production rate, growth efficiency) and all groups together was 1.7%, and for diet fractions was 0.6%. Large but not implausible changes in biomass, production/biomass, and production/consumption parameters were needed to balance the microzooplankton (34-47%), ice bacteria (61-72%), and ice protozoa (24-54%), components of the model. Trophic levels are in close agreement with those derived from isotopic analyses and other ecosystems. In the balanced model, there is only enough large (>100 cm) toothfish production to satisfy 6.6% of the diet of Weddell seals, 5.9% of the diet of orca, and 2.8% of the diet of sperm whales. The model does not support the hypothesis that depletion of Antarctic toothfish by fishing would change the diet of predators of toothfish (Weddell seals, orca, sperm whales) by large amounts throughout the Ross Sea, though the importance of toothfish as prey items to these predators is not tested. The model shows that large toothfish consume 61% of the annual production of medium sized demersal fishes and 14% of the annual production of small demersal fishes, implying a potential for the fishery to affect these prey through trophic cascades. There is a need to establish monitoring of medium and small demersal fishes in the Ross Sea, and to model potential changes to these groups due to the fishery.

Pinkerton, M., S. Bury H., S.M. Hanchet & D. Thompson. (2007) **Stable isotope analysis of southern ocean fish tissue samples to investigate trophic linkages of Antarctic toothfish (*Dissostichus* mawsoni).** . CCAMLR, Hobart, Australia.
WG-EMM-07/19.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Flesh tissue samples were collected by scientific observers on-board New Zealand fishing vessels during the 2005/06 season in the Ross Sea CCAMLR Subarea 88.1 in order to investigate trophic links between toothfish and demersal fish. Muscle samples were collected from: Antarctic toothfish TOA (*Dissostichus mawsoni*) n=142;
Patagonian toothfish TOP (*D. eleginoides*) n=2; Whitson's grenadier WGR (*Macrourus whitsoni*) n=107; icefish CHW (*Chionobathyscus dewitti*) n=48; blue antimora ANT (*Antimora rostrata*) n=103; moray cod MRL (*Muraenolepididae*) n=1. Samples were lipid extracted, and analysed to determine C and N stable isotope composition. Values of δ15N and δ13C suggested that a minimum of three trophic levels exist between icefish occupying the lowest trophic level, and Antarctic toothfish occupying the highest level. Some Antarctic toothfish sampled in this study occupied a similar trophic level according to their δ15N signatures to killer whales and Weddell seals in McMurdo Sound, bluefin tuna in the Atlantic, and sperm whales from the Gulf of Mexico. There was high variance in δ15N and δ13C values for each

of the species sampled, on the order of 3-4 ‰ for δ15N (which equates to one trophic level) and 4 ‰ for δ13C (suggesting multiple primary sources of organic matter). For each species where sufficient data exist (TOA, ANT, CHW, WGR), a stepwise generalised linear model was used to identify significant relationships between the two dependent variables, δ15N and δ13C, and four variables: location (SSRU), fish length, sex, and depth. Location and a positive relationship with fish length were usually the only variables identified as significant. The isotope data agrees with previous work that the diet of the Antarctic toothfish varies with location, but the spatial patterns are not clear. Positive relationships between length and δ15N indicates that larger fish consume prey of a higher trophic level than smaller fish, which may be due to ontogentic changes in diet, and/or progressive consumption of larger individuals of the same species with age. There was significant residual variance in δ15N and δ13C values for each of the species sampled. Applying typical isotope fractionation factors for one trophic level (+0.4 for δ15N, and +3.4 for δ13C) allowed us to plot "prey polygons" for SSRUs 88.1C, 88.1H and 88.1I. Antarctic toothfish generally lay outside the prey polygons implying that the isotopic composition of tissue of the predator was not explained by the isotopic composition of prey sampled in that area. This may be due to: (1) variability in isotopic ratios within species and SSRU; (2) uncertainty in trophic fractionation (in both C and N) between trophic levels; (3) missing prey items (probably Antarctic silverfish, smaller fish species, crustaceans and squid); (4) movement since formation of the muscle (number of years). The work reported here is very much a preliminary analysis of the data. We plan further analysis of the data and further sampling (including more prey species, simultaneous stomach and stable isotope analysis, and muliple tissue sampling) to investigate these factors.

Pinkerton, M.H & B. Sharp. (2012) **Preliminary plan for research and monitoring in the Ross Sea region, in association with spatial marine protection.** . CCAMLR, Hobart, Australia.
WG-EMM-12/57.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: This document provides a preliminary version of a research and monitoring plan to accompany a proposal to CCAMLR for the establishment of a system of MPAs in the Ross Sea region in 2012. The draft Conservation Measure which with this research and monitoring plan is associated includes eight protection objectives as identified in Sharp & Watters (2011). Within each of these eight objectives there are identified specific objectives each of which is associated with an explicit spatial distribution or 'target area' defining the geographic extent of the feature (e.g. key ecosystem processes, habitats, species, populations and/or life-history stages) that has been identified as a priority for protection. This draft MPA research and monitoring plan is structured consistent with these specific objectives and priority features. Pursuant of each specific objective we identify the following categories of inquiry: i) research and monitoring to ensure that the boundaries of the priority feature as defined in the target area remain accurate, and/or to determine to what extent those boundaries may be moving; ii) research and monitoring to further understand the ecosystem role and importance of the priority feature, and/or to understand the environmental or biological processes that affect it, including potential threats from fishing; and iii) research and monitoring to demonstrate the extent to which achievement of the specific objective is being met,i.e. to demonstrate whether identified or plausible threats are being effectively mitigated by the MPA New Zealand welcomes feedback from and collaboration with other Members in the development of a draft research and monitoring plan. The plan will be revised following discussion for resubmission to SC-CCAMLR-XXXI in September 2012.

Pinkerton, M.H. & J.M. Bradford-Grieve. (2012) **Netword characterisation of the food-web of the Ross Sea, Antarctica**, pp. 23. CCAMLR, Hobart, Australia.
WG-EMM-12/53.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)

ABSTRACT: A balanced ecosystem model is used to explore the system-level characteristics of the food-web of the Ross Sea shelf and slope before the advent of commercial fishing for Antarctic toothfish (*Dissostichus mawsoni*) in the region. We evaluate: (1) biomass and flow of organic matter by trophic level; (2) mixed trophic impact; and (3) ecological importance. Note that the analysis considers food-web structure and function at the spatial, temporal and ecological scale of the ecosystem model, i.e. the whole Ross Sea shelf and slope area, averaged over a typical year, and in 35 trophic groups. Effects at smaller spatial and temporal scales, and effects concerning only parts of trophic groups, are not resolved by this analysis. The Ross Sea food-web is a partially inverted biomass pyramid with a pronounced peak in biomass in the lower-middle part of the food-web, a result of high biomass of mesozooplankton and benthic invertebrates. The biomass of top predators (trophic levels>4.5) is only 0.5% of the total living biomass in the Ross Sea (bacteria excluded). The six groups with the highest 'indices of ecological importance' in the food-web of the Ross Sea are phytoplankton, mesozooplankton, Antarctic silverfish (*Pleuragramma antarcticum*), small demersal fishes, Antarctic krill (*Euphausia superba*) and cephalopods. Pelagic fishes and crystal krill (*E. crystallorophias*) are also likely to have high importance in the Ross Sea food-web. These eight groups should be the priorities for monitoring for large-scale ecosystem change in the region, for example due to climate change, trophic cascades or regime shift. The analysis presented here does not support the hypothesis that changes to the abundance of toothfish in the Ross Sea will propagate through the food-web; it appears that Antarctic toothfish only have a moderate index of ecological importance in the food-web of the Ross Sea shelf and slope. Changing the biomass of Antarctic toothfish on the Ross Sea shelf and slope is likely to have the greatest effect on the demersal fish community there.

Pinkerton, M.H., J.M. Bradford-Grieve & S.M. Hanchet. (2008) **A preliminary balanced trophic model of the ecosystem of the Ross Sea, Antarctica, with emphasis on apex predators.** CCAMLR, Hobart,
Australia.
WG-EMM-08/42.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: 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, animalmounted 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.

Pinkerton, M.H., A. Dunn & S M Hanchet. (2007) **Ecological risk management and the fishery for Antarctic Toothfish (*Dissostichus mawsoni*) in the Ross Sea, Antarctica**, pp. 21. CCAMLR, Hobart, Australia.
WG-EMM-07/24.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Ecological risk management is increasingly being applied to marine fisheries worldwide as an aid to developing management strategies to avoid, mitigate, or manage adverse outcomes. Risk management encompasses four major steps: recognition of risk; assessment of risk; development of strategies to avoid, mitigate, manage or tolerate risk; and monitoring of risk. Here we begin the development of an ecological risk assessment for Antarctic Toothfish (*Dissostichus mawsoni*) longline fishery in the Ross Sea, Antarctica. We propose that, by defining risks and quantifying potential impacts, the limited research and management resources can be prioritised so as to meet the objectives of Article II of CCAMLR. Risks are considered in 4 categories:
1. Target species harvest: Risks of depletion of Antarctic Toothfish to below a level that ensuresstable recruitment.
2. Bycatch species harvest: Risks of depletion of other harvested species to below a level thatensures stable recruitment.
3. Ecosystem impacts: Risks of changes to the marine ecosystem relationships due to the removal ofharvested and bycatch species.
4. Exogenous effects: Risks of change in the marine ecosystem due to, or exacerbated by, exogenouseffects (e.g., the introduction of alien species, effects of associated activates on the ecosystem, and effects of environmental change).
The assessment of risk is based on combining the likelihood of an adverse outcome occurring and the consequence should it occur. Numerical models, such as stock or ecosystem mass-balance models can provide insights into these factors for some risks. In addition, semi-quantitative and qualitative estimates are needed because of a lack of knowledge and inability to predict the future dynamics of some parts of the system. It is also recognised that some risks (e.g., impacts of climate change) may not be able to be well predicted. The uncertainty arising from the complexity of the system and external factors acting on it means that risk management and ongoing monitoring will be required to ensure that the fishery is managed according to the conservation principles of Article II of CCAMLR.

Pinkerton, M.H., J. Forman, S.J. Bury, J. Brown, P. Horn & R.L. O'Driscoll. (2012) **Diet and trophic niche of Antarctic silverfish (*Pleuragramma antarcticum*) in the Ross Sea, Antarctica.** . CCAMLR, Hobart, Australia.
WG-EMM-12/54.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: The diet of Antarctic silverfish (*Pleuragramma antarcticum*) was evaluated by examining stomach contents of specimens collected in the Ross Sea (71°-77°S, 165°E-180°) in January-March 2008. Silverfish (50-236 mm standard length, SL) and silverfish prey items were analysed for stable isotopic composition of carbon and nitrogen. According to index of relative importance (IRI), the most important prey items of silverfish were copepods (IRI 81% over all specimens), predominantly *Metridia gerlachei* and *Paraeuchaeta* sp., with krill and fish having low IRI (IRI 2.2% and 5.6% overall). However, according to weight of prey in stomachs, fish (silverfish and lanternfish) and krill dominated diet overall (48% and

22% respectively), with copepods being a relatively minor constituent of overall diet by weight (9.9%). Piscivory by silverfish occurred mainly in the extreme south-west of the region and near the continental slope. By weight, krill identified to species level in silverfish stomachs were predominantly *Euphausia superba* (14.1%) with some *E. crystallophorias* (4.8%). were identified in silverfish stomachs. Both distLM modelling (PRIMER-permanova+) on stomach contents (by IRI) and stepwise generalised linear modelling on stable isotopes showed that SL and location were significant predictors of silverfish diet. Larval/post-larval silverfish (standard length, SL<90 mm) consumed exclusively copepods. Large adult silverfish (SL>179 mm) consumed predominantly fish by weight, especially in the north (near the Ross Sea slope) and in the SW of the Ross Sea. Juvenile silverfish (SL 96-151 mm) consumed predominantly krill by weight. Amphipods were important prey items for large adult silverfish in the west of the Ross Sea. General concordance between stomach contents and trophic level of silverfish and prey based on δ15N was demonstrated. Silverfish trophic level was 3.5 (larval/post-larval fish) and 4.0 (fish aged 3+).

Pinkerton, M.H., S.M. Hanchet & J. Bradford-Grieve. (2007) **A balanced trophic model of the ecosystem of the Ross Sea, Antarctica for investigating effects of the Antarctic toothfish fishery.** . CCAMLR, Hobart, Australia.
WG-EMM-07/18.Used for Ross Sea Toothfish MSC 2008 (Unpublished manuscript presented at the
Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: We report on the development of a mass balanced carbon-budget trophic model of the Ross Sea with which to investigate effects of the fishery for Antarctic toothfish (*Dissostichus mawsoni*). A survey of the available literature provided an initial set of parameters describing the abundance (seasonal and spatial where possible), energetics (growth, reproduction, consumption), and trophic linkages (diets, predators) for major groups of biota. We also estimated the level of uncertainty on these parameters. The Ross Sea is a low primary production system, with high seasonal, spatial and interannual variability in primary production. In the relative absence of krill, Antarctic silverfish (Pleuragramma antarctica) and mesozooplankton (mainly copepods) are probably the major middle-trophic level link between primary production and the larger predators, though the role of cepahlopods in the system is poorly known. A number of demersal fish species (including *Macrourus whitsoni*, *Bathyraja eatonii*, *Chionobathyscus dewitti*, *Antimora rostrate*, *Chionodraco hamatus*) are present, but their abundances and feeding characteristics are not well known. Toothed and baleen whales visit the Ross Sea in summer in relatively large numbers. Adelie and emperor penguins have breeding colonies along the Victoria Land coast, and petrels, skua and albatross are seasonal visitors. Weddell, crabeater, leopard and Ross seals are also present in summer, and some may stay in the region year-round.
The trophic model was balanced by adjusting the initial set of parameters obtained from the literature and available datasets. We present a novel objective method of adjustment that takes into account estimates of parameter uncertainty, and appropriately handles the huge range of magnitude (>5 orders of magnitude) in trophic flows between different groups of organisms. Biomass, production rates, consumption rates 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: up to 62% (biomass, production, consumption), and 40% (diet fractions). The balanced model presented here has not yet been validated and should be considered a work in progress. The current version of the trophic model suggests that Antarctic toothfish have the potential to exert considerable predation pressure on some species of demersal fish. More information on demersal fish abundance is required to validate this result. Information on what the various species of demersal fish consume is needed to estimate the potential for trophic cascades due to the toothfish fishery. The significance of toothfish in the diets of predators (especially Weddell seal, type-C killer whale, sperm whale) are low in the model, but the model does not consider sub-populations of predators, or localized dependencies on toothfish as prey. More complete information on the abundances, diets, and population

structures of top predators in the Ross Sea are needed to investigate these potential effects.

Pinkerton, M.H., P.J. McMillan, J. Forman, P. Marriott, P. Horn, S.J. Bury & J. Brown. (2012) **Distribution, morphology, growth, reproduction, diet and trophic position of two species of grenadier (*Macrourus whitsoni* and *M. caml*) in the Ross Sea region of the Southern Ocean (CCAMLR Subareas 88.1 nad 88.2)**, pp. 33. CCAMLR, Hobart, Australia.
WG-FSA-12/54.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: We present the first differentiated information on the biology and ecological niche of
Macrourus whitsoni and M. caml in the Ross Sea region of the Southern Ocean. Fish were caught by
New Zealand vessels in the fishery for Antarctic toothfish (*Dissostichus mawsoni*) between December 2011 and February 2012 from CCAMLR subareas 88.1B, 88.1C, 88.1G, 88.1H, 88.1K and
88.2H. In total, 227 *M. whitsoni* and 636 *M. caml* were examined. *Macrourus caml* grows larger than *M. whitsoni* and is about 19% heavier for a given length. The largest M. caml examined was 84 cm total length (TL) and 5.4 kg, whereas the largest *M. whitsoni* examined was 65 cm TL and 1.3 kg. The two main morphological characters (number of rays in the left pelvic fin; number of rows of teeth in the lower jaw) were very effective at distinguishing between the two species. Scientific observers on New Zealand vessels had an success rate of identification of the two species of 94% overall. We found that total length (TL) was no less precise a measurement than pre-anal length (PAL), even after catching fish on longlines, freezing and rethawing. On the broad scale, *Macrourus whitsoni* and M. caml seem to be almost completely sympatric by depth and area, with both appearing to be abundant between depths of 900 and 1900 m. There was a small but significant increase in the proportion of *M. whitsoni* relative to M. caml caught on baited autolines with increasing depth. Catches of females of both species exceeded that of males (especially for M. caml) and this sexselectivity was not explained by size or age of fish. Otolith aging data show that the two species have very different growth rates; *M. whitsoni* approaches full size at about 10-15 years of age and can live to at least 27 years; in *M. caml*, full size is attained at about 15-20 years of age and they can live in excess of 60 years. However, sexual maturity in female *M. whitsoni* is reached at longer length and older age than in female M. caml (length at maturity 52/46 cm TL; age at maturity 16/13 y for M. whitsoni/M. caml respectively). Our data were insufficient to estimate onset of sexual maturity for males of either species. Gonad staging data imply that the spawning period of both species may be extended, starting within or before December-January, and with the main part of the spawning occuring later than February. Gonad stage data did not reveal any substantial differences in spawning characteristics between areas. Most stomachs from both species everted on capture, so we augmented stomach contents data with examination of material from intestines. Our diet data are preliminary but are consistent with previous feeding studies of *Macrourus* spp., suggesting that *M. whitsoni* and *M. caml* are euryphagous predators and scavengers. Both species were found to be partially piscivorous, and amphipods were probably one of the main crustaceans consumed. Our data suggest that M. caml may feed more benthically than *M. whitsoni* (evidence of feeding on coral, ophiuroid, echinoderm, benthic polychaetes), though both species had been recently feeding on both benthic and pelagic prey, and the sample size was small. Isotopic analysis of muscle samples led to an estimated trophic level of 4.4 for M. caml and 4.1-4.2 for *M. whitsoni*.

Pinkerton, M.H., S. Mormede & S M Hanchet. (2010) **Towards a Minimum Realistic Model for investigating trophic relationships between Antarctic toothfish and demersal fish in the Ross Sea, Antarctica**, pp. 15. CCAMLR, Hobart, Australia.
WG-SAM-10/21.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)

ABSTRACT: We report on progress towards developing a Minimum Realistic Model for investigating trophic relationships between Antarctic toothfish (*Dissostichus mawsoni*) and four groups of demersal fish in the Ross Sea, Antarctica. These demersal fish are known to form a part (in some cases a substantial part) of the diet of Antarctic toothfish of a size commonly taken by the Ross Sea fishery and are also taken as bycatch by the fishery:
(1) macrourids (especially Whitson's grenadier, *Macrourus whitsoni*);
(2) icefish (especially *Chionobathyscus dewitti*);
(3) deep sea cods (especially violet cod, *Antimora rostrata*); and
(4) eel (moray) cods (*Muraenolepsis* spp.). Changes to the abundance of Antarctic toothfish due to fishing could affect these prey groups and the trophic relationship between these groups and toothfish. A Minimum Realistic Model is the most appropriate modelling approach to investigate what changes in the abundances of these four demersal fish prey/bycatch groups in the Ross Sea are possible, and what changes in the trophic relationships between Antarctic toothfish and these prey groups may occur. Feedback on the model is sought. Work on this model will continue through 2010 and 2011 and will be presented to CCAMLR in due course.

Pinkerton, M.H., C. O Maolagain, J. Forman & P. Marriott. (2014) **Discrimination of two species of grenadier (Gadiformes, Macrouridae), *Macrourus whitsoni* and *M. caml*, in the Ross Sea region of the Southern Ocean (CCAMLR Subareas 88.1 and 88.2) on the basis of otolith orphometrics**. CCAMLR, Hobart, Australia.
WG-FSA-14/63.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Two species of grenadier are predominatly taken as bycatch in the Ross Sea region, *Macrourus whitsoni* and *M. caml*. A total of 220 otoliths from *M. whitsoni* and 307 otoliths of *M. caml* from fish taken as bycatch in the Ross Sea on New Zealand fishing vessels in the 2011-12 fishing year were used to test whether the otoliths of the two species can be discriminated. Samples of both species of macrourid were obtained from SSRUs 88.1B, 88.1C, 88.1H, 88.1J, 88.1K and from 88.2H. Lengths of M. whitsoni in the sample were 34.5-65.1 cm total length (TL), and 12.0-24.0 cm pre-anal length (PAL); lengths of *M. caml* in the sample were 34.5-81.5 cm TL and 11.0-30.0 cm PAL. Both males and females were included in the sample, but females predominated. A linear function of fish total length (cm), depth of the whole otolith (Depth, mm), and maximum cross-sectional area of the otolith (Area, mm2) gave excellent discrimination between the two species:
♋ = 1.254 + 0.03512*TL - 0.02463*Depth - 0.7668*Area
Where □<0.5 indicates M. caml and □>0.5 indicates *M. whitsoni*. Based on withholding data for testing in 10 folds, the multiple linear regression coefficient, R=0.776 [F(4, 522) = 272.9, p < 0.001], the proportion correctly identified was 92% (483 / 527), and the area under the receiver-operator characteristic (ROC) was 0.968. A similar discriminant function based on PAL (cm) rather than TL performed almost as well (90% correctly identified, ROC 0.97):
♋ = 1.330 + 0.09022*PAL - 0.02453*Depth - 0.6915*Area
There was no significant variation in the discriminant values (□) according to sex of the fish or for Subarea of capture for M. caml (CCAMLR Subareas 88.1 versus 88.2). However, there was a small but significant difference in □□for *M. whitsoni* between subareas 88.1 and 88.2 [t(218) = 4.20, p < 0.001 ***], which provides some evidence that they could be separate stocks in the two CCAMLR Subareas.

Ponganis, P.J. & T.K. Stockard. (2007) **The Antarctic toothfish: how common a prey for Weddell seals?** *Antarctic Science,* 19, 441-442.
MSC Reference for the initial certification of the Ross Sea Toothfish Fishery 2008
ABSTRACT: The Antarctic toothfish (*Dissostichus* mawsoni Norman) has been considered an occasional large prey item of the Weddell seal (Leptonychotes weddellii Lesson) (Kooyman 1967, Calhaem & Christoffel 1969, Testa et al. 1985, Castellini et al. 1992, Davis et al. 1999, Fuiman et al.

2002). The seal's most common prey is the Antarctic silverfish (Pleuragramma antarcticum Boulenger) as well as benthic and sub-ice fish, cephalopods, and crustaceans (Dearborn 1965, Green & Burton 1987, Plotz 1987, Plotz et al. 1991, Castellini et al. 1992, Burns et al. 1998).

Robinson, L.M. & K. Reid. (2014) **Modelling the circumpolar distribution of Antarctic toothfish using correlative species distribution modelling methods**, pp. 15. CCAMLR, Hobart, Australia.
WG-FSA-14/65.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This paper presents correlative species distribution modelling methods that could be used to predict the circumpolar distribution of habitat suitability for Antarctic toothfish. Potential environmental covariates that could be included in these models are presented for discussion and feedback, as are the types of CCAMLR data (i.e. presence of the species and/or attributes) and modelling algorithms that may be included in future work. Methods for dealing with issues such as sampling bias in model fitting, extrapolation in model predictions and spatial sorting bias in model evaluation are also suggested and highlighted for discussion. Preliminary results are provided to demonstrate the application of two methods (BIOCLIM and Maxent). For simplicity models included two environmental covariates (bathymetry and latitude) and default model settings were used. Evaluation of prediction accuracy included a select number of test statistic (i.e. AUC, max Kappa and point-biserial correlation) with some preliminary consideration of spatial sorting bias.

S.J. Parker, R.G. Cole and S.M. Hanchet. (2010) **Spatial scales of benthic invertebrate habitats from fishery by catch and video transect data in the Ross Sea region.** . CCAMLR, Hobart, Australia.
WG-EMM-10/28.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: High resolution VME taxa bycatch data (at the longline segment level) has been collected for two fishing seasons, with 4728 longline segments observed. Several regions with consistent presence of sponge and/or gorgonian bycatch are identifiable, as are several areas of dense fishing effort with no evidence of sponge or gorgonian presence. Identifiable sponge and/or gorgonian habitats occurred at a typical scale of 10-30 km2, though some sponge habitats appeared larger. Spatial analysis of these data allows the detectability of sponges and gorgonian corals to be estimated, along with changes in catch rate at different densities. Results indicate that sponge patches are detected more than 70% of the time when present, and gorgonian patches are detected more than 60% of the time. Video transects on the Ross Sea slope from New Zealand's 2008 IPY voyage provided data on the fine scale distributions (i.e. < 600 m) of sponges, stony corals, and ascidians. The prevalence of sponge and gorgonian habitats also varies among four benthic bioregions developed for the Ross Sea. Together, the data show that sponges and other vulnerable taxa occur in complex mosaic patterns of small patches dispersed within larger habitats.
Confirmation of these results is necessary using independent methods such as underwater video and would provide a method to link bycatch observations to habitat density on the seafloor.

S.J. Parker, R.G. Cole and S.M. Hanchet (2010) **Further analysis of spatial patterns of benthic invertebrate habitats from fishery by-catch in the Ross Sea region.** . CCAMLR, Hobart, Australia.
WG-FSA-10/30.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: High resolution VME taxa bycatch data (at the longline segment level) have been collected for two fishing seasons, with 4 728 longline segments observed. Several regions with consistent presence of VME taxa bycatch are identifiable, as are several areas

of dense fishing effort with no evidence of VME taxa. Identifiable sponge and/or gorgonian habitats occurred at a typical scale of 10-30 km2, though some sponge habitats may have been larger. Other taxa were not clustered at small scales, but were at larger scales. Spatial analysis of these data allows the detectability of prevalent taxa to be estimated, along with changes in catch rate at different levels of observed bycatch. Results indicate that several VME taxa are detected between 60% and 80% of the time when present, and that probability of detection was higher near areas with other high bycatch observations. Video transects on the Ross Sea slope from New Zealand's 2008 IPY voyage were used to characterise the fine scale distributions (i.e. < 600 m) of sponges, stony corals, and ascidians. The prevalence of six VME taxa also varies among four benthic bioregions developed for the Ross Sea. Together, the data show that vulnerable taxa occur in complex mosaic patterns of small patches dispersed within larger habitats. Confirmation of these results is necessary using independent methods such as underwater video and would provide a method to link bycatch observations to habitat density on the seafloor.

Schulz, Michael & Karl Stattegger. (1997) **SPECTRUM: Spectral analysis of unevenly spaced paleoclimatic time series**. *Computers and Geosciences,* 23, 929–945.
ABSTRACT: A menu-driven PC program (SPECTRUM) is presented that allows the analysis of unevenly spaced time series in the frequency domain. Hence, paleoclimatic data sets, which are usually irregularly spaced in time, can be processed directly. The program is based on the Lomb-Scargle Fourier transform for unevenly spaced data in combination with the Welch-Overlapped-SegmentAveraging procedure.
SPECTRUM can perform: (1) harmonic analysis (detection of periodic signal components), (2) spectral analysis of single time series, and (3) cross-spectral analysis (cross-amplitude, coherency, and phase-spectrum). Cross-spectral analysis does not require a common time axis of the two processed time series. (4) Analytical results are supplemented by statistical parameters that allow the evaluation of the results. During the analysis, the user is guided by a variety of messages. (5) Results are displayed graphically and can be saved as plain ASCII files. (6) Additional tools for visualizing time series data and sampling intervals, integrating spectra and measuring phase angles facilitate the analysis.
Compared to the widely used Blackman-Tukey approach for spectral analysis of paleoclimatic data, the advantage of SPECTRUM is the avoidance of any interpolation of the time series. Generated time series are used to demonstrate that interpolation leads to an underestimation of high-frequency components, independent of the interpolation technique.

Secretariat. (2013) **Mapping trends in activity of illegal, unreported and unregulated (IUU) fishing in the CAMLR Convention Area**, pp. 15. CCAMLR, Hobart, Australia.
ccamlr-XXXII/BG/09.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Data related to IUU (and probable IUU) activity submitted to the Secretariat were used to provide an overview of the potential spatial and temporal distribution of recent IUU activity in the CAMLR Convention Area. Combining all information available to the Secretariat indicates that IUU is concentrated in the Indian Ocean Sector; however, the spatial and temporal pattern of IUU activity based on sightings data alone provides a restricted view these activities. This combined analysis also indicates the presence of IUU activity in Subarea 48.6 and more persistent activity in the Indian Ocean Sector on Ob, Lena, Elan and BANZARE banks as well as on the boundary of the Kerguelen and Heard Island EEZs. With the information currently provided to the Secretariat it may not be possible to distinguish between an apparent decrease in IUU catch and a decrease in surveillance effort that results in fewer sightings. A potential approach to understanding the actual 'surveillance' potential of licenced fishing vessels, by developing a better understanding of the probability that another vessel will be detected, is provided.

Secretariat. (2014) **Review of skate (Rajiformes) by-catch in CCAMLR toothfish**

fisheries, pp. 25. CCAMLR, Hobart, Australia.
WG-FSA-14/12.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Available data on the by-catch of Rajiformes was extracted from the CCAMLR database. These records included commercial catch data as well as observer data. Spatial distribution and biological data was broadly consistent with current literature although there were indications of larger spatial ranges for some species. The data collected as part of CCAMLR fisheries represents a very substantial repository of information on Southern Ocean Rajiformes; realising the full potential of this data will require a review of the consistency and accuracy of identification of taxa and this might be a useful for a future focus topic in the SISO.

Secretariat, CCAMLR. (2014) **Mapping trends in activity of illegal, unreported and unregulated (IUU) fishing in the CAMLR Convention Area**. CCAMLR.
CCAMLR-XXXIII/BG/28 Rev. 1.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: 1. At CCAMLR-XXXII, the Secretariat provided an overview of the spatial and temporal distribution of illegal, unreported and unregulated (IUU) fishing activity within the Convention Area in recent years (CCAMLR-XXXII/BG/09 Rev. 1). The objective of the analysis was not to estimate areaspecific IUU catch amounts, but to spatially characterise observed IUU activity, including IUU fishing gear recoveries, in the CAMLR Convention Area.
2. The paper noted that, with the information currently provided to the Secretariat, it is not possibleto distinguish between an apparent decrease in IUU catch over time and a decrease in surveillance effort that results in fewer sightings.
3. The evidence, combined with surveillance data from France, suggested that IUU detection isconcentrated in the Indian Ocean sector at both high and low latitudes (i.e. Divisions 58.4.1, 58.4.2, 58.4.3a, 58.4.3b, 58.4.4, and outside EEZs in Divisions 58.5.1, 58.5.2 and Subareas 58.6 and 58.7).
4. Using all available data, rather than concentrating on vessel sightings, suggested that observedIUU fishing is more persistent in the northern part of the Indian Ocean and has also occurred in Subarea 48.6 (where no IUU vessel sightings have been reported).

Sharp, B., S. Parker & N. Smith. (2008) **Methods for implementing Conservation Measure 22-06: An impact assessment framework for bottom impacting fishing methods in the CCAMLR area**. CCAMLR, Hobart, Australia.
WG-FSA-08/53.Used for Ross Sea Toothfish MSC 2011 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This paper presents a framework to assess and quantify the likely cumulative impact on potential VMEs from bottom fishing activity. application across gear types and areas to allow comparisons between fisheries employing different bottom impacting fishing methods. 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 standardized 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.

Sharp, B.R and Parker S.J. . (2010) **An updated glossary of terms relevant to the management of Vulnerable Marine Ecosystems (VMEs) in the CCAMLR Area.** CCAMLR, Hobart, Australia.
WG-FSA-10/28.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)

ABSTRACT: In 2009 SC-CCAMLR identified a list of tasks to be considered intersessionally to progress a framework to manage the risk that bottom fishing in the CCAMLR Area may produce significant adverse impacts on certain benthic habitats, termed Vulnerable Marine Ecosystems (VMEs). One of the identified intersessional tasks was to produce a glossary of terms relevant to the management of VMEs (SC-CAMLR XXVIII, paragraph 4.251(iii)). In 2010 WG-EMM discussed a proposed VME glossary (WG-EMM-10/29) and recommended adoption of six key terms. Other VME relevant terms were also discussed but referred to WG-FSA (WG-EMM 2010, paragraph 3.2-3.3). This paper updates the previous VME glossary to reflect the definitions agreed by WG-EMM and proposes definitions for additional terms consistent with the previous advice within CCAMLR and new advice from WG-EMM. A conceptual diagram is also provided to illustrate the relationships between the terms and the means by which terms might be combined quantitatively to inform the evaluation of fishing impacts on VMEs.

Sharp, B.R. (2010a) **Revised impact assessment framework to estimate the cumulative footprint and impact on VME taxa of New Zealand bottom longline fisheries in the Ross Sea region**. CCAMLR, Hobart, Australia.
WG-SAM-10/20 Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: In 2008-2009 New Zealand developed an impact assessment framework to estimate the likely impacts of bottom longline fishing on vulnerable benthic invertebrate taxa, termed Vulnerable
Marine Ecosystems (VMEs), consistent with the requirements of Conservation Measure 22-06 (Bottom fishing in the Convention area). The impact assessment framework was subsequently endorsed within CCAMLR for routine application by Members submitting notifications of their intent to participate in new or exploratory fisheries using bottom fishing gear (SC-CAMLR XXVIII, paragraph 4.247 v-vii), and was applied to estimate the cumulative historical bottom fishing footprint of all fisheries in the CCAMLR area. The Scientific Committee called for additional work to address remaining uncertainties about the nature and extent of bottom fishing impacts on potential VMEs (SC-CAMLR-XXVIII paragraph 4.251). The purpose of this paper is: i) to estimate impacts on VMEs per unit effort using a simulation approach with explicit incorporation of uncertainties in the input assumptions; ii) to examine the application of the impact assessment framework at different spatial scales, and implications for the validity of the underlying structural assumptions of the assessment framework; and iii) to express impact estimates in a spatially explicit manner with reference to areas of distinct environmental characteristics arising from a benthic bioregionalisation of the Ross Sea region (Sharp et al. 2010). We conclude that bottom fishing impacts on VME taxa in the Ross Sea are low.

Sharp, B.R. (2010b) **Updated impact assessment framework to estimate the cumulative footprint and impact on VME taxa of bottom longline fisheries in the CCAMLR Area.** CCAMLR, Hobart,
Australia.
WG-FSA-10/31.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Since 2008 New Zealand has been developing an impact assessment framework to estimate the likely impacts of bottom longline fishing on Vulnerable Marine Ecosystems (VMEs), as required by Conservation Measure 22-06. The most recent iteration of the impact assessment (Sharp 2010) was recommended in 2010 by WG-SAM (paragraph 4.16) and WG-EMM (paragraph 3.20) as the basis by which Members submitting new and exploratory fishery notifications should estimate impacts on VMEs associated with their proposed bottom fishing activities, as well as the basis by which WG-FSA might complete cumulative impact assessments for all gear types combined at the scale of entire fisheries. Both WG-SAM and WG-EMM gave specific guidance as to how the framework might best

be applied. This paper updates the impact assessment taking account of the specific recommendations of WG-SAM and WG-EMM 2010 and incorporating new information arising from WG-EMM 10/33, including the choice of improved input distributions representing key variables driving the impact simulation and the use of alternate assumptions in which lateral movement frequency is negatively correlated with depth. Impact estimates are summarized separately for each of 17 benthic bioregions defined in Sharp et al. (2010), and displayed as frequency distributions of fine-scale pixels experiencing different levels of impact, as advised by WGSAM 2010 (paragraph 4.18). We conclude that the relationship between depth and lateral line movement is highly uncertain, but it is likely that improved understanding of this relationship will yield impact estimates that are slightly higher for shallow habitats on the shelf relative to previous estimates, and substantially lower for deep habitats. Overall estimates of impact remain low within all bioregions.

Sharp, B.R. & K. Ollivier. (2012) **A customised Marine Spatial Planning tool in Arc-GIS to facilitate development and evaluation of Marine Protected Area scenarios in the CCAMLR Area**, pp. 9. CCAMLR, Hobart, Australia.
WG-EMM-12/56.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: We describe the use of a GIS-based Marine Spatial Planning (MSP) tool designed to aid the development and transparent evaluation of MPA scenarios with reference to spatially explicit protection objectives and cost layers representing rational use in a systematic conservation planning framework. The MSP tool has been customised to enable rapid set-up and use in any of the nine CCAMLR MPA planning domains.

Sharp, B.R., S.J. Parker, M.H. Pinkerton, B.B. Breen, V. Cummings, A. Dunn , S.M. Grant, S.M.
Hanchet, H.J.R. Keys, S.J. Lockhart, P. O'B. Lyver, R.L. O'Driscoll, M.J.M. Williams, P.R. Wilson (2010) **Bioregionalisation and spatial ecosystem processes in the Ross Sea region.** CCAMLR, Hobart,
Australia.
WG-EMM-10/30.Used for Ross Sea Toothfish MSC 2011 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Since 2005, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has progressed plans to implement spatial management for purposes of marine conservation (i.e. networks of Marine Protected Areas, or MPAs). In 2008 CCAMLR utilized a circumpolar-scale 'bioregionalisation' to identify areas within which MPA designation should be considered as a matter of high priority. Members have been encouraged to progress spatial management planning at regional scales, using both fine-scale bioregionalisation and 'systematic conservation planning' (SC-CAMLR XXVII, paragraph 3.55). In 2009 the CCAMLR Scientific Committee agreed a series of milestones to achieve a representative network of MPAs in the CCAMLR Area by 2012. New Zealand has been an active contributor to the CCAMLR spatial management planning process, and has declared its interest in progressing spatial marine protection in the Ross Sea region. To this end, in June 2009 New Zealand hosted a Ross Sea Region Bioregionalisation and Spatial Ecosystem Processes international expert workshop, tasked with assembling and analysing available environmental and biological spatial data for the Ross Sea region and summarizing this information to inform spatial management design, consistent with CCAMLR endorsed methods. The workshop met for five days and was attended by twenty-one international experts with a range of relevant expertise. Analytical methods were as in previous CCAMLR Bioregionalisation workshops (Grant et al. 2006, SC-CAMLR XXVI/9), i.e. automated environmental classification using cluster analyses of environmental datasets, iteratively selected and validated with reference to expert knowledge and spatial biological data, with additional expert consultation to identify areas containing ecosystem processes of particular importance. Outputs from the workshop include the following:

i) a fine-scale benthic bioregionalisation of the Ross Sea

region; ii) a fine-scale pelagic bioregionalisation of the Ross

Sea region; and

iii) an agreed list and map of spatially bounded ecosystem processes of particular importance for conservation of the regional ecosystem.
The purpose of this paper is to describe the 2009 Ross Sea region Bioregionalisation and Spatial Ecosystem Processes expert workshop including available input data, workshop methodology, and workshop outputs-and to present these outputs for consideration by CCAMLR and the wider Antarctic science and marine management community, to inform spatial management planning in the Ross Sea region. In isolation any one of the three main workshop outputs provides an incomplete picture. It is New Zealand's intention that these three outputs be utilized together to guide ongoing efforts by New Zealand and other CCAMLR Members to design and implement a representative and effective marine spatial protection and management network, to safeguard the environmental values and ecosystem integrity of the Ross Sea region while providing for rational use, consistent with the CCAMLR mandate.

Sharp, B.R. & G.M. Watters. (2011) **Marine protected area planning by New Zealand and the United States in the Ross Sea region**, pp. 40. CCAMLR, Hobart.
WS-MPA-11/25.Used for Ross Sea Toothfish MSC 2011 (Unpublished work presented at the Marine Protected Areas Workshop of CCAMLR)
ABSTRACT: Since 2005, CCAMLR has progressed plans to implement Marine Protected Areas (MPAs) to achieve the aims of Article II of the Convention. CCAMLR has agreed a list of milestones for establishing a system of MPAs in the Convention Area by 2012 (SC-CAMLR XXVIII, 3.28) and has encouraged Members to design and propose MPA scenarios on a regional basis. The 2011 CCAMLR MPA Workshop is intended to facilitate this process by reviewing MPA scenarios prepared and submitted by Members and providing a forum for discussing appropriate methods by which further MPA planning should proceed. This paper describes MPA planning processes undertaken by New
Zealand and the United States, working in parallel and in collaboration with each other, to design MPA scenarios in the Ross Sea region. The paper presents separate MPA scenarios by New Zealand and by the United States consistent with their own planning processes and conservation objectives. It is the intention of both Members that these scenarios, following review by the MPA workshop and discussions with other Members, be used to inform the development of one or more formal MPA proposals for the Ross Sea region. The paper also presents a detailed description of tools and methods by which MPA planning was conducted by New Zealand and by the United States, to guide similar efforts by other CCAMLR Members.

Smith, P.J., C.D. Roberts, A.L. Stewart, M. McVeagh & C.D. Struthers. (2007) **Identification and speciation of Antarctic skates**, pp. 45. CCAMLR, Hobart, Australia.
WG-FSA-07/27.Used for Ross Sea Toothfish MSC 2008 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Two regions of mitochondrial (mt) DNA: cytochrome b and cytochrome c oxidase subunit 1(COI) were sequenced in 9 species of Bathyraja skates from the Southern Oceans and New Zealand. Based on significant sequence divergence, the species that has been referred to as *Bathyraja eatonii* from the Antarctic shelf and slope is a species distinct from B. eatonii from the Kerguelen Plateau (the type locality), and is a new and undescribed species, and should be provisionally referred to as *Bathyraja* n. sp. cf *eatonii*. There was no sequence divergence among samples of *B.* n. sp. "dwarf" from the Ross Sea and South Atlantic. However, for *Bathyraja* n. sp. cf. *eatonii* and *Bathyraja maccaini* in the Ross Sea and South Atlantic Ocean, the DNA sequence divergences are indicative of differentiation

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

Southwell, C., P. Trathan, W. Trivelpiece, M. Goebel & P. Wilson. (2007) **Developments, considerations and recommendations by the land-based predator survey correspondence group: a second summary and update.** . CCAMLR, Hobart, Australia.
WG-EMM-07/20.Used for Ross Sea Toothfish MSC 2007 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: This paper briefly summarises deliberations of the predator survey correspondence group since 2006. In particular, some general principles for estimating predator demand are outlined, and draft terms of reference for a workshop in 2008 presented.

Stevens, D.W. (2006) **Stomach contents of sub-adult Antarctic toothfish (*Dissostichuis mawsoni*) from the Western Ross Sea, Antarctica**, pp. 14. CCAMLR, Hobart.
FSA-06/27.Used for Ross Sea Toothfish MSC 2006 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The stomach contents of 190 sub-adult (51-100 cm TL) Antarctic toothfish (*Dissostichus mawsoni*) captured by bottom longline in the western Ross Sea were analysed. Fish were sampled during the 2005 fishing (Dec 2004 to Jun 2005) season and caught in 398-1678 m depths. Sub-adult *D. mawsoni* are primarily piscivorous, feeding on a wide variety of small to medium sized fish. Icefish (*Channichthyidae*) were the most important prey by frequency, weight and IRI, while small notothens (*Nototheniidae*) were more numerous. Whitson's grenadier (*Macrourus whitsoni*), dragonfish (*Bathydraconidae*), and eel cods (Muraenolepididae) were also important. Glacial squid (*Psychroteuthis glacialis*) were found in about 20% of stomachs, but only 6% by IRI. Samples were collected mainly from the continental slope along the northern edge of the Ross Sea. Although the study provides an important comparison of diet of adult and sub-adult fish collected from the same area, the results may not reflect the diet of the main part of the sub-adult population which is thought to reside on the main shelf to the south. It is therefore recommended that further stomach samples be collected from further south on the Ross Sea shelf.

Stevens, D.W., M.R. Dunn, M.H. Pinkerton & J.S. Forman. (2012) **Diet of Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea region, Antarctica**, pp. 22. CCAMLR, Hobart, Australia.
WG-FSA-12/52.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The diet of Antarctic toothfish (*Dissostichus mawsoni)* in the Ross Sea region was examined based on stomach samples obtained from observers on New Zealand fishing vessels in 2003 and 2010. Overall, the diet of sub-adult toothfish was similar to that of adult toothfish, with a dominance of piscivory on benthic fishes and cephalopods, augmented by benthic invertebrates. Sub-adult toothfish ate a greater variety of smaller prey than adults, including smaller fishes (such as *Trematomus* sp., dragonfish, mainly *Bathydraco* spp.), and large decapod prawns (*Nematocarcinus*).

By weight and index of relative importance (IRI), grenadiers (*Macrourus* spp.) were the most important fish and overall prey species. The study did not distinguish between *M. whitsoni* and *M. caml*, but this should occur in future. Over the Ross Sea continental shelf, icefish (probably mainly *Chionobathyscus dewitti*), and eel cods (probably mainly *Muraenolepis evseenkoi*) were important prey items. Glacial squid, *P. glacialis*, were the most important cephalopod prey species, especially over the northwest Iselin Bank. On oceanic seamounts, toothfish fed substantially on *Macrourus* spp. but also deep sea cod (*Antimora rostrata*), a variety of cephalopods and the occasional mesopelagic to epipelagic fish. A key aim of this study was to see whether stomach contents of toothfish could be used to detect ecosystem change in the Ross Sea region, with a focus on the area of highest fishing intensity - the northern parts of the Mawson and Iselin Banks on the Ross Sea continental slope (70°-73°S, 175°E-175°W). Variation of stomach contents with toothfish length, weight, sex, month, depth and location was analysed to investigate whether a residual year effect was discernible in stomach contents in this region between 2003 and 2010. Although these factors explained some variation in stomach contents in the Mawson and Iselin Bank block, the proportion of variance explained was relatively small, and we found no statistically significant change in toothfish diet between 2003 and 2010. Holling type I and type II feeding relationships were determined for the Mawson and Iselin Bank on the continental slope using catch per unit effort (CPUE, fish per 1000 hooks) for grenadiers, ice fish and eel cods. Compared to CPUE, icefish and eel cods were over-represented in toothfish stomachs relative to grenadiers. The fitted feeding selectivity for toothfish relative to the selectivity of baited autoline fishing gear was found to be nearly 11 times higher for icefish than for grenadiers; the relative selectivity was more than 4 times higher for eel cods than that for grenadiers. It is not known whether this is due to lower catchability by longlines, greater availability to toothfish predation for a given abundance, or higher toothfish feeding preference for icefish and eel cods relative to grenadiers.

Stevenson, M.J., S.M. Hanchet, S. Mormede & A. Dunn. (2014) **A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997–98 to 2013–14**. CCAMLR, Hobart, Australia.
WG-FSA-14/52.Used for Ross Sea Toothfish MSC 2014 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: This report summarises the timing, depth, and location of fishing together with the biological aspects and catch of Antarctic toothfish up to an including the 2014 season. In 2014, the Ross Sea slope SSRUs were not constrained by sea ice and catches were evenly distributed across the three SSRUs. As in recent years, the remaining catches came mainly from SSRUs 88.1C, 88.1J, and 88.2H. Unstandardised Antarctic toothfish CPUE in the Ross Sea and Subarea 88.2 fisheries have fluctuated over the past 12 years with a slight decline in the past two years. Length frequency distributions of Antarctic toothfish in the Ross Sea fishery have continued to be stable in the North and variable on the Shelf. The strong mode of smaller (90-120 cm TL) toothfish present in the Slope fishery from 2010-2013 was not present in the 2014 season, and the size composition in 2014 was more similar to that in the early period of the fishery - the reason for this is unclear. There has been a slight reduction in mean age in SSRU 88.2H, but the data are very uncertain due to the paucity of otolith readings and it is recommended that additional otolith readings for this area are given a high priority. There was a marked increase in the proportion of males in the Ross Sea North fishery from 2001 to 2009, but this has decreased slightly since then. There has been little change in sex ratio in the other areas.

Stevenson, M.L., S.M. Hanchet, S. Mormede & A. Dunn. (2012) **A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2011/12**, pp. 38. CCAMLR, Hobart, Australia.
WG-FSA-12/42.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: The exploratory fishery for *Dissostichus* spp. has now been operating for 16

years in Subarea 88.1 and for 10 years in Subarea 88.2. This report summarises the timing, depth, and location of fishing together with the catch of *Dissostichus* spp. and bycatch species by year for the period 1997-98 to 2011-12. During the 2011-12 fishing year most of the catch in Subarea 88.1 came from the slope SSRU 88.1K. About 70% of the catch in the north was taken from 88.1C, and about 85% of the catch on the shelf was taken from 88.1J. As in the past, most of the catch in Subarea 88.2 was taken from SSRU 88.2H in the north. Unstandardised Antarctic toothfish CPUE (catch per hook and catch per set) in the Ross Sea and Subarea 88.2 fisheries have fluctuated over the past 10 years with no overall upward or downward trend. There is no evidence of any truncation of the overall length frequency distribution in any of the SSRUs, but there has been a marked reduction in median fish length in SSRUs 88.1H and 88.1I over the last 2-3 years. This appears to be at least partly a result of vessels carrying out more fishing in shallower parts of the slope, but could also reflect fishing on different parts of the slope, or a pulse of strong year classes. We conclude that there is no evidence for substantial changes in population structure or abundance of Antarctic toothfish at the regional (Subarea) or local (SSRU) level. We also present a characterisation of the main six bycatch groups including macrourids, skates, icefish, eel cods, morid cods and rock cods and ice cods for the first time. For each bycatch group the main species are identified and the location and depth distribution of catches and catch rates rates are plotted.

Sutton, C.P., P.L. Horn & S.J. Parker. (2012) **Manual for age determination of Antarctic toothfish, *Dissostichus maswoni* V2**, pp. 30. CCAMLR, Hobart, Australia.
WG-FSA-12/43.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: An age determination manual for Antarctic toothfish (*Dissostichus mawsoni*) was produced for CCAMLR in 2010. The manual has been updated to include the development and use of a reference set to provide training and refresher material for agers, and to formally track reader performance and reader drift. In addition, standardized analysis and data reporting are recommended to allow the evaluation of *D. mawsoni* aging data for use in stock assessment.

Thompson, D.R., M.H. Pinkerton, D.W. Stevens, Y. Cherel & S.J. Bury. (2012) **The Ross Sea cephalopod community: insights from stable isotope analysis**. CCAMLR, Hobart, Australia.
WG-EMM-12/55.Used for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Ecosystem Monitoring and Management Working Group of CCAMLR)
ABSTRACT: Based on mass balance modeling and mixed trophic impact analysis, cephalopods have been identified as having relatively high importance in the food-web of the Ross Sea. However, information on the trophic ecology of the cephalopod assemblage of the Ross Sea region is poor.
Stable isotope signatures of nitrogen (δ15N) and carbon (δ13C) were determined in muscle and beak tissue from a range of cephalopod taxa sampled from the Ross Sea region. Samples were acquired through scientific trawls and from stomachs of Antarctic toothfish *Dissostichus mawsoni* returned from the longline fishery. Most octopods were not identified to species which limits analysis. All squid samples were identified to species, but isotopic comparisons were made at the level of genus to accommodate the uncertainty in octopod identifications. Generally, squid clustered into two distinct isotopic groups, one with depleted isotope signatures typical of feeding on relatively low trophic level prey within the Ross Sea, and the second with elevated isotopic signatures typical of feeding on relatively high trophic level prey with some suggestion of either movement northwards out of the Ross Sea or of coupling with the benthic system. In contrast, octopod genera exhibited relatively elevated and diverse isotope signatures, typical of benthic feeding where nutrients tend to be recycled repeatedly. Beak isotope values were consistently depleted compared to those in muscle tissue, whereas carbon isotope values were similar in both beak and muscle tissues. Size (and hence age) was an important factor in explaining variation in both beak and

muscle tissue isotope signatures in only one species - the colossal squid *Mesonychoteuthis hamiltoni*: both isotope signatures were positively and significantly correlated with beak size. The utility and value of applying stable isotope analyses to cephalopod taxa from the Ross Sea is discussed.

USA, Delegation of of New Zealand and the. (2013) **Science supporting the joint New Zealand–United States proposal for the establishment of a marine protected area in the Ross Sea Region**, pp. 27. CCAMLR, Hobart.
SC-CAMLR-IM-I/08.Used for Ross Sea Toothfish MSC 2013
ABSTRACT: The Commission has asked the Scientific Committee to review the science supporting a joint New Zealand-United States proposal to establish a marine protected area (MPA) in the Ross Sea Region (RSR). A substantial amount of material has already been presented to the Scientific Committee and its working groups, and here we provide an abridged and annotated summary of that material. We organize our summary by linking spatial data to the specific protection and scientific objectives of the jointly proposed MPA, and we summarize science pertaining to coastal areas and the continental shelf, the continental slope, the Balleny Islands and vicinity, and the northern RSR. A set of maps (provided in an Appendix) illustrates the distributions of animals and ecosystem process areas in relation to the boundaries of the jointly proposed MPA. When all relevant distributions are simultaneously overlaid on a single map it is clear that the MPA can achieve significant protection and science outcomes, the latter of which may help the Scientific Committee to understand the ecosystem effects of fishing distinct from those of climate change and thus improve the management of toothfish fisheries generally. To achieve the protection and science objectives of the jointly proposed MPA, the Commission will need to redistribute catches taken by the longline fishery for Antarctic toothfish. About 20% of the historical catch taken by the fishery was removed from within the boundaries of the proposed MPA. Although it is not possible to estimate a specific period of time for which the proposed MPA would need to remain in force, several decades are needed to deliver the science outcomes related to understanding the distinct effects of climate change and fishing.

USA, Delegations of New Zealand and the. (2012) **A proposal for the establishment of a Ross Sea region Marine Protected Area**.
CCAMLR-XXXI/16 Rev. 1.Used for Ross Sea Toothfish MSC 2012
ABSTRACT: The delegation of New Zealand proposes the establishment by the Commission for the Conservation of Antarctic Living Marine Resources (Commission or CCAMLR) of a marine protected area (MPA) in the Ross Sea Region ("Ross Sea Region Marine Protected Area"). In recognition of the globally significant ecological, environmental, scientific and historic values of the Ross Sea Region, and in line with the work plan of the Scientific Committee to develop a representative system of Antarctic MPAs, the New Zealand delegation proposes to establish this MPA in order to achieve the conservation of Antarctic marine living resources. This proposal is consistent with the general framework for establishing CCAMLR marine protected areas (CM 91-04 (2011)) and with the process by which New Zealand developed its MPA scenario, reviewed favorably by the Scientific Committee in 2011.

Webber, D.N. & S. Parker. (2012) **Estimating unaccounted fishing mortality in the Ross Sea region and Amundsen sea (CCAMLR Subareas 88.1 and 88.2) bottom longline fisheries targeting Antarctic toothfish**. *CCAMLR Science,* 19, 17-30.
MSC Reference for Ross Sea Toothfish annual surveillance in 2012
ABSTRACT: Stock assessments rely on estimates of total mortality resulting from fishing activities. However, fish that are captured by fishing gear that is not subsequently retrieved are generally not counted in estimates of total fishing removals or otherwise accounted for in stock assessment models. The mortality resulting from the loss of sections of bottom longline gear in the Ross Sea region and Subarea 88.2 Antarctic toothfish (*Dissostichus*

mawsoni) fisheries is not currently known.
A method to estimate unaccounted fishing mortality from lost lines in these fisheries is provided. These estimates suggest that on average 208 tonnes of Antarctic toothfish mortality may be unaccounted for annually. While the current estimates may be improved through the adoption of better data reporting practices, these estimates were incorporated as sensitivity analyses in the 2011 stock assessments for the Ross Sea region and Subarea 88.2 toothfish fisheries.

Yeon, I., H.-S. Jo, C. Lim, S.M. Hanchet, D.-W. Lee & C.-K. Kang. (2012) **Fatty acid analysis to infer diet of Antarctic toothfish caught in February 2012 in the southern Ross Sea**, pp. 12. CCAMLR, Hobart,
Australia.
WG-FSA-12/61.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: To infer important prey resources for Antarctic toothfish (*Dissostichus mawsoni*) in the south of SSRUs 881.J and 881.L in the southern Ross Sea, their lipid composition was determined and compared to lipid profiles of fish and invertebrate species taken as bycatch in the fishery or collected from stomachs of toothfish. Stable carbon and nitrogen isotope ratios were also determined to further identify feeding relationships between these species. The aim of this study was to establish the feasibility of tracking main dietary items of pre-recruit Antarctic toothfish by comparing results of biomarker analysis and conventional diet analysis. Sampling collections were made during a longline survey of pre-recruit toothfish from research vessel in February 2012. Results of fatty acid (FA) and stable isotope analyses from this study provide evidence that a combination of these two techniques can delineate the main prey items of Antarctic toothfish and trophic structure of the toothfish-related fish food web in the southern Ross Sea ecosystem. Similarities in total FA compositions and the FA profiles in muscle tissue of Antarctic toothfish and *Pleuragramma antarctica*, *Pogonophryne barsukovi*, *Dacodraco hunteri*, and *Trematomus loennbergii* indicated a trophic connection between toothfish and these fish species. Meanδ15N values of Antarctic toothfish were higher than those of *P. antarcticum*, *P. barsukovi*, and *T. loennbergii*, indicating a higher trophic position of the toothfish. In contrast, similar δ15N values between Antarctic toothfish and icefish (*D. hunteri*) suggested that they occupy the same trophic position. Overall results of this survey are consistent with the frequency and percentage occurrence of prey in Antarctic toothfish stomachs. Further collection and subsequent biomarker analyses for more pelagic and benthic biota are needed to better understand entire food web structure in the southern Ross Sea.

Yeon, I., Y.J. Kwon, S.G. Choi, K.J. Seok, D.W. Lee, J.M. Jeong, S.J. Ye, H.J. Kim & G.W. Baeck. (2013)
Revised diet composition and feeding strategy of Antarctic toothfish, *Dissostichus mawsoni* in SSRU 58.4.1.C-a for the 2012/2013 Korean exploratory longline fishery, pp. 14. CCAMLR, Hobart,
Australia.
WG-FSA-13/43.Used for Ross Sea Toothfish MSC 2013 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Stocks of *Dissostichus mawsoni* in Division 58.4.1 were vulnerable with a big range of about 1,000-2,000 t per SSRU in Division 58.4.1. However, there is not enough data and information to assess the robust stocks and deliberate proper measurements for sustainable utilize, especially relate to diet and feeding strategy which may lead to think about ecosystem based stock assessments and fishery managements. Therefore, the Korean scientists analyze diet composition and feeding strategy of Antarctic toothfish, *Dissostichus mawsoni* in SSRU 58.4.1.C-a as a part of Korean research plan for the exploratory longline fishery for *Dissostichus* spp. in SSRUs of 58.4.1 C and E during 2012/2013 season. This study was carried out based on the results of stomach content

identification of the Antarctic toothfish caught in SSRU 58.4.1 C-a in CCAMLR Conversion Area in March, 2013. The diet composition and feeding strategy of *Dissostichus mawsoni* were studied using 36 specimens (104 to 176 cm in total length). *D. mawsoni* is a carnivore and piscivorous fish that mainly consumed fishes, especially *Macrourus whitsoni* with 14.72% of the diet by weight. Its diet also included small quantities of mollusks, crustaceans, and seaweeds. In this study, fishes were the dominant prey item in all size classes (I, 104-140 cm TL, and II, 140-176 cm TL). The graphical method for feeding strategy revealed that *D. mawsoni* is an opportunistic and specialized predator on fishes and showed narrow niche width.

Zaytsev, A.K. (2012) **Some aspects of size composition dynamics of Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea (Statistical Subarea 88.1)**, pp. 7. CCAMLR, Hobart, Australia.
WG-FSA-12/17.Used for Ross Sea Toothfish MSC 2012 (Unpublished report presented at the Fish Stock Assessment Working Group of CCAMLR)
ABSTRACT: Considering the graphs of size composition, two characteristic regularities can be noted.
First, during both fishery periods, identical groupings of fish prevailed in catches practically in all SSRUs of subarea 88.1. Second, the portion of small-sized immature fish in the southern statistical areas (SSRU H, I, K, L) increased except for the most northern SSRU "C" where both size composition and the average sizes of captured fish remained constant. Besides, the average sizes of fish in catches did not change considerably We also have analyzed materials we have from the point of view of catch of fish which matured for the first time and fish which had not achieve sexual maturity. In all the southern areas (SSRU H, I, K, L), the portion of fish matured for the first time was rather significant in catches. In view of the fact that catches of Antarctic toothfish in the considered time interval did not vary considerably, it is possible to assume, that in the Antarctic toothfish population of Ross Sea, one can observe significant recruitment of fish of younger size-age groups accumulated in the feeding areas which are the southern sites of the shelf and continental slope.
Delegation of New Zealand & Delegation of the USA. (2013a) **Analysis of potential threats from fishing to the objectives of a proposed Ross Sea region MPA**, pp. 30. CCAMLR, Hobart.
SC-CAMLR-IM-I/09.Used for Ross Sea Toothfish MSC 2013
ABSTRACT: We present an analysis of potential threats from fishing to the achievement of MPA objectives identified in the Ross Sea region MPA proposal submitted jointly by New Zealand and the USA. Ecosystem threats from fishing potentially undermine the requirements of Article II(3) paragraphs b and c. Fishing may also threaten science objectives, e.g. preventing establishment of scientific reference areas, or undermining ongoing efforts to understand environmental change unconfounded by human impacts. Where particular threats can be foreseen and located in space, MPA designation is one effective means of avoiding or mitigating ecosystem risks and promoting scientific objectives. Both threat-based objectives and scientific objectives were always implicit in the systematic process of MPA design used by New Zealand and the USA over several years; in this paper we make the underlying logic more explicit, drawing upon new and previously submitted material to identify threats to the MPA objectives, map those threats in space, and detail plausible mechanisms by which those threats can be expected to occur.
Delegation of New Zealand, & Delegation of the USA. (2013b) **A draft plan for research and monitoring in the Ross Sea region, in association with spatial marine protection**, pp. 21. CCAMLR, Hobart.
SC-CAMLR-IM-I/BG/03 Rev. 1.Used for Ross Sea Toothfish MSC 2013
ABSTRACT: This document provides a draft research and monitoring plan to accompany a proposal to CCAMLR for the establishment of an MPA in the Ross Sea region. The purposes of research and monitoring associated with this spatial protection are to deliver the scientific knowledge sufficient to allow the Scientific Committee to advise the Commission

on: (i) the degree to which the specific objectives of the MPA are being achieved; (ii) the degree to which the MPA objectives are still relevant in different areas of the MPA; and (iii) what management actions may be required to improve the achievement of the objectives for this MPA.
This draft MPA research and monitoring plan is structured spatially: (i) Ross Sea continental shelf; (ii) Ross Sea continental slope; (iii) Balleny Islands and vicinity; and (iv) Northern Ross Sea region and seamounts.
This draft research and monitoring plan includes the activities considered to be of high priority at the time of writing but also achievable in the short to medium term. This plan is not intended to be exhaustive, exclusive nor fixed. Advances in knowledge and/or changes to ecosystems, management and fisheries in the Southern Ocean may mean that some research and monitoring activities identified here may become less relevant over time, and other activities not identified here may become more important. The plan will require periodic update involving ongoing discussion and coordination among all CCAMLR Members.
Feedback from and collaboration with other Members in the further development of a draft research and monitoring plan is welcomed.

New Zealand (2012) **Notification for scientific research in 2012/13 and 2013/14**
Proposal to continue the time series of CCAMLR sponsored research surveys to monitor abundance of pre-recruit antarct toothfish in the southern ross sea in 2013
CCAMLR, Hobart, Australia.
for Ross Sea Toothfish MSC 2012 (Unpublished manuscript presented at the Statistics, Assessments, and Modelling Working Group of CCAMLR)
ABSTRACT: 1. MAIN OBJECTIVE
The objective of the survey time series is to provide a time series of relative abundance indices of pre-recruit Antarctic toothfish in the Ross Sea region to:
(i) detect changes in relative abundance of recruitment over time; and (ii) estimate variability and autocorrelation in recruitment.
The objectives of this second survey of the time series are as follows:
(i) To carry out the second of a time series of longline surveys to monitor pre-recruit (<110 cm TL) toothfish in the south of SSRUs 881.J and 881.L in the southern Ross Sea (Strata A12-C12) using standardised gear in a standardised manner
(ii) To carry out additional experimental stations in adjacent areas to identify areas of high prerecruit abundance which could potentially be included as additional strata in future annual surveys.
At its 2010 meeting the Scientific Committee noted that the research and assessment work in
Subarea 88.1 and SSRU 88.2E on the distribution, abundance and demography of Antarctic toothfish
(*D. mawsoni*) had led to an estimate of the fisheries potential yield, and allowed the CCAMLR Scientific Committee to formulate and provide advice to the Commission on appropriate harvest levels and other aspects of conservation over the last eight years (SC-CAMLR-XXIX, para. 3.129). Although robust stock assessments are now available, there is still uncertainty over key aspects of Antarctic toothfish reproductive dynamics, including recruitment variability, recruitment autocorrelation, and the value of the stock recruitment relationship steepness parameter. At its 2011 meeting, the Scientific Committee agreed that a time series of relative recruitments from a well-designed survey could be a useful input into the Ross Sea stock assessment model and endorsed a proposal to carry out this work once the fishery had closed at the end of the 2011/12 season (SC-CAMLR-XXX). The first survey was successfully completed in February 2012 and the results presented to the 2012 meeting of WG-SAM (Hanchet et al. 2012a). A proposal for the second survey in the time series was also presented to the 2012 meeting of WG-SAM (Hanchet et al. 2012b).
The working group supported the proposed design of the repeat survey in 2013 (WG-SAM report 2012, paragraph 4.22). We present here the formal notification for this research

survey in accordance with Conservation Measure 24-01, using the prescribed Format 2.

Appendix 7.2 NGO References

The following are comments from the Environment and Conservation Organisations of NZ Inc (ECO), but include suggestions from the Antarctic and Southern Ocean Coalition (ASOC).

Generic References

We note there are a number of generic CCAMLR reports – Commission, Fish Stock Working Group and Scientific Committee Reports that are not included in the reference list. These reports should be included and will likely be included in later submissions.

Specific References

The following specific references are relevant to the re-assessment and should be included in the list of references.

Ackley S.F., Bengtson J.L., Boveng P., Castellini M., Daly K.L., Jacobs S., Kooyman G.L., Laake J., Quentin L., Ross G., Siniff D.B., Stewart D.B., Stirling I., Torres J. Yochem P.K. 2003. A top-down, multidisciplinary study of the structure and function of the pack-ice ecosystem in the eastern Ross Sea, Antarctica. Polar Record 39 (210): 219230;

Ainley D.G. and Catteneo-Vietti R. 2007. Trophic interactions within the Ross Sea continental shelf ecosystem. Philosophical Transactions of The Royal Society B. 362: 95-111.

Ainley D.G. 2010. A history of the exploitation of the Ross Sea, Antarctica. Polar Record. 46(238): 233-243.

Ainley, D.G., Ballard, G., and Weller, J. 2010. Ross Sea Bioregionalization Part I: Validation of the 2007 CCAMLR Bioregionalization Wokshop Results Towards Including the Ross Sea in a representative Network of Marine Protected Areas in the Southern Ocean CCAMLR Report, WG-EMM-10/11. Hobart, Tasmania Allen S.E., Vindeirinho C., Thomson R.E., Foreman M.G.G. and Mackas D.L. 1999. Physical and biological processes over a submarine canyon during an upwelling event. Canadian Journal of Fisheries and Aquatic Sciences 58: 671-684.

Arrigo K.R., Worthen D.L., Schnell A. and Lizotte M.P. 1998. Primary production in Southern Ocean waters. Journal of Geophysical Research. 103: 1558715600.

Azzali M.; Leonori I., De Felice A., Russo A. 2006. Spatial-temporal relationships between two euphausiid species in the Ross Sea. Chemistry and Ecology (Suppl.) 22: 219-233.

Ballard, G., Jongsomjit, D. and Ainley, D.G. 2010. Ross Sea Bioregionalization Part II: Patterns of co-occurrence of mesopredators in an intact polar ocean ecosystem. CCAMLR Report, WG-EMM-10/12. Hobart, Tasmania.

Barry, J.P., Grebmeier J.M., Smith J. and Dunbar R.B. 2003. Oceanographic Versus Seafloor-Habitat Control of Benthic Megafaunal Communities in The S.W. Ross Sea, Antarctica. Paleobiology And Paleoenvironments Of Eocene Rocks, Antarctic Research Series Volume 76: 335-347.

Bowden D.A., Schiaparelli S., Clark M.R., and Rickard G.J. 2011. A lost world? Archaic crinoiddominated assemblages on an Antarctic seamount. Deep-Sea Research Part IITopical Studies in Oceanography 58: 119-127.

Bradford-Grieve, J. and Fenwick, G. 2001. A review of the current knowledge describing the biodiversity of the Ross Sea region. Final research paper for the Ministry of Fisheries

Research Project ZBD2000/01 Objective 1. National Institute of Water and Atmospheric Research;

Bullivant J.S. and Dearborn J.H. 1967. The Fauna of the Ross Sea. Part 5, General accounts, station lists, and benthic ecology. New Zealand Oceanographic Institute, Bulletin 176: Pp. 49-75;

Bull, B., R.I.C.C. Francis, A. Dunn, A. McKenzie, D.J. Gilbert and M.H. Smith. 2005. CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.072005/08/21. *NIWA Technical Report*, 127: 272 pp.

Cameron, A, Campbell S, C Christian, and R Nicoll (2009) Antarctic Ocean Legacy: A Marine Reserve for the Ross Sea. Antarctic Oceans Alliance 24p..

CCAMLR 2013 Fishery Report 2013: Exploratory fishery for Dissostichus spp. In Subareas 88.1 and 88.2. CCAMLR. 42p.

Chiantore M., Cattaneo-Vietti R., Albertelli G., Misic C. and Fabiano M. 1998. Role of filtering and biodeposition by Adamussium colbecki in circulation of organic matter in Terra Nova Bay (Ross Sea, Antarctica). Journal of Marine Systems 17: 411-424.

Choudhury M. and Brandt A. 2009. Benthic isopods (Crustacea, Malacostraca) from the Ross Sea, Antarctica: species checklist and their zoogeography in the Southern Ocean. Polar Biology 2009 32: 599-610.

Clarke A. and Johnston, N.M. 2003. Antarctic marine benthic diversity. Oceanogr. Marine Biology. 41:47-114.

Constable A.J., Doust S. 2009. Southern Ocean Sentinel – an international program to assess climate change impacts on marine ecosystems: report of an international Workshop, Hobart, April 2009. ACE CRC, Commonwealth of Australia, and WWF-Australia.

Cushing D.H. 1971. Upwelling and production on Fish. Advances in Marine Biology 9: 255262.

Douglass L.L., Turner J., Grantham H.S., Kaiser S., Nicoll R., Post A., Brandt A., Beaver D. 2014. A hierarchical classification of benthic biodiversity and assessment of protected areas in the Southern Ocean, PLoS One. 9(7): e100551. DOI:
10.1371/journal.pone.0100551

Eastman J.T. 2005. The nature of the diversity of Antarctic Fishes. Polar Biology, 28:93–107.

Eastman J. T. And Hubold G. 1999. The fish fauna of the Ross Sea, Antarctica. Antarctic Science. 11:293-304.

Falkowski, P., Barber, R. & Smetacek, V. 1998. Biogeochemical controls and feedbacks on ocean primary production. Science, 281, 200.

Folland C., et al. Observed climate variability and change. In: Houghton J.T., Ding Y., Griggs D.J., Noguer M., van den Linden P.J, Dai X., Maskell K. and Johnson C.A, editors. Climate change 2001: the scienti!c basis. Cambridge University Press; Cambridge, UK: 2001. pp. 99-182.

Francis, R.I.C.C. (2011) Corrigendum: Data weighting ins statistical fisheries stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences 68*: 2228.

Gatti S. 2002. The Role of Sponges in High-Antarctic Carbon and Silicon Cycling – a Modelling Approach. Ber. Polarforsch. Meeresforsch, 434

Gelatt T.S., Davis C.S., Stirling I., Siniff D.B., Strobeck C. and Delisle I. 2010. History and fate of a small isolated population of Weddell Seals at White Island, Antarctica. Conservation Genetics. 11: 721 –735.;

Hanchet S.M., Rickard G.J., Fenaughty J.M., Dunn A. and Williams M.J. 2008. A hypothetical life cycle for Antarctic toothfish Dissostichus mawsoni in Antarctic waters of CCAMLR Statistical Area 88. CCAMLR Science 15: 35-54.

Holland D.M., Jacobs S.S. and Jenkins A. 2002. Modelling the ocean circulation beneath the Ross Ice Shelf. Antarctic Science. 15(1): 13-23.

Howard W.R., Havenhand J., Parker L., Raftos D., Ross, P., Williamson J. and Matear R. (2009) Ocean acidification. In A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009 (Eds. E.S. Poloczanska, A.J. Hobday and A.J.

Richardson), NCCARF Publication 05/09, ISBN 978-1-921609-03-9

Jacobs S.S., Giulivi C.F. and Mele P.A. 2002. Freshening of the Ross Sea during the Late 20th century. Science 297: 386–389

Jenouvrier S., Caswell H., Barbraud C., Holland M.,Stroeve J. and Weimerskirch H. 2009. Demographic models and IPCC climate projections predict the decline of an emperor penguin population. Proceedings of the ational Academy of Sciences of the United States of America 106: 1844-1847.

Johnson G. L., Kyle P. R., Vanney J. R. and Campsie J. 1982. Geology of Scott and Balleny Islands, Ross Sea, Antarctica, and morphology of adjacent seafloor. New Zealand Journal of Geology and Geophysics, 25: 427-436.

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

Lefebvre W. and Goosse H. 2008. Analysis of the projected regional sea-ice changes in the Southern Ocean during the twenty-!rst century. Climate Dynamics. Turner et al.

report only that it will be an area much less affected by sea ice loss that other portions of the Southern Ocean.

McClintock J.B., Amsler C.D., Baker B.J. and van Soest R.W.M. 2005. Ecology of Antarctic Marine Sponges: An Overview. Integr. Comp. Biol. 45: 359-368.

McMillan, P., T. Iwamoto, A. Stewart and P.J. Smith. 2012. A new species of grenadier, genus *Macrourus* (Teleostei, Gadiformes, Macrouridae) from the southern hemisphere and a revision of the genus. *Zootaxa*, 3165: 1–24.

Morin P.A., Archer F.I., Foote A.D., Vilstrup E.E., Wade P., Durban J., Parsons K., Pitman

R., Li L., Bouffard P., Abel Nielsen S.C., Rasmussen M., Willerslev E., Gilbert M.T.P. and Harkins T. 2010. Complete mitochondrial genome phylogeographic analysis of killer whales (Orcinus orca) indicates multiple species. Genome Research. 20:908–916

Nicol, S., et al., Ocean circulation off east Antarctica affects ecosystem structure and sea-ice extent. Nature, 2000. 406(6795): p. 504-507

O'Brien, P.E., Post, A.L. & Romeyn, R. 2009. Antarctic-wide Geomorphology as an aid to habitat mapping and locating vulnerable marine ecosystems. Submitted to the Science Committee to the Commission of Antartctic Marine Living Resources (SC-CAMLRXXVIII/10) Workshop on Vulnerable Marine Ecosystems held in La Jolla, CA, USA 3-7th August 2009. Document number WS-VME-09/10. Canberra, Australia: GeoScience Australia.

Orr J., Fabry V.J., Aumont O., Bopp L., Doney S.C., Feely R.A., Gnanadesikan A., Gruber

N., Ishida A., Key R.M., Lindsay K., Maier-Reimer E., Matear R., Monfray P., Mouchet A., Najjar R.G., Plattner G.-K., Rodgers K.B., Sabine C.L., Sarmient, J.l., Schlitzer R., Slater R.D., Totterdell I.J., Weirig M.-F., Yamanaka Y. And Yool A., 2005, 'Anthropogenic ocean acidification over the twenty-first century and its impacts on calcifying organisms', Nature 437: 681-686.

Orsi, A.H. and C.L. Wiederwohl. 2009. A recount of Ross Sea waters, Deep Sea Research II 56: 778-795. 75.

Orsi A.H., Whitworth T III, Nowlin W.D. Jr. 1995. On the meridional extent and fronts of the Antarctic Circumpolar Current. Deep-Sea Research I 42: 641-673. 76. Ainley, D.G. & Jacobs, S.S. 1981 Seabird affinities for ocean and ice boundaries in the Antarctic. Deep-Sea Research, 28, 1173–1185.

Pinkerton M., Hanchet S. and Bradford-Grieve J. 2007. Finding the role of Antarctic toothfish in the Ross Sea ecosystem. Water & Atmosphere 15(1): 20-21.

Pinkerton, M.H., J.M. Bradford-Grieve and S.M. Hanchet. 2010. A balanced model of the food web of the Ross Sea, Antarctica. *CCAMLR Science*, 17: 1–31.

Pinkerton, M., P.J. McMillan, J. Forman, P. Marriott, P. Horn, S.J. Bury and J. Brown. 2013. Distribution, morphology and ecology of *Macrourus whitsoni* and *M. caml* (gadiformes, macrouridae) in the Ross Sea region. *CCAMLR Science*, 20: 37–61.

Roeder A.D., Marshall R.K., Mitchelson A.J., Visagathilgar T., Ritchie P.A., Love D.R., Pakai

T.J., McPartlan H.C., Murray N.D., Robinson N.A., Kerry K.R., and Lambert D.M. 2001. Gene flow on the ice: genetic differentiation among Adelie penguin colonies around Antarctica. Molecular Ecology. 10:1645-1656.

Rogers AD, Tyler PA, Connelly DP, Copley JT, James R, et al. 2012. The Discovery of New Deep-Sea Hydrothermal Vent Communities in the Southern Ocean and Implications for Biogeography. PLoS Biology 10(1): e1001234. doi:10.1371/journal.pbio.1001234

Sala A., Azzali M. and Russo A. 2002. Krill of the Ross Sea: distribution, abundance and demography of *Euphausia superba* and *Euphausia crystallorophias* during the Italian Antarctic Expedition (January–February 2000). Sci. Mar. 66: 123–133;

SC-CAMLR. 2009. Report on the Workshop of Vulnerable Marine Ecosystems. In: *Report of the Twenty-eighth Meeting of the Scientific Committee (SC-CAMLR-XXVIII), Annex 10.* CCAMLR, Hobart, Australia: 537–571.

Sharp, B. 2010. Bioregionalisation and Spatial Ecosystem Processes in the Ross Sea Region. XXXIII ATCM/Information Paper 107. Punta del Este, Uruguay: XXXIII Antarctic Treaty Consultative Meeting.

Sharp, B.R., S.J. Parker and N. Smith. 2009. An impact assessment framework for bottom fishing methods in the CAMLR Convention Area. *CCAMLR Science*, 16: 195–210.

Smith, P.J. and P.M. Gaffney. 2005. Low genetic diversity in the Antarctic toothfish (*Dissostichus mawsoni*) observed with mitochondrial and intron DNA markers. *CCAMLR Science*, 12: 43–51.

Smith, P.J., D. Steinke, P.J. McMillan, A.L. Stewart, S.M. McVeagh, J.M. Diaz de Astarloa, D. Welsford and R.D. Ward. 2011. DNA barcoding highlights a cryptic species of grenadier *Macrourus* in the Southern Ocean. *J. Fish Biol.*, 78: 355–365.

Smith, W. and D. Sandwell, Measured and Estimated Seafloor Topography Version 13.1. 2010, World Data Center-A for Marine Geology and Geophysics. Available http://www.ngdc.noaa.gov/mgg/#iers/97mgg03.html as at November 2010.

Smith W.O., Halpern B.S., Walbridge S., Selkoe,K.A., Kappel C.B., Micheli F., D'Agrosa C., Bruno J.F., Casey K.S., Ebert C., Fox H.E., Fujita R., Heinemann D., Lenihan H.S., Madin E.M.P., Perry M.T., Selig E.R., Spalding M., Steneck R. and Watson R. 2008. A global map of human impact on marine ecosystems. Science 319:948-951. Supporting Online Material for A Global Map of Human Impact on Marine Ecosystems, Halpern et al., (2008) http://www.sciencemag.org/content/suppl/2008/02/12/319.5865.948.DC1/Halpern_SOM.pdf

Smith W.O. Jr., Ainley D.G., Cataneo-Vietti R. and Hofmann E.E. 2012. The Ross Sea continental shelf: regional biogeochemical cycles, trophic interactions, and potential future changes. In Antarctic Ecosystems: An extreme environment in a changing world. J. Wiley and Sons, London.

Smith W.O., Sedwick P.N., Arrigo K.R., Ainley D.G. and Orsi A. 2012.. The Ross Sea in a Sea of Change. *Oceanography* 25(3):90–103, http://dx.doi.org/10.5670/oceanog.2012.80

Sokolov, S. and S.R. Rintoul, 2009. The circumpolar structure and distribution of the Antarctic Circumpolar Current fronts. Part 1: Mean circumpolar paths. Journal of Geophysical Research – Oceans. 114(C11).

Sokolov, S.and Rintoul, S. 2007. On the relationship between fronts of the Antarctic Circumpolar Current and surface chlorophyll concentrations in the Southern Ocean. Journal of Geophysical Research, 112, C07030

Spreen G., Kaleschke L. and Heygster G. 2008. Sea ice remote sensing using AMSR-E 89 GHz channels. Journal of Geophysical Research. 113: p. 3481–3484.

Turner, J., Bindschadler, R., Convey, P., di Prissco, G., Fahrbach, E., Gutt, J., Hodgson, D., Mayewski, P. and Summerhayes, C. (eds.) 2009. Antarctic climate change and the environment. Scienti!c Committee on Antarctic Research http://www.scar.org/publications/occasionals/acce.html .

Turner J., Comiso J. C., Marshall G. J., Lachlan-Cope T. A., Bracegirdle T., Maksym T., Meredith M.P., Wang Z., and Orr A. 2009. Non-annular atmospheric circulation change induced by stratospheric ozone depletion and its role in the recent increase of Antarctic sea ice extent. Geophysical Research Letters 36: L08502.)

Van Franeker J.A. Gravilo M., Mehlum F., Veit R.R. and Woehler E.J. 1999. Distribution and abundance of the Antarctic Petrel. Waterbirds 22: 14-28.

Weimerskirch H. and Cherel Y. 1998. Feeding ecology of short-tailed shearwaters: breeding in Tasmania and foraging in the Antarctic? Marine Ecology Progress Series 167: 261274.

Note: some of these references are updated versions or published in CCAMLR Science versions of papers presented to the CCAMLR Scientific Committee Working Groups and cited in the client paper.

Regards

Barry Weeber
For ECO NZ

CC ASOC