Appendix N

Fishery Report: Exploratory fishery for *Dissostichus* spp. (TOT) in Subareas 88.1 and 88.2

CONTENTS

Page

Throughout this report the CCAMLR fishing season is represented by the year in which that season ended, e.g. 2012 represents the CCAMLR fishing season from 1 December 2011 to 30 November 2012.

FISHERY REPORT: EXPLORATORY FISHERY FOR *DISSOSTICHUS* SPP. (TOT) IN SUBAREAS 88.1 AND 88.2

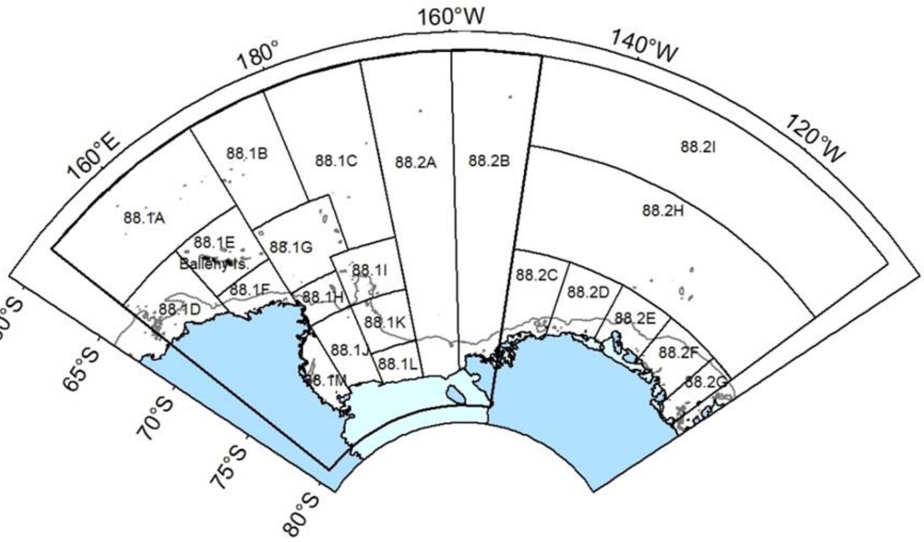

Figure 1: Ross Sea (Subarea 88.1 and SSRUs 882A–B) (bounded region) and SSRUs 882C–I. Depth contour plotted at 1 000 m.

1. Details of the fishery

1. Subareas 88.1 and 88.2 are split into two areas for the purposes of stock assessment: (i) the Ross Sea (Subarea 88.1 and SSRUs 882A–B) and (ii) SSRUs 882C–H.

2. The distribution of catch limits for the SSRUs in the Ross Sea was part of a three-year experiment starting in 2006 when the SSRUs between 150°E and 170°E (881A, D, E, F) and between 170°W and 150°W (882A–B) were closed to fishing to ensure that effort was retained in the area of the experiment (SC-CAMLR-XXIV, paragraphs 4.163 to 4.166). To assist administration of the fishery, the catch limits for SSRUs 881B, C and G were combined into a 'north' region (BCG), those for SSRUs 881H, I and K were combined into a 'slope' region (HIK) and those for SSRUs 881J and L into a shelf region (JL) and catch limits were then allocated based on the proportions 13%, 74% and 13% respectively.

3. In 2011, the Commission revised the boundaries of the SSRUs in Subarea 88.2 such that 76% of the yield was assigned to the region between 70°50'S and 65°00'S (SSRU 882H) and the remaining 24% of the yield was assigned to the region south of 70°50'S (SSRUs 882C–G) as outlined in SC-CAMLR-XXX, paragraph 6.127 (see Figure 1).

4. The limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 are described in Conservation Measure (CM) 41-09. In 2012, the fishery was limited to Japanese, Korean, New Zealand, Norwegian, Russian, Spanish and UK flagged vessels using longlines only. The precautionary catch limit for *Dissostichus* spp. of 3 282 tonnes applied as follows: 428 tonnes total could be taken in SSRUs BCG; 2 423 tonnes total in SSRUs HIK; 351 tonnes

in SSRUs JL (Figure 1). Five SSRUs (A, D, E, F and M) were closed to fishing. The catch limits for by-catch species were defined in CMs 33-03 and 41-09. The fishing season was from 1 December 2011 to 31 August 2012.

5. The limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.2 are described in CM 41-10. In 2012, the fishery was limited to Korean, New Zealand, Norwegian, Russian, Spanish and UK flagged vessels using longlines only. The precautionary catch limit for *Dissostichus* spp. of 530 tonnes applied as follows: 124 tonnes total could be taken in SSRUs C–G; and 406 tonnes could be taken in SSRU H (Figure 1). Three SSRUs (A, B and I) were closed to fishing. The catch limits for by-catch species were defined in CMs 33-03 and 41-10. The fishing season was from 1 December 2011 to 31 August 2012.

6. Details of notifications of intentions to fish in 2013 are summarised in CCAMLR-XXXI/12. For Subarea 88.1, notifications were submitted by eight Members with a total of 24 vessels. For Subarea 88.2, notifications were submitted by seven Members with a total of 23 vessels.

1.1 Reported catch

7. In 2012, six Members and 15 vessels fished in the exploratory fishery in Subarea 88.1 (Table 1). The total reported catch of *Dissostichus* spp. was 3 175 tonnes (97% of the limit), and the following SSRUs were closed during the course of fishing:

- SSRUs BCG closed on 13 December 2011, triggered by the catch of *Dissostichus* spp. (total catch 551 tonnes; 129% of the catch limit)

- SSRUs HIK closed on 27 January 2012, triggered by the catch of *Dissostichus* spp. (total catch 2 309 tonnes; 95% of the catch limit).

8. Four Members and six vessels fished in the exploratory fishery in Subarea 88.2 (Table 2). The total reported catch of *Dissostichus* spp. was 414 tonnes and the following SSRU was closed during the course of fishing:

- SSRU H closed on 27 March 2012, triggered by the catch of *Dissostichus* spp. (total catch 396 tonnes; 98% of the catch limit).

9. In Subarea 88.2, an additional 10 tonnes of *D. mawsoni* was taken during research fishing in SSRU 882A.

Table 1: Number of vessels authorised in CM 41-09, number of vessels that fished, and the catch of *Dissostichus* spp. in Subarea 88.1 in 2011/12. (Source: catch and effort reports.)

Flag State	Vessels authorised in CM 41-09	Number of vessels that fished	Reported catch (tonnes)		
			D. mawsoni	*D. eleginoides*	Total
Japan	1	0			
Korea, Republic of	4	4	874	1	875
New Zealand	4	4	789	3	792
Norway	1	1	172	0	172
Russia	5	3	499	1	500
Spain	1	1	523	0	523
UK	2	2	313	0	313
Total	18	15	3 170	5	3 175

Table 2: Number of vessels authorised in CM 41-10, number of vessels that fished, and the catch of *Dissostichus* spp. in Subarea 88.2 in 2012. (Source: catch and effort reports.) Research fishing activity in SSRU 882A is not included.

Flag State	Vessels authorised in CM 41-10	Number of vessels that fished	Reported catch (tonnes)		
			D. mawsoni	*D. eleginoides*	Total
Korea, Republic of	3	1	25	0	25
New Zealand	4	2	152	<1	152
Norway	1	0			
Russia	5	2	33	<1	33
Spain	1	0			
UK	2	1	204	0	204
Total	16	6	414	<1	414

10. The Ross Sea fishery saw a steady expansion of effort (number of sets) from 1998 to 2001, a slight drop in 2002, followed by an increase in 2003, and an almost three-fold increase in 2004. Since 2005 effort has been slightly more stable ranging from 1 000 to 1 500 sets per year. Although most SSRUs in Subareas 88.1 and 88.2 have been fished over time, the proportion of effort in each SSRU has varied considerably each year in relation to the catch limits of the target and by-catch species and ice conditions. The two slope SSRUs 881H and I have been the most consistently fished SSRUs. In years with favourable ice conditions (2005, 2009, 2011) fishing has extended into 881K. 2012 was an unusual ice year in Subarea 88.1, with an abnormal thawing pattern in the north, and an early thawing in the southeast, leading to the highest historical catch from SSRU 881K (WG-FSA-12/42).

11. The length of the fishing season in the Ross Sea fishery has contracted over time. In the first few years the fishery was mainly carried out from January to March, and between 2001 and 2003 extended into April and May. More recently, fishing has started in early December (ice permitting) and has usually finished in January or February. Fishing in SSRU 882H and, to a lesser extent SSRUs 882C–G, has shown a similar pattern with a trend towards starting and finishing earlier over the course of the fishery.

12. Catches of *D. eleginoides* have mainly come from the northwest of the Ross Sea region in SSRUs 881A–C (WG-FSA-10/23). Catches were quite high in the early part of the fishery, particularly in 2001, but have been relatively low since then. The catch rates for *D. eleginoides* have been much higher in SSRU 881A than the other SSRUs.

13. The catch of *D. mawsoni* has been above 2 000 tonnes per season since 2004, and reached 3 170 tonnes in 2012.

14. Catches and catch limits for *Dissostichus* spp. and by-catch species by SSRU and SSRU groups reported from Subareas 88.1 and 88.2 in 2012 are summarised in Table 3.

Table 3: Catches and catch limits for *Dissostichus* spp. and by-catch species (macrourids, rajids and other species) by SSRU and SSRU groups reported from Subareas 88.1 and 88.2 in 2012. (Source: catch and effort reports.) SSRUs are as defined in CM 41-01.

SSRU	*Dissostichus* spp. catch (tonnes)		Macrourids catch (tonnes)		Rajids catch (tonnes)		Other species catch (tonnes)	
	Limit	Catch	Limit	Catch	Limit	Catch*	Limit	Catch
881A	0	0	0	0	0	0	0	0
881B, C, G	428	551	40	1	50	0	60	1
881D	0	0	0	0	0	0	0	0
881E	0	0	0	0	0	0	0	0
881F	0	0	0	0	0	0	0	0
881HIK	2423	2309	320	118	121	1	60	3
881JL	351	314	70	4	50	1	40	0
882A	0	0	0	0	0	0	0	0
882B	0	0	0	0	0	0	0	0
882C–G	124	18	20	1	50	0	100	0
882H	406	396	64	27	50	0	20	11
882I	0	0	0	0	0	0	0	0

* Note: Includes skates landed, and excludes skates cut-off at surface or tagged and released.

15. The historical catches of *Dissostichus* spp. caught in Subareas 88.1 and 88.2 are given in Tables 4 and 5 respectively.

Table 4: Catch history for *Dissostichus* spp. in Subarea 88.1. Reported catch includes catch from research fishing. (Source: STATLANT data for past seasons, and catch and effort reports for current season, past reports for IUU catch.)

Season	Regulated fishery						Estimated IUU catch (tonnes)	Total removals (tonnes)
	Effort (number of vessels)		*Dissostichus* spp.					
			Catch limit (tonnes)	Reported catch (tonnes)				
	Limit	Reported		*D. eleginoides*	*D. mawsoni*	Total		
1997	-	1	1 980	0	0	0	0	0
1998	-	1	1 510	1	41	42	0	42
1999	2	2	2 281	1	296	297	0	297
2000	-	3	2 090	0	751	751	0	751
2001	6	10	2 064	34	626	660	0	660
2002	10	3	2 508	12	1 313	1 325	92	1 417
2003	13	10	3 760	26	1 805	1 831	0	1 831
2004	26	21	3 250	13	2 184	2 197	240	2 437
2005	21	10	3 250	7	3 098	3 105	28	3 133
2006	21	13	2 964	1	2 968	2 969	0	2 969
2007	21	15	3 072*	12	3 079	3 091	0	3 091
2008	21	15	2 700	9	2 251	2 259	272	2 531
2009	21	13	2 700	17	2 432	2 448	0	2 448

(continued)

Table 4 (continued)

Season	Regulated fishery						Estimated IUU catch (tonnes)	Total removals (tonnes)
	Effort (number of vessels)		*Dissostichus* spp.					
			Catch limit (tonnes)	Reported catch (tonnes)				
	Limit	Reported		*D. eleginoides*	*D. mawsoni*	Total		
2010	15	12	2 850	<1	2 868	2 869	0	2 869
2011	19	15	2 850	3	2 879	2 882	0	2 882
2012	18	15	3 282*	5	3 170	3 175	**	3 175

* Includes 40 tonnes for research fishing in 2007 and 80 tonnes for research fishing in 2012.
** Not estimated.

Table 5: Catch history for *Dissostichus* spp. in Subarea 88.2. Reported catch includes catch from research fishing. (Source: STATLANT data for past seasons, and catch and effort reports for current season, past reports for IUU catch.)

Season	Regulated fishery						Estimated IUU catch (tonnes)	Total removals (tonnes)
	Effort (number of vessels)		*Dissostichus* spp.					
			Catch limit (tonnes)	Reported catch (tonnes)				
	Limit	Reported		*D. eleginoides*	*D. mawsoni*	Total		
1997	-	0	1 980	0	0	0	-	0
1998	-	0	63	0	0	0	-	0
1999	-	0	0	0	0	0	-	0
2000	-	0	250	0	0	0	-	0
2001	2	0	250	0	0	0	-	0
2002	7	1	250	0	41	41	0	41
2003	9	2	375	0	106	106	0	106
2004	18	3	375	0	374	375	0	375
2005	10	4	375	0	411	411	0	411
2006	17	7	487	0	514	514	15	529
2007	16	7	567*	0	347	347	0	347
2008	15	4	567	<1	416	416	0	416
2009	19	10	567	<1	484	484	0	484
2010	15	5	575	0	314	314	0	314
2011	17	12	575*	0	590	590	0	590
2012	16	5	530*	<1	414	414	**	414

* Includes 20 tonnes for research fishing in 2007 (CCAMLR-XXV, paragraph 12.60) and 10 tonnes for research fishing in 2011 and 2012.
** Not estimated.

1.2 IUU catch

16. The estimated IUU catch in Subarea 88.1 was 92 tonnes in 2002, 240 tonnes in 2004, 28 tonnes in 2005 and 272 tonnes in 2008 (Table 4). There was no evidence of IUU fishing in Subarea 88.1 in 2010 (WG-FSA-10/06 Rev. 1).

17. There was an estimated 15 tonnes of IUU catch in Subarea 88.2 (SSRU 882A) in 2006 (Table 5). This was the only observed occurrence of IUU fishing in Subarea 88.2, and there was no further evidence of IUU fishing in Subarea 88.2 in 2010 (WG-FSA-10/06 Rev. 1).

18. While the Secretariat did not estimate the amount of IUU catch of *Dissostichus* spp. in 2011 and 2012, there were no reports of IUU activity in either Subarea 88.1 or 88.2 in these years.

1.3 Size distribution of the catches

19. *Dissostichus mawsoni* ranged from 50 to 180 cm (Figures 2 and 3). In all seasons, there was a broad mode of adult fish at about 120–170 cm. In years when fishing occurred in the south of Subarea 88.2, there was also a strong mode at about 60–80 cm. These fish were predominantly caught at the edge of the continental shelf. In 2006 there was a strong mode at about 60 cm in Subarea 88.2. These fish were predominantly caught at the edge of the continental shelf in SSRUs 882F and G. This mode was again apparent in 2009 when fishing occurred on the shelf and slope in SSRUs 882D, E and F. These length-frequency distributions of catches are unweighted and the interannual variability shown in the figure may reflect differences in the fished population but are also likely to be biased by changes in factors such as the characteristics/number of vessels in the fishery and the spatial and temporal distribution of fishing. A description of how length data are used in assessments is provided in the relevant section of this report.

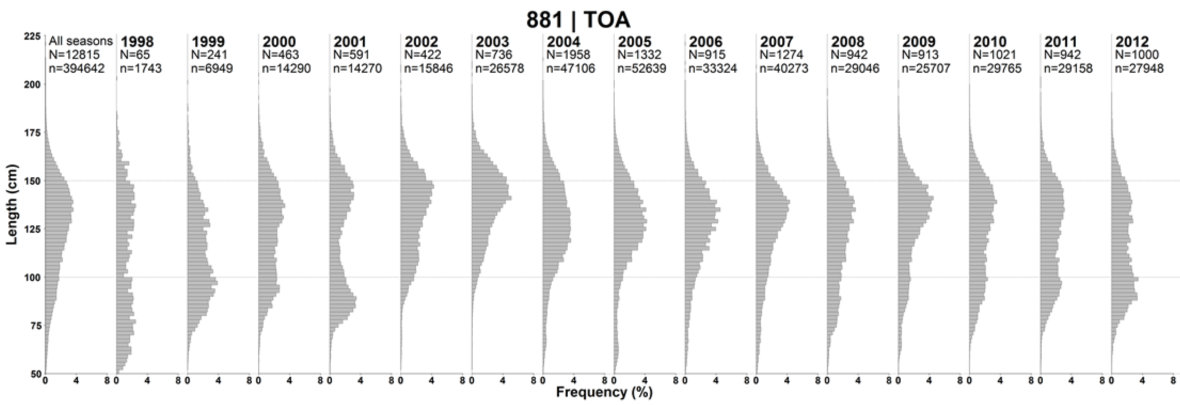

Figure 2: Length frequencies for *Dissostichus mawsoni* (TOA) in Subarea 88.1 from 1998 to present using observer data. The number of hauls (N) and the number of fish measured (n) in each year are given at the top of each panel.

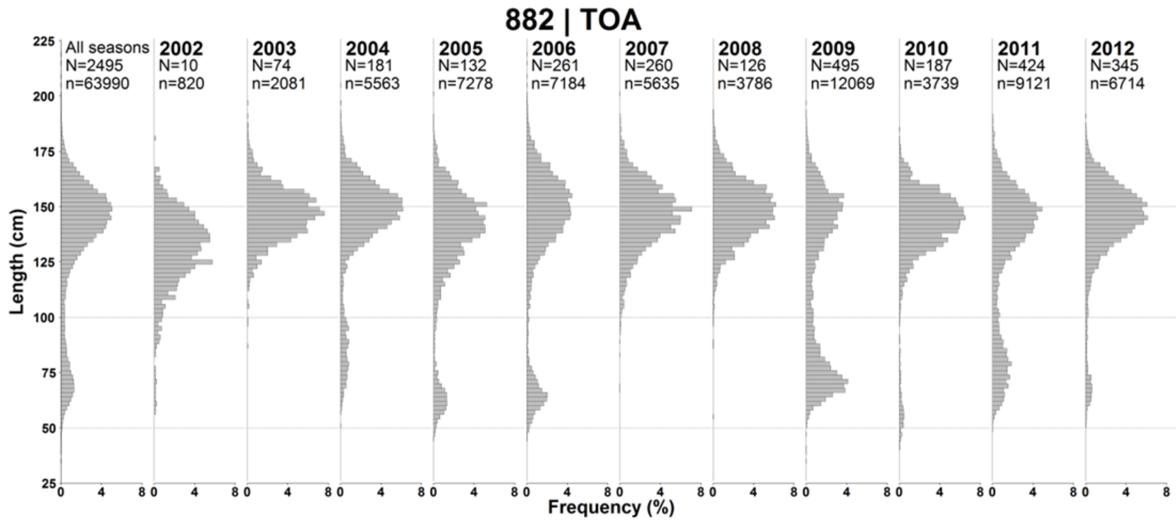

Figure 3: Length frequencies for *Dissostichus mawsoni* (TOA) in Subarea 88.2 from 2002 to present using observer data. The number of hauls (N) and the number of fish measured (n) in each year are given at the top of each panel.

20. The length-frequency data from the Ross Sea *D. mawsoni* fishery have remained consistent over recent seasons. There was 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 (WG-FSA-12/42). Although moderate numbers of small fish have been 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, and there was no evidence for recent strong variation in year-class strength in the fishery (WG-FSA-12/42).

21. *Dissostichus eleginoides* length-frequency data for all years were presented in WG-FSA-10/23. While the data were sparse in some years with very few fish caught and/or measured, the length-frequency distributions for most years were remarkably consistent (see WG-FSA-10/23, Table 9, Figure 13). The notable exception was 2009 where the modal length was much larger and males outnumbered females, and it was likely that the fish measured were misidentified *D. mawsoni*.

2. Stocks and areas

22. Analysis of the genetic diversity for *D. mawsoni* from Subareas 48.1 and 88.1 and Division 58.4.2 found weak genetic variation between the three areas (Smith and Gaffney, 2005). This differentiation is supported by oceanic gyres, which may act as juvenile retention systems, and by limited movement of adult tagged fish. Kuhn and Gaffney (2008) expanded the work of Smith and Gaffney (2005) by examining nuclear and mitochondrial single nucleotide polymorphisms (SNPs) on tissue samples collected from Subareas 48.1, 88.1 and 88.2 and Division 58.4.1. They found broadly similar results to those of the earlier studies, with some evidence for significant genetic differentiation between the three ocean sectors but limited evidence for differentiation within ocean sectors.

23. The present hypothesis regarding spawning dynamics and early life history of *D. mawsoni* in Subareas 88.1 and 88.2 is that spawning takes place to the north of the Antarctic continental slope, mainly on the ridges and banks of the Pacific–Antarctic Ridge

(Hanchet et al., 2008). 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 (a small clockwise rotating western gyre located around the Balleny Islands and a larger clockwise rotating eastern gyre covering the rest of Subareas 88.1 and 88.2), and may either move west settling out around the Balleny Islands and adjacent Antarctic continental 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). The fish gradually move deeper as they mature, feeding in the slope region in depths of 1 000–1 500 m, where they gain condition before moving north onto the Pacific–Antarctic Ridge to start the cycle again. Spawning fish may remain in the northern area for up to two or three years. They then move southwards back onto the shelf and slope where productivity is higher and food is more plentiful and where they regain condition before spawning.

24. A multidisciplinary approach incorporating otolith chemistry, age data and Lagrangian particle simulations reached similar conclusions (WG-FSA-12/P02).

25. *Dissostichus eleginoides* in Subarea 88.1 are clearly at the southern edge of their range, only extending into the northwest corner of Subarea 88.1 in significant numbers. The fishery catches very few small fish (<50 cm) and the origin of *D. eleginoides* in this area is unclear. It is possible that these fish may be related to *D. eleginoides* around Macquarie Island as one *D. eleginoides* tagged at Macquarie Island was caught in SSRU 881B in 2007.

3. Parameter estimation

3.1 Observations

Catch history

26. The catch history of *D. mawsoni*, used in the Ross Sea and SSRUs 882C–H assessment models, is given in Table 6.

Table 6: Total *Dissostichus mawsoni* catch (tonnes) for the Ross Sea and SSRUs 882C–H for the seasons 1997 to 2012. (Source: C2 data.) The Ross Sea shelf, slope and north fisheries are defined in WG-FSA-SAM-05/08. The SSRUs 882C–H south and north fisheries are defined in WG-FSA-11/43.

Season	Ross Sea				882C–H		
	Shelf	Slope	North	Total	South	North	Total
1997	0	0	0	0	-	-	-
1998	6	26	4	36	-	-	-
1999	14	282	0	296	-	-	-
2000	64	688	0	752	-	-	-
2001	113	347	132	592	-	-	-
2002	10	933	412	1355	-	-	-
2003	2	609	1158	1769	-	106	106
2004	141	1667	370	2177	-	362	362
2005	397	2262	550	3210	-	270	270

(continued)

Table 6 (continued)

Season	Ross Sea				882C–H		
	Shelf	Slope	North	Total	South	North	Total
2006	251	2373	343	2967	41	384	425
2007	68	2438	573	3079	-	347	347
2008	61	1939	251	2250	-	416	416
2009	135	1904	393	2432	157	327	484
2010	328	2171	370	2868	-	314	314
2011	483	2052	347	2882	162	406	568
2012	551	2309	314	3174	18	396	414
Total	2624	22000	5217	29839	378	3328	3706

Standardised CPUE

27. Raw CPUE indices have shown no trend over time for any area (WG-FSA-12/42). Standardised CPUE analyses of *D. mawsoni* in the Ross Sea were not updated for 2011 or used within the assessment models, as the Working Group considered that CPUE indices do not provide an index of abundance at the current time.

Catch-at-age

28. Strata for the *D. mawsoni* length- and age-frequency data for the Ross Sea were determined using a tree-based regression (a post-stratification method) (WG-FSA-SAM-05/08). The analysis used the median length of fish in each longline set, and the explanatory variables SSRU and depth.

29. On average, about 800 *D. mawsoni* otoliths collected by observers from NZ vessels were selected for ageing each year, and used to construct annual area-specific age–length keys (ALKs). Age data were available for the 1999 to 2010 seasons, but were not yet available for 2011 and 2012. In the Ross Sea, ALKs for each sex were applied to the shelf/slope fisheries and the north fishery separately. The ALKs were applied to the scaled length-frequency distributions for each year to produce catch-at-age distributions (WG-FSA-11/45). In SSRUs 882C–H, otoliths were only available from the New Zealand fleet, that did not fish those SSRUs every year. Therefore, for those SSRUs, a single ALK for each sex using otolith ages from all available years was used to construct annual age frequencies.

Recruitment surveys

30. The first research longline survey of pre-recruit (70–110 cm long) toothfish in the southern Ross Sea was carried out in 2012 (WG-FSA-12/41). It is intended that this survey series will be used to index recruitment in future years.

Tag-release and recapture

31. Under CM 41-01, each longline vessel fishing in exploratory fisheries for *Dissostichus* spp. is required to tag and release *Dissostichus* spp. at the rate of one toothfish per tonne of green weight caught throughout the season. A limit of 500 fish tagged per vessel applied until the end of 2007. Tagging rates, by vessel and Flag State since 2007, are given in Tables 7 and 8 for Subareas 88.1 and 88.2 respectively. The tagging rates were determined from tagging data and catch and effort reports submitted to the Secretariat.

32. Vessels catching more than 2 tonnes of *Dissostichus* spp. were required to achieve a minimum tag-overlap statistic of 50% in 2011 and of 60% from 2012 onwards (Annex 41-01/C). All vessels fishing in Subareas 88.1 and 88.2 in 2012 achieved a tag-overlap statistic greater than 60% (range 61–96%, Table 9).

Table 7: Number of individuals of *Dissostichus* spp. (a) tagged and released and (b) the tagging rate reported by vessels operating in the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 since 2007. (Source: observer data and catch and effort reports.)

(a) Number of individuals of *Dissostichus* spp. tagged and released. The number of *D. eleginoides* is indicated in brackets. NT – no tagging reported.

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
Argentina	*Antartic II*	228 (0)					
	Antartic III		NT				
	Argenova XXI				33 (0)		
Chile	*Isla Eden*			139 (0)			
Korea, Republic of	*Hong Jin No. 701*						109 (3)
	Hong Jin No. 707		255 (0)	237 (84)	368 (0)	252 (34)	462 (0)
	Insung No. 1			158 (15)	313 (0)	*	
	Insung No. 2		13 (8)				
	Insung No. 7					46 (0)	
	Insung No. 22	352 (20)					
	Jung Woo No. 2	198 (19)	212 (11)	242 (0)	268 (0)	285 (0)	186 (0)*
	Jung Woo No. 3			164 (0)	185 (0)	157 (0)	236 (0)
New Zealand	*Antarctic Chieftain*			185 (0)	164 (0)	238 (0)	128 (1)
	Avro Chieftain	289 (0)	50 (0)				
	Janas	184 (0)	179 (0)	166 (0)	415 (0)	172 (0)	168 (0)
	San Aotea II	385 (10)	196 (3)	186 (0)	288 (0)	323 (2)	304 (15)
	San Aspiring	463 (1)	370 (0)	265 (1)	515 (2)	202 (3)	528 (1)
Norway	*Froyanes*	168 (0)					
	Seljevaer						178 (0)
Russia	*Chio Maru No. 3*					196 (0)	203 (2)
	Gold Gate					99 (1)	
	Ostrovka					18 (0)	
	Sparta					110 (0)	2 (2)
	Volna	103 (0)					
	Yantar	375 (0)	283 (0)				
	Yantar 31						362 (0)

(continued)

Table 7(a) (continued)

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
South Africa	*Ross Mar*	51 (0)	128 (3)				
Spain	*Tronio*		46 (38)	507 (13)	308 (0)	430 (1)	546 (0)
UK	*Argos Froyanes*		370 (0)	302 (1)	158 (0)	332 (0)	38 (0)
	Argos Georgia	249 (20)	196 (14)		51 (0)	213 (0)	
	Argos Helena	270 (3)	181 (1)	338 (1)			
Uruguay	*Ross Star*	152 (2)	95 (1)	54 (0)			
	Viking Sur	141 (0)					

* Vessel sunk

(b) Tagging rate (number of fish tagged per tonne of green weight caught) of *Dissostichus* spp. NT – no tagging reported.

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
Argentina	*Antartic II*	1.5					
	Antartic III		NT				
	Argenova XXI				1.1		
Chile	*Isla Eden*			1.4			
Korea, Republic of	*Hong Jin No. 701*						1.3
	Hong Jin No. 707		1.2	1.2	1.1	1.1	1.0
	Insung No. 1			1.3	1.1	*	
	Insung No. 2		1.2				
	Insung No. 7					1.0	
	Insung No. 22	1.2					
	Jung Woo No. 2	1.2	1.0	1.1	1.2	1.1	1.2*
	Jung Woo No. 3			1.5	1.1	1.0	1.2
New Zealand	*Antarctic Chieftain*			1.1	1.0	1.0	1.2
	Avro Chieftain	1.1	1.2				
	Janas	1.1	1.0	1.1	1.0	1.0	1.3
	San Aotea II	1.2	1.2	1.1	1.1	1.1	3.8***
	San Aspiring	1.1	1.1	1.1	1.1	1.1	1.1
Norway	*Froyanes*	1.1					
	Seljevaer						1.0
Russia	*Chio Maru No. 3*					1.4	1.0
	Gold Gate					1.3	
	Ostrovka					1.0	
	Sparta					1.2	1.6
	Volna	1.0					
	Yantar	1.1	1.1				
	Yantar 31						1.2
South Africa	*Ross Mar*	1.0	1.1				
Spain	*Tronio*		1.0	1.4	1.0	1.0	1.0

(continued)

Table 7(b) (continued)

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
UK	*Argos Froyanes*		1.1	1.1	1.0	1.1	1.3
	Argos Georgia	1.0	1.3		1.1	1.0	1.1
	Argos Helena	1.4	1.3	1.3			
Uruguay	*Ross Star*	1.1	1.6	1.1			
	Viking Sur	1.3					
Required rate		1**	1	1	1	1	1

* Vessel sunk.
** Limit of 500 fish per vessel.
*** Increased tagging rate due to requirement to tag at rate of five tags per tonne during the pre-recruit survey.

Table 8: Number of individuals of *Dissostichus* spp. (a) tagged and released and (b) the tagging rate reported by vessels operating in the exploratory fishery for *Dissostichus* spp. in Subarea 88.2 since 2007. (Source: observer data and catch and effort reports.)

(a) Number of individuals of *Dissostichus* spp. tagged and released. The number of *D. eleginoides* is indicated in brackets. NT – no tagging reported.

Flag State	Vessel name	Season											
		2007		2008		2009		2010		2011		2012	
Argentina	*Antartic II*	2	(0)										
	Argenova XXI							8	(0)				
Chile	*Isla Eden*					5	(0)						
Korea, Republic of	*Hong Jin No. 707*					17	(0)			40	(0)	38	(0)
	Jung Woo No. 3							6	(0)	35	(0)		
New Zealand	*Antarctic Chieftain*					78	(0)			46	(0)	59	(0)
	Avro Chieftain			349	(0)								
	Janas					58	(0)			30	(0)	99	(0)
	San Aspiring									190	(0)		
Norway	*Froyanes*	97	(0)										
Russia	*Chio Maru No. 3*									90	(0)		
	Gold Gate									44	(0)		
	Sparta									50	(0)	36	(0)
	Volna	55	(0)										
	Yantar	100	(0)	NT									
South Africa	*Ross Mar*					120	(0)						
Spain	*Tronio*					15	(0)	52	(0)				
UK	*Argos Froyanes*			38	(0)	51	(0)	250	(0)	68	(0)	210	(0)
	Argos Georgia	NT				182	(0)	9	(0)	58	(0)		
	Argos Helena	14	(0)			24	(0)						
Uruguay	*Ross Star*			2	(0)	52	(0)			16	(0)		
	Viking Sur	10	(0)										

(b) Tagging rate (number of fish tagged per tonne of green weight caught) of *Dissostichus* spp. NT – no tagging reported.

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
Argentina	*Antartic II*	0.1					
	Argenova XXI				1.0		
Chile	*Isla Eden*			1.2			
Korea, Republic of	*Hong Jin No. 707*			1.3		0.9	1.5
	Jung Woo No. 3				1.1	1.1	
New Zealand	*Antarctic Chieftain*			1.8		1.0	1.0
	Avro Chieftain		1.0				
	Janas			1.2		1.1	1.0
	San Aspiring					1.1	
Norway	*Froyanes*	0.9					
Russia	*Chio Maru No. 3*					2.2	
	Gold Gate					1.1	
	Sparta					1.2	1.1
	Volna	1.0					
	Yantar	1.0	NT				
South Africa	*Ross Mar*			1.0			
Spain	*Tronio*			1.2	1.2		
UK	*Argos Froyanes*		1.1	2.2	1.0	1.0	1.0
	Argos Georgia	NT		1.1	1.1	1.1	
	Argos Helena	0.5		1.9			
Uruguay	*Ross Star*		0.2	1.4		1.2	
	Viking Sur	1.1					
Required rate		1*	1	1	1	1	1

* Limit of 500 fish per vessel.

Table 9: Time series of the tag-overlap statistic (CM 41-01) for *Dissostichus mawsoni* and *D. eleginoides* tagged (a) in Subarea 88.1 and (b) in Subarea 88.2. The statistic was implemented in 2011, and comparative values were calculated for previous seasons. Values were not calculated for total catches of less than 2 tonnes (*) and length data were aggregated by 10 cm length intervals. Only vessels fishing in CCAMLR fisheries in 2012 are listed in the table.

(a) Time series of the tag-overlap statistic in Subarea 88.1.

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
D. mawsoni							
Korea, Republic of	*Hong Jin No. 701*						72
	Hong Jin No. 707		18	25	50	64	71
	Jung Woo No. 2	29	25	19	26	93	91
	Jung Woo No. 3			21	42	88	86
New Zealand	*Antarctic Chieftain*			57	61	96	89
	Janas	69	80	43	79	85	81
	San Aotea II	52	69	77	79	88	88
	San Aspiring	76	74	81	88	90	92
Norway	*Seljevaer*						79

(continued)

Table 9(a) (continued)

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
Russia	*Chio Maru No. 3*					78	75
	Sparta					63	*
	Yantar 31						90
Spain	*Tronio*		22	19	69	69	69
UK	*Argos Froyanes*		46	43	53	75	61
	Argos Georgia	55	65		47	69	89
D. eleginoides							
Korea, Republic of	*Hong Jin No. 701*						*
	Hong Jin No. 707			21	*	*	
	Jung Woo No. 2	56	43				*
	Jung Woo No. 3						*
New Zealand	*Antarctic Chieftain*					*	*
	Janas	*	*	*		*	*
	San Aotea II	*	*	*	*	*	71
	San Aspiring	*	*	*	*	*	*
Russia	*Chio Maru No. 3*					*	*
	Sparta					*	*
Spain	*Tronio*		75	*	*	*	
UK	*Argos Froyanes*			*			
	Argos Georgia	*	*			*	*

(b) Time series of the tag overlap statistic in Subarea 88.2

Flag State	Vessel name	Season					
		2007	2008	2009	2010	2011	2012
D. mawsoni							
Korea, Republic of	*Hong Jin No. 707*			36		73	62
	Jung Woo No. 3				15	84	
New Zealand	*Antarctic Chieftain*			61		92	96
	Janas			73		81	83
	San Aspiring					77	
Russia	*Chio Maru No. 3*					55	69
	Sparta					79	62
Spain	*Tronio*			17	49		
UK	*Argos Froyanes*		31	55	54	75	65
	Argos Georgia			56	100	50	
D. eleginoides							
New Zealand	*Antarctic Chieftain*						*

33. A high-quality tag dataset for the assessment of *D. mawsoni* was selected on the basis of data quality metrics for individual trips (WG-FSA-11/42). The method first selected an initial informative dataset comprising trips (i) with high (above median) rates of recovery of previously released tags, and (ii) where tagged fish released on the trip were subsequently recaptured at a high rate. The method then used these trips to define the upper and lower bounds of data quality metrics that were informative with respect to tagging data. Other trips with data quality metric values within these ranges were then added to the initial informative dataset.

34. Since 2001, more than 29 000 *Dissostichus* spp. have been tagged in Subareas 88.1 and 88.2, with almost 26 000 and 2 600 *D. mawsoni* in the Ross Sea and SSRUs 882C–H respectively. The number of released and recaptured *D. mawsoni* from selected trips with high-quality tagging data used in the Ross Sea and the SSRUs 882C–H assessments are given in Tables 10(a) and 10(b) respectively. Note that within-season recaptures are ignored.

Table 10(a): Numbers of *D. mawsoni* with tags released for the years 2001 to 2010 for selected trips with high-quality tagging, and the number recaptured in 2002 to 2011, ignoring within-season recaptures and recaptures after >6 years (WG-FSA-11/42).

Tagged fish released		Tagged fish recaptured										
Year	Number	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
2001	259	1	1	0	0	0	1					3
2002	684	-	5	4	9	8	13	6				45
2003	844	-	-	10	8	2	9	2	2			33
2004	2030	-	-	-	21	19	32	23	8	14		117
2005	2914	-	-	-	-	26	26	28	5	47	13	145
2006	3023	-	-	-	-	-	86	47	12	28	19	192
2007	2780	-	-	-	-	-	-	52	17	49	21	139
2008	2125	-	-	-	-	-	-	-	10	35	18	63
2009	1791	-	-	-	-	-	-	-	-	38	27	65
2010	3064	-	-	-	-	-	-	-	-	-	57	57
Total	19514	1	6	14	38	55	167	158	54	211	155	859

Table 10(b): Numbers of *D. mawsoni* with tags released in the SSRUs 882C–H north region for the years 2003 to 2010 for selected data quality trips, and the number recaptured in the SSRUs 882C–G north region for the years 2004 to 2011, ignoring within-season recaptures and recaptures after >6 years (WG-FSA-11/43).

Tagged fish released		Tagged fish recaptured								
Year	Number	2004	2005	2006	2007	2008	2009	2010	2011	Total
2003	94	1	1	2	0	0	0			4
2004	397	-	10	9	3	1	0	0		23
2005	269	-	-	4	1	1	1	1	0	8
2006	276	-	-	-	18	3	2	1	2	26
2007	166	-	-	-	-	6	4	2	0	12
2008	351	-	-	-	-	-	11	6	0	17
2009	318	-	-	-	-	-	-	16	10	26
2010	316	-	-	-	-	-	-	-	31	31
Total	2187	1	11	15	22	11	18	26	44	147

3.2 Fixed parameter values

35. Natural mortality, length–mass, growth and maturity parameters for *D. mawsoni* in Subareas 88.1 and 88.2 are given in Table 11.

36. The mean age- and length-at-50%-spawning for females on the Ross Sea slope region were 16.6 years and 133.2 cm and for the mean age- and length-at-50%-maturity for males were 12.8 years and 120.4 cm. The Working Group noted that the female estimates were

based on the slope, which included fish which were skip spawning, and that estimates including fish from the north would lead to a slightly smaller age- and length-at-50%-spawning. These estimates were updated in 2012 to 16.9 years and 135 cm for females and 12.0 years and 109 cm for males (WG-FSA-12/40).

37. A total of 18 *Dissostichus* spp. tags (1.2%) from Subareas 88.1 and 88.2 were not able to be linked to a release event (WG-FSA-11/42). To account for these unlinked tags, a tag-detection rate of 98.8% was assumed in the assessment models.

Table 11: Parameter values for *Dissostichus mawsoni* in Subareas 88.1 and 88.2.

Component	Parameter	Value			Units
		Male	Female	All	
Natural mortality	M	0.13	0.13		y^{-1}
VBGF	K	0.093	0.090		y^{-1}
VBGF	t_0	–0.256	0.021		y
VBGF	L_∞	169.07	180.20		cm
Length-to-mass	‘a’	0.00001387	0.00000715		cm, kg
Length-to-mass	‘b’	2.965	3.108		
Length-to-mass variability (CV)				0.1	
Maturity	L_{m50}	12.8	16.6		y
Range: 5 to 95% maturity		9.3–16.3	9.3–23.9		y
Recruitment variability	σ_R			0.6	
Stock recruit steepness (Beverton-Holt)	h			0.75	
Ageing error (CV)				0.1	
Initial tagging mortality				10%	
Instantaneous tag-loss rate (single-tagged)				0.039	y^{-1}
Instantaneous tag-loss rate (double-tagged)				0.0084	y^{-1}
Tag detection rate				98.8%	
Tagging-related growth retardation (TRGR)				0.5	y

4. Stock assessment

4.1 Model structure and assumptions

Population dynamics

38. The Ross Sea (Subarea 88.1 and SSRUs 882A–B) and SSRUs 882C–H were assessed using CASAL integrated stock assessment models for *D. mawsoni*.

39. The CASAL stock models were sex- and age-structured, with ages from 1–50 and the last age group was a plus group (i.e. an aggregate of all fish aged 50 and older). The annual cycle is given in Table 12. Various model structures were investigated, and the base-case model and sensitivity models for the Ross Sea and SSRUs 882C–H are described below (WG-FSA-11/42 and 11/43). A complete description of the CASAL modelling software was given in WG-FSA-05/P03.

Table 12: Annual cycle of the stock model, showing the processes taking place at each time step, their sequence within each time step, and the available observations. Fishing and natural mortality that occur within a time step occur after all other processes, with half of the natural mortality for that time step occurring before and half after the fishing mortality.

Step	Period	Processes	M^1	Age[2]	Observations	
					Description	M^3
1	November–April	Recruitment and fishing mortality	0.5	0.0	Tag-recapture	0.5
					Catch-at-age proportions	0.5
2	May–November	Spawning	0.5	0.0		
3	-	Increment age	0.0	1.0		

1 *M* is the proportion of natural mortality that was assumed to have occurred in that time step.
2 Age is the age fraction, used for determining length-at-age, that was assumed to occur in that time step.
3 *M* is the proportion of the natural mortality in each time step that was assumed to have taken place at the time each observation was made.

40. The Secretariat undertook 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.

41. The models were run from 1995 to 2011 (Ross Sea) or 2002–2011 (SSRUs 882C–H), and were initialised assuming an equilibrium age structure at an unfished equilibrium biomass, i.e. a constant recruitment assumption. Recruitment was assumed to occur at the beginning of the first (summer) time step. Recruitment was assumed to be 50:50 male to female.

42. The Ross Sea base-case model was implemented as a single-area three-fishery model. A single area was defined with the catch removed using three concurrent fisheries (slope, shelf and north). Each fishery was parameterised by a sex-based double-normal selectivity ogive (i.e. domed selectivity) and allowed for annual selectivity shifts that shifted left or right (shelf fishery) with changes in the mean depth of the fishery (slope and north fisheries in the Ross Sea). The double-normal selectivity was parameterised using four estimable parameters and allowed for differences in maximum selectivity by sex – the maximum selectivity was fixed at one for males, but estimated for females. The double-normal selectivity ogive was employed as it allowed the estimation of a declining right-hand limb in the selectivity curve. The SSRUs 882C–H model was implemented as a single-area two-fishery model. A single area was defined with the catch removed using two concurrent fisheries (north and south of 70.85°S). Each fishery was parameterised by a sex-based double-normal selectivity ogive (i.e. domed selectivity) and allowed for annual selectivity shifts that shifted left or right with changes in the mean depth of the fishery.

43. Fishing mortality was applied only in the first (summer) time step. The process was to remove half of the natural mortality occurring in that time step, then apply the mortality from the fisheries instantaneously, then to remove the remaining half of the natural mortality.

44. The population model structure includes tag-release and tag-recapture events. Here, the model replicated the basic age-sex structure described above for each tag-release event. The age and sex structure of the tag component was seeded by a tag-release event. Tagging was applied to a ‘cohort’ of fish simultaneously (i.e. the ‘cohort’ of fish that were tagged in a given year and time step). Tagging from each year was applied as a single tagging event. The

usual population processes (natural mortality, fishing mortality etc.) were then applied over the tagged and untagged components of the model simultaneously. Tagged fish were assumed to suffer a retardation of growth from the effect of tagging (TRGR), equal to 0.5 of a year.

Model estimation

45. The model parameters were estimated using a Bayesian analysis, first by maximising[1] 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[2] using Monte Carlo Markov Chains (MCMCs).

46. Initial model fits were evaluated at the MPD by investigating model fits and residuals.

47. Parameter uncertainty was estimated using MCMCs. These were estimated using a burn-in length of 5×10^5 iterations, with every 1 000th sample taken from the next 1×10^6 iterations (i.e. a final sample of length 1 000 was taken).

Observation assumptions

48. The catch proportions-at-age data for the 1998–2010 (Ross Sea) or 2004–2010 (SSRUs 882C–H) seasons were fitted to the modelled proportions-at-age composition using a multinomial likelihood.

49. Tag-release events were defined for the 2001–2010 (Ross Sea) or 2004–2010 (SSRUs 882C–H) seasons, and tag-recapture observations for the 2001–2011 (Ross Sea) and 2004–2011 (SSRUs 882C–H) seasons. Within-season recaptures and recaptures after 6 years at liberty were ignored. Tag-release and tag-recapture observations from the SSRUs 882C–G (south) fishery were also ignored because of the very few recoveries (WG-FSA-11/43). Tag-release events were assumed to have occurred at the end of the first (summer) time step, following all (summer) natural and fishing mortality.

50. The estimated number of scanned fish (i.e. those fish that were caught and inspected for a possible tag) was derived from the sum of the scaled length frequencies from the selected trips with high-quality tagging data (for the base case), plus the numbers of fish tagged and released from all trips. Tag-recapture events were assumed to occur at the end of the first (summer) time step, and were assumed to have a detection probability of 98.8% to account for unlinked tags.

---

1 Technically, this is done by minimising the negative log objective function.

2 The analysis produces point estimates of parameters, but this ignores uncertainty in their values. Other combinations of parameters may also be likely, though not necessarily as likely as the point estimates. Bayesian posterior distributions describe the likely distribution of the parameters, given the uncertainty in the observations and model. One way of finding these distributions is to search within the parameter space of all parameters, using a technique called Monte Carlo Markov Chains (MCMC). A useful analogy is a landscape in which the lowest point (the point estimate) is found by juggling a ball around the landscape (the parameter space). Then look around the landscape and find all the other places that, given the uncertainty about the measurements, might also be low. In a Bayesian analysis, the resulting distribution is referred to as a Bayesian posterior distribution.

51. For each year, the recovered tags-at-length for each release event were fitted, in 10 cm length classes (range 40–230 cm), using a binomial likelihood.

Process error and data weighting

52. Additional variance, assumed to arise from differences between model simplifications and real-world variation, was added to the sampling variance for all observations. Adding such additional errors to each observation type has two main effects: (i) it alters the relative weighting of each of the datasets (observations) used in the model, and (ii) it typically increases the overall uncertainty of the model, leading to wider credible bounds on the estimated and derived parameters.

53. The additional variance, termed process error, was estimated for the base-case MPD run, and the total error assumed for each observation was calculated by adding process error and observation error. A single process error was estimated for each of the observation types (i.e. one for the age data and one for the tag data).

Penalties

54. Two types of penalties were included within the model. First, the penalty on the catch constrained the model from returning parameter estimates where the population biomass was such that the catch from an individual year would exceed the maximum exploitation rate (here, set equal to 0.999). Second, a tagging penalty discouraged population estimates that were too low to allow the correct number of fish to be tagged.

Priors

55. The parameters estimated by the models, their priors, starting values for the minimisation, and their bounds are given in Table 13. In models presented here, priors were chosen that were relatively non-informative but also encouraged lower estimates of B_0.

Table 13: Number (*N*), start values, priors and bounds for the free parameters (when estimated) for the base-case and sensitivity models.

Parameter		*N*	Start value	Prior	Bounds	
					Lower	Upper
B_0		1	80 000	Uniform-log	1×10^4	1×10^6
Male fishing selectivities	a_1		8.0	Uniform	1.0	50.0
	s_L		4.0	Uniform	1.0	50.0
	s_R	9	10.0	Uniform	1.0	500.0
Female fishing selectivities	a_{max}		1.0	Uniform	0.01	10.0
	a_1		8.0	Uniform	1.0	50.0
	s_L		4.0	Uniform	1.0	50.0
	s_R	12	10.0	Uniform	1.0	500.0
Selectivity shift (yr km^{-1})	E	2	0.0	Uniform	0.0	50.0
Annual selectivity shift (shelf)	E_f	14	Mean depth	Uniform	–10.0	10.0

Yield calculations

56. Yield estimates were calculated by projecting the estimated current status for each model under a constant catch assumption, using the rules:

1. Choose a yield, γ_1, 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, γ_2, 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 γ_1 and γ_2 as the yield.

57. The depletion probability was calculated as the proportion of samples from the Bayesian posterior where the predicted future spawning stock biomass (SSB) was below 20% of B_0 in any one year, for each year over a 35-year projected period.

58. The level of escapement was calculated as the proportion of samples from the Bayesian posterior where the predicted future status of the SSB was below 50% of B_0 at the end of a 35-year projected period.

59. Note that in applying the CCAMLR decision rules using CASAL, the pre-exploitation median SSB was replaced with the estimate of B_0 in each sample. This will result in a small downwards bias of the status of the stock in each trial and a small upwards bias in the probability of depletion. The effect of these biases will be a small downwards bias in the estimate of yield. The probability of depletion and the level of escapement were calculated by projecting forward for a period of 35 years, under a scenario of a constant annual catch (i.e. for the period 2012–2046), for each sample from the posterior distribution.

60. Recruitment from 2003 to 2045 was assumed to be lognormally distributed with a standard deviation of 0.6 with a Beverton-Holt stock-recruitment steepness $h = 0.75$.

61. For the Ross Sea, future catch was assumed to follow the same split between fisheries as that in the most recent three seasons (i.e. based on the distribution of the 2009–2011 catch, 11.3%, 75.4% and 13.3% of the total future catch was allocated to the shelf, slope and north fisheries respectively). The selectivity shift was assumed to be the average of shifts estimated for the years 1998–2011.

62. For SSRUs 882C–H, future catch was assumed to follow the same split between fisheries as that in the most recent three seasons (i.e. based on the distribution of the 2009–2011 catch, 24%, and 76% of the total future catch was allocated to the south of 70.85°S and north of 70.85°S fisheries respectively).

63. Note that historically, the catch limit has not always been fully taken due to adverse ice conditions. Possible ice-cover restrictions on future catch are ignored and the yields were calculated assuming that for each future season the total available catch would be taken, subject to the maximum exploitation rate constraint (here, set equal to 0.999).

4.2 Model estimates

Likelihood profiles

64. The likelihood profiles for the Ross Sea base-case model are given in Figure 4. The likelihood profiles were carried out by fixing B_0 at values across a range of plausible values (i.e. 40 000–120 000 tonnes), while estimating the remaining model parameters. The catch-at-age data and tag-recaptures from 2003 and 2005 suggested that very low biomass levels were less likely, whilst tag-recaptures from 2004, 2006 and 2007 suggested that very high biomass estimates were less likely.

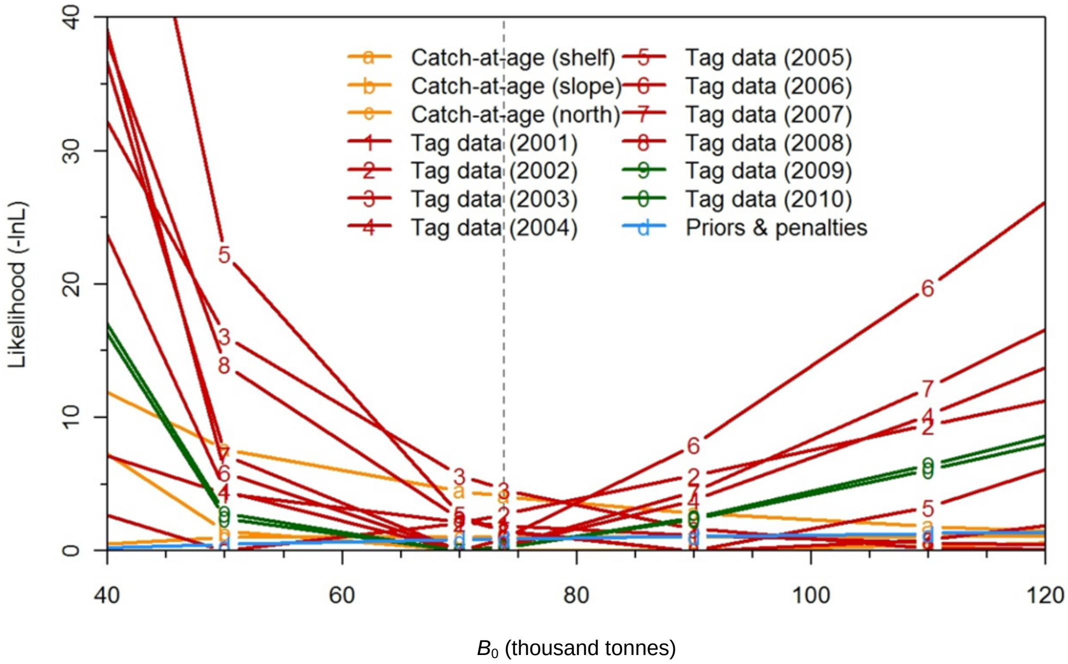

Figure 4: Likelihood profiles for the base-case model for the Ross Sea fishery for values of B_0. Negative log likelihood values were rescaled to have minimum 0 for each dataset. The dashed vertical line indicates the MPD.

MCMC diagnostics

65. For the base-case model run, 1 000 MCMC posterior samples were taken from 1 000 000 iterations, after a burn-in of 500 000 iterations. MCMC diagnostics suggested no evidence of poor convergence in the key biomass parameters and between-sample autocorrelations were low.

Ross Sea model estimates

66. Key output parameters for the Ross Sea base-case assessment model are summarised in Table 13. MCMC estimates of initial (equilibrium) spawning stock abundance (B_0) were 73 870 tonnes (95% credible interval (CI) 69 070–78 880 tonnes), and current ($B_{current}$)

biomass was estimated as 80% B_0 (95% CI 76.8–81.3%). The projected biomass trajectory assuming a future constant catch of 3 282 tonnes is shown in Figure 5.

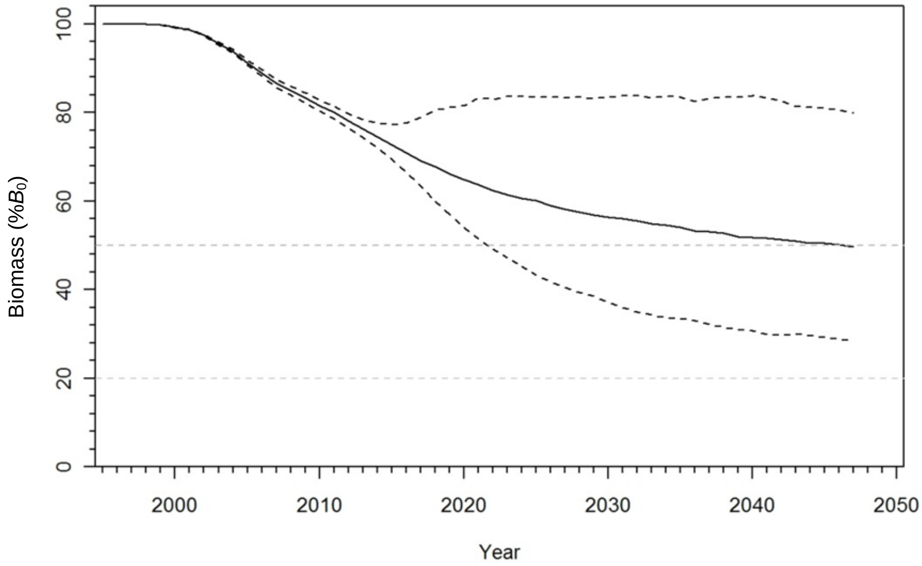

Figure 5: Estimated spawning stock biomass median (solid line) and 95% CI (dashed lines) for the base-case Ross Sea model.

SSRUs 882C–H model estimates

67. Key output parameters for the SSRUs 882C–H base-case assessment model are summarised in Table 14. MCMC estimates of initial (equilibrium) spawning stock abundance (B_0) were 11 720 tonnes (95% CI 9960–13 720 tonnes), and current (B_{current}) biomass was estimated as 84% B_0 (95% CI 80–86%). The projected biomass trajectory assuming a future constant catch of 530 tonnes is shown in Figure 6.

Table 14: Median MCMC estimates (and 95% CI) of B_0, B_{current} and B_{current} as %B_0 for the Ross Sea and SSRUs 882C–H base-case models.

Model	B_0	B_{current}	B_{current} (%B_0)
Ross Sea base case	73870 (69070–78880)	59110 (54370–64240)	80.0 (78.6–81.3)
882C–H base case	11720 (9960–13720)	9670 (7960–11720)	82.7 (79.4–85.6)

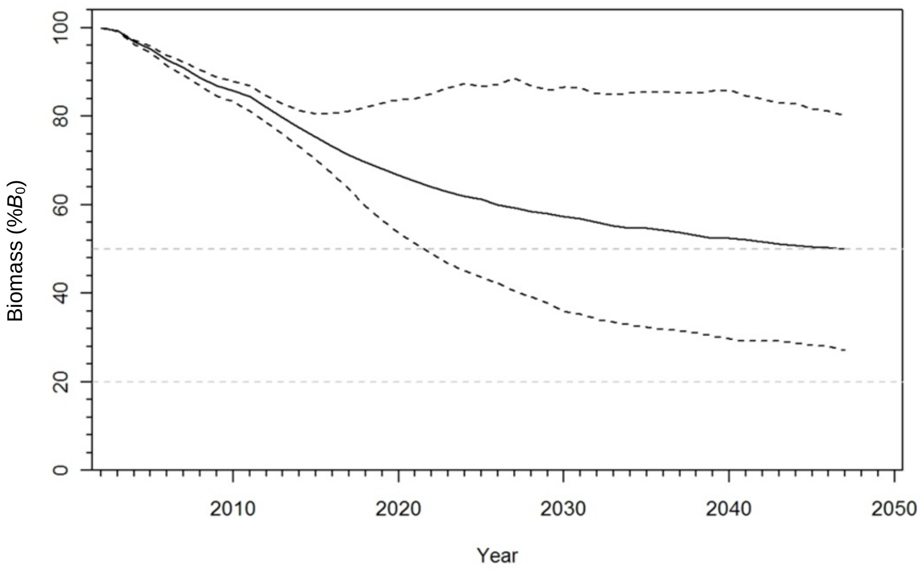

Figure 6: Estimated spawning stock biomass median (solid line) and 95% CI (dashed lines) for the base-case SSRUs 882C–H model.

68. Plots of the observed proportions-at-age of the catch versus expected values showed little evidence of inadequate model fit for either the Ross Sea or SSRUs 882C–H assessment models. Estimated selectivity curves for the Ross Sea base-case model (Figure 7) and SSRUs 882C–H base-case model (Figure 8) appeared reasonable, with strong evidence of dome-shaped selectivity in the three fisheries. Fits to the tag data appeared adequate, and posterior densities of the observed and expected number of tags at length, by release event and recapture year, are given in Figure 9.

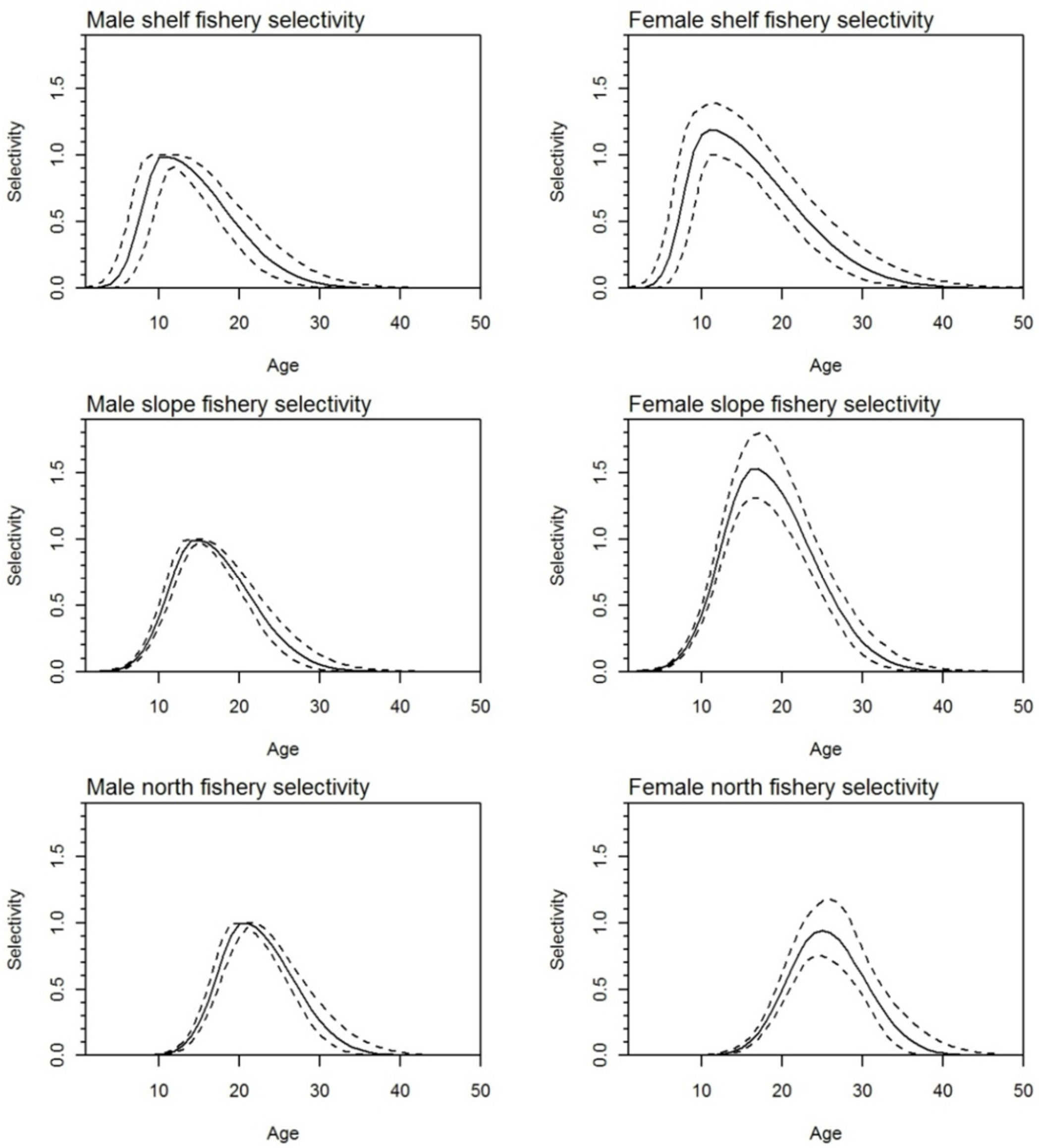

Figure 7: Estimated male and female selectivity ogives for the shelf, slope and north fisheries for the Ross Sea base-case model (solid lines indicate the median, and dashed lines indicate the marginal 95% CI).

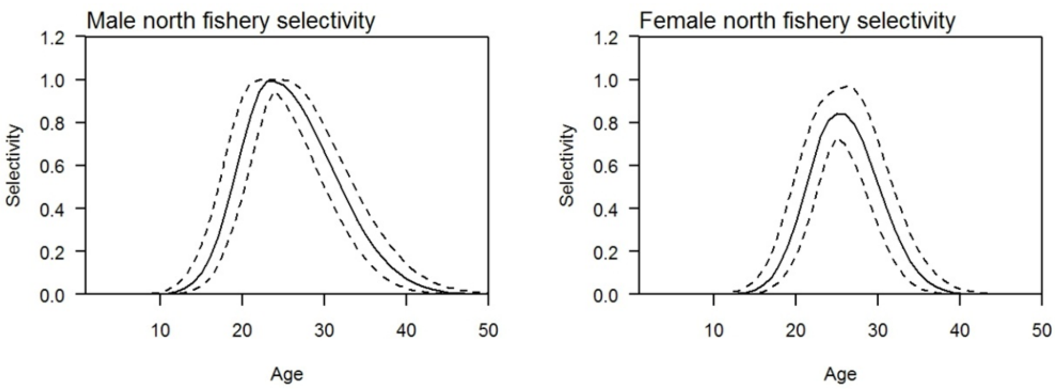

Figure 8: Estimated male and female selectivity ogives for the north of 70.85°S fishery for the SSRUs 882C–H base-case model (solid lines indicate the median, and dashed lines indicate the marginal 95% CI). Note: the selectivity ogives for the fishery south of 70.85°S were not available when the Fishery Report was produced.

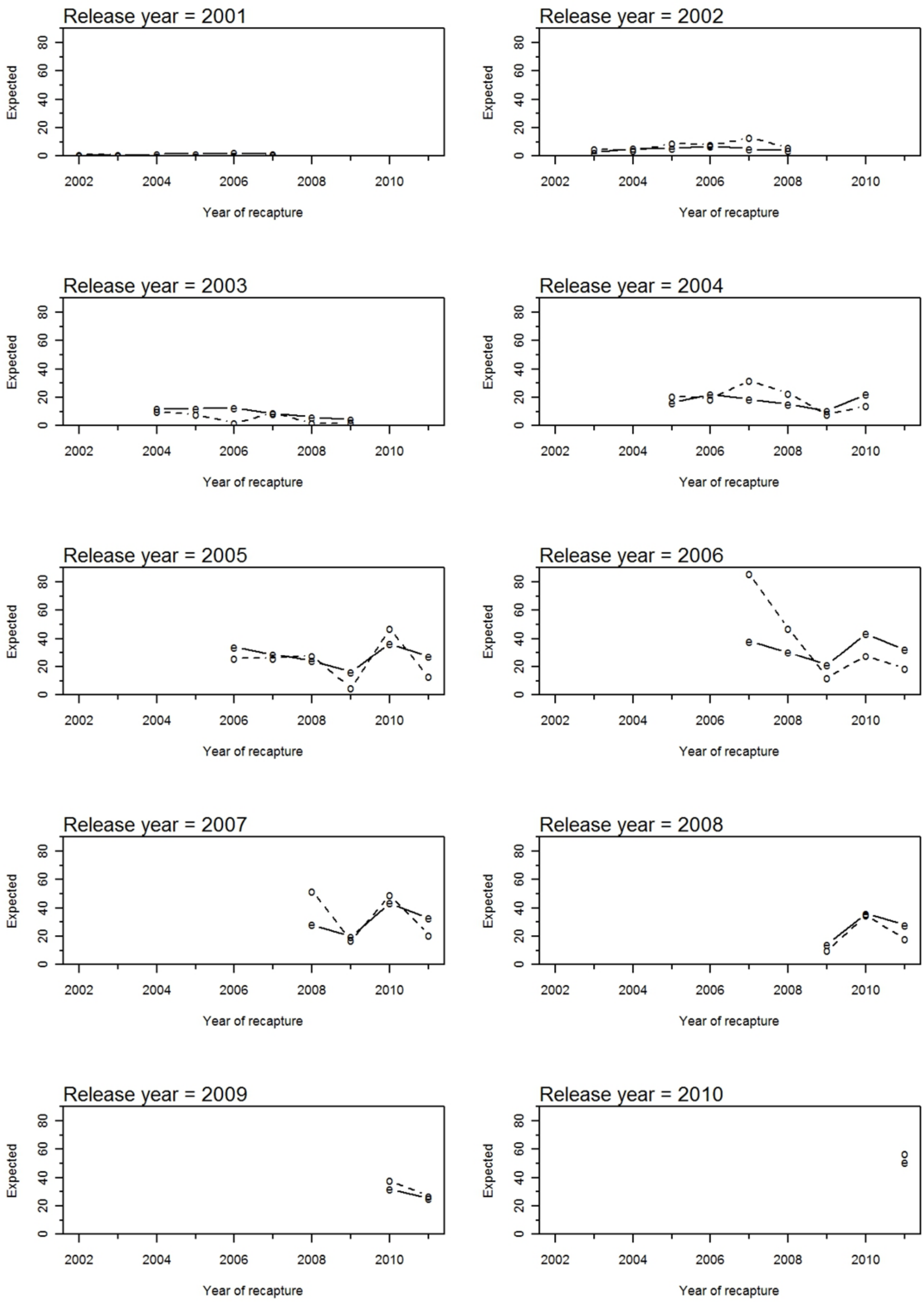

Figure 9(a): Observed (dashed lines) and MPD estimates (solid lines) of the total number of tags recaptured (y-axis) by year of recapture (x-axis) for each year of release for the Ross Sea base-case model.

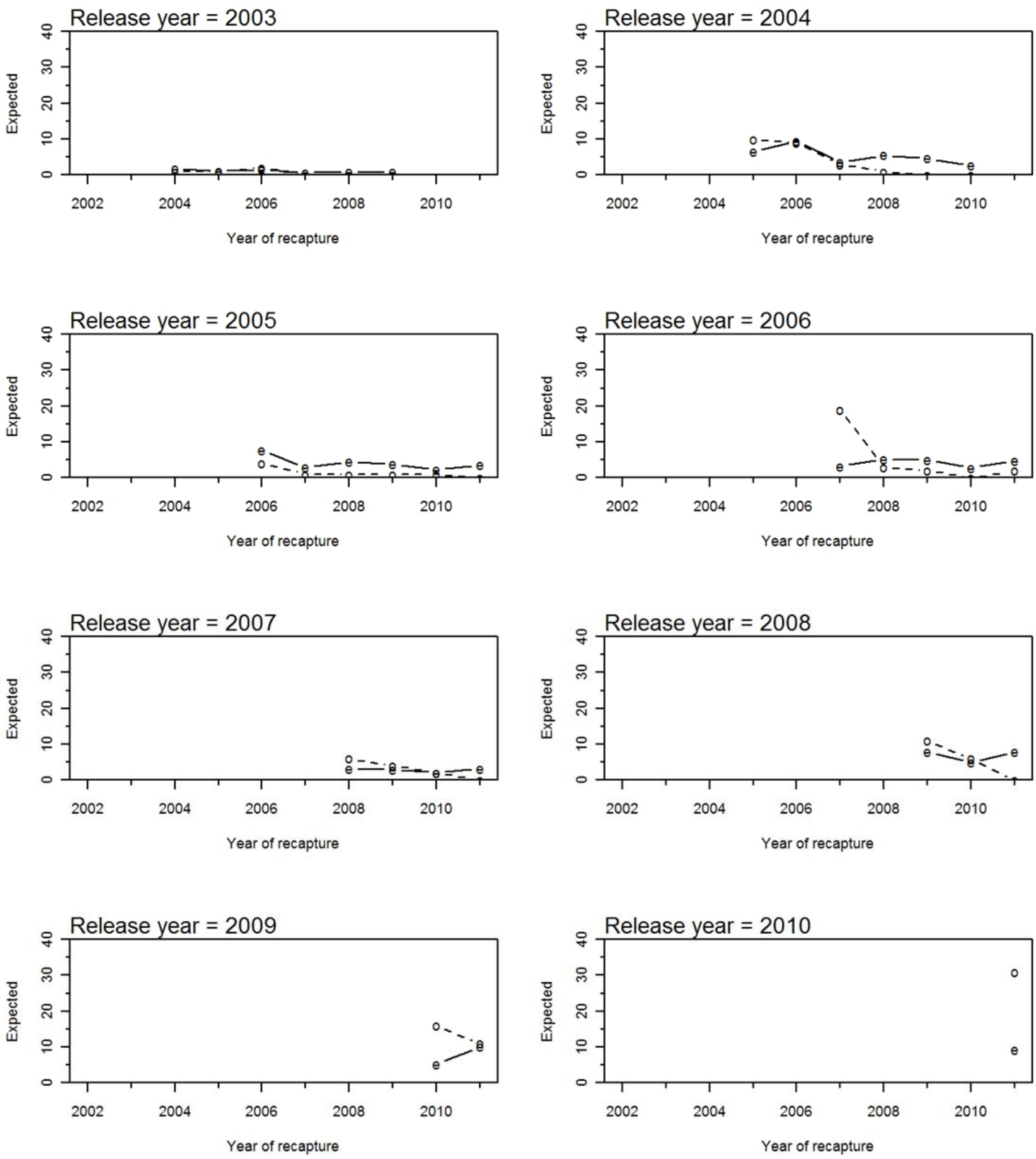

Figure 9(b): Observed (dashed lines) and MPD estimates (solid lines) of the total number of tags recaptured (y-axis) by year of recapture (x-axis) for each year of release for the SSRUs 882C–H base-case model.

Sensitivity analyses

69. Model sensitivity runs for the Ross Sea are described in Table 15(a). The base-case models included tag-release and recapture data from selected data quality trips. Sensitivity runs were determined as modifications to the base-case runs, and were chosen to investigate the effect of the inclusion of unaccounted mortality from lost lines and the inclusion of data from all vessels.

70. Model sensitivity runs for SSRUs 882C–H are described in Table 15(b). The base-case models included tag-release and recapture data from selected data quality trips and the selection of the catch and age-frequency data from all SSRUs. Sensitivity runs were determined as modifications to the base-case runs, and were chosen to investigate the effect of the exclusion of catch and age-frequency data from south of 70.85°S, the inclusion of unaccounted mortality from lost lines, and the inclusion of data from all vessels.

Table 15(a): Labels and description of the Ross Sea assessment model sensitivity runs. The run number refers to the model run reported in WG-FSA-11/42.

Model run		Description
R1	Base	Base-case run (i.e. 2011 reference case reported in WG-FSA-11/42).
R2.3	90th percentile unaccounted mortality	The base-case run, but including unaccounted mortality from lost gear.
R3	All vessel trips	The base-case run, but using the tag-release and recapture data from all vessel trips.

Table 15(b): Labels and description of the SSRUs 882C–H assessment model sensitivity runs. The run number refers to the model run reported in WG-FSA-11/43.

Model run		Description
R3	Base	Base-case run (i.e. including the catch and age-frequency data from the south reported in WG-FSA-11/43).
R1	Reference case	2011 reference case using selected vessel trips' tag-data and north fishery data only.
R2.3	90th percentile unaccounted mortality	Model R3, excluding catch from the south but including unaccounted mortality from lost gear.
R4		Model R1, but including catch, age frequency and tag observation data from the south.
R5	All vessel trips	Model R1, but using the tag-release and recapture data from all vessel trips

71. For the Ross Sea assessment models, the selected trips' model runs (R1) indicated a lower biomass than that indicated by the use of tag data from all vessel trips. The inclusion of unaccounted mortality from lost gear had little impact on the model estimates, even if the upper 90% CI of the mortality estimates was used (model R2.3). In all sensitivity cases, current biomass was estimated to be at 76–84% B_0.

72. For the SSRUs 882C–H assessment model, the selected trips' model run using catch from the south (R3) indicated a slightly lower biomass than that indicated by the use of tag data from all vessel trips (R5), and a very similar biomass to the models that excluded data from the south (model R1) or included unaccounted mortality from lost gear (model R2.3). The inclusion of tag data from the south (model R4) suggested a slightly higher biomass than the base-case model. In all sensitivity cases, current biomass was estimated to be at 78–88% B_0.

4.3 Yield estimates

Ross Sea

73. The constant catch for which there was median escapement of 50% of the median pre-exploitation spawning biomass level at the end of the 35-year projection period was 3 282 tonnes. At this yield there is less than a 10% chance of spawning biomass dropping to less than 20% of the initial biomass. Following the third CCAMLR decision rule, the yield of 3 282 tonnes is recommended.

SSRUs 882C–H

74. The constant catch for which there was median escapement of 50% of the median pre-exploitation spawning biomass level at the end of the 35-year projection period was 530 tonnes. At this yield there is less than a 10% chance of spawning biomass dropping to less than 20% of the initial biomass. Following the third CCAMLR decision rule, the yield of 530 tonnes is recommended.

4.4 Discussion of model results

75. The Working Group recommended that the model described as the 2011 reference case in WG-FSA-11/42 be the base-case assessment model for the Ross Sea, and that the model described as the model R3 in WG-FSA-11/43 be the base-case assessment model for SSRUs 882C–H.

4.5 Future research requirements

76. The Working Group recommended that, in order to distinguish between different methods for providing advice on harvest strategies, the robustness of different assessment methods for achieving the objectives of the Commission be evaluated using simulation evaluation methods.

5. By-catch of fish and invertebrates

5.1 By-catch removals

77. Catches of by-catch species groups (macrourids, rajids and other species) reported in fine-scale data, their respective catch limits, and number of rajids cut from lines and released alive are summarised for Subareas 88.1 and 88.2 in Tables 16 and 17 respectively.

Table 16: Catch history for by-catch species (macrourids, rajids and other species), catch limits and number of rajids released alive in Subarea 88.1. Catch limits are for the whole fishery (see CM 33-03 for details). (Source: fine-scale data.)

Season	Macrourids		Rajids			Other species	
	Catch limit (tonnes)	Reported catch (tonnes)	Catch limit (tonnes)	Reported catch (tonnes)	Number released	Catch limit (tonnes)	Reported catch (tonnes)
1997	-	0	-	0	-	-	0
1998	-	9	-	5	-	50	1
1999	-	22	-	39	-	50	5
2000	-	74	-	41	-	50	7
2001	-	61	-	9	-	50	14
2002	100	154	-	25	-	50	10
2003	610	65	250	11	966	100	12
2004	520	319	163	23	1 745	180	23
2005	520	462	163	69	5 057	180	24
2006	474	258	148	5	14 640	160	18
2007	485	153	152	38	7 336	160	43
2008	426	112	133	4	7 190	160	20
2009	430	183	135	7	7 088	160	16
2010	430	119	142	8	6 796	160	15
2011	430	189	142	4	5 409	160	8
2012	430	143	164	1	2 237	160	4

Table 17: Catch history for by-catch species (macrourids, rajids and other species), catch limits and number of rajids released alive in Subarea 88.2. Catch limits are for the whole fishery (see CM 33-03 for details). (Source: fine-scale data.)

Season	Macrourids		Rajids			Other species	
	Catch limit (tonnes)	Reported catch (tonnes)	Catch limit (tonnes)	Reported catch (tonnes)	Number released	Catch limit (tonnes)	Reported catch (tonnes)
1997	-	0	-	0	-	-	0
1998	-	0	-	0	-	-	0
1999	-	0	-	0	-	-	0
2000	-	0	-	0	-	-	0
2001	-	0	-	0	-	-	0
2002	40	4	-	0	-	20	0
2003	60	18	-	0	-	140	8
2004	60	37	50	0	107	140	8
2005	60	21	50	0	-	140	3
2006	78	92	50	0	923	100	12
2007	88	54	50	0	-	100	13
2008	88	17	50	0	-	100	4
2009	90	58	50	0	265	100	14
2010	92	49	50	0	-	100	15
2011	92	52	50	0	171	100	13
2012	84	29	50	0	-	120	11

78. The macrourid by-catch limit was exceeded in Subarea 88.2 in 2006, but no catch limits have been exceeded in either area since 2007.

79. Current catch limits for rajids in the Ross Sea are proportional to the catch limit of *Dissostichus* spp. in each SSRU based on the following rule from CM 33-03:

- the limit for rajids is 5% of the catch limit of *Dissostichus* spp. or 50 tonnes, whichever is greater.

80. Current catch limits for macrourids in SSRUs 881H–L were based on a biomass of the IPY-2008 trawl survey from the slope of the Ross Sea (see below). Yield estimates for macrourids were calculated from that estimate, and then apportioned across the five SSRUs, taking into account maximum historical catches.

81. A characterisation of the by-catch (WG-FSA-12/42) showed that the three other most important by-catch species were icefish (mainly *Chionobathyscus dewitti*), eel cods (probably mainly *Muraenolepis evseenkoi*) and morid cods (mainly *Antimora rostrata*). The total catch for each of these species groups from 1998 to 2012 was 100, 102 and 97 tonnes respectively and each formed about 0.3% of the total catch. Further details on the catch and biology of the eel cods is summarised in WG-FSA-12/50.

5.2 Assessments of impacts on affected populations

Macrourids

82. The estimate of γ for *Macrourus* spp. in Subarea 88.1 in 2003 was 0.01439 for a CV of 0.2 (SC-CAMLR-XXII, paragraph 4.132) or 0.01814 for a CV of 0.5 (SC-CAMLR-XXII, Annex 5, paragraph 5.242).

83. WG-FSA-08/32 provided biomass and yield estimates of *Macrourus* spp. for the Ross Sea fishery (Subarea 88.1 and SSRUs 882A–B) based on extrapolations under three different density assumptions from a trawl survey (Table 18). The resulting biomass estimates had a CV of about 0.3. The Working Group agreed to use estimates of biomass for Subarea 88.1, noting that SSRUs 882A–B are currently closed.

Table 18: Biomass estimates from the trawl surveys for the BioRoss 400–600 and 600–800 m and IPY-CAML 600–1 200 and 1 200–2 000 m strata (bold numbers) and extrapolated biomass estimates (with CVs) for the remaining strata based on three methods of extrapolation.

Survey	Depth range (m)	Biomass (tonnes)	Extrapolated biomass (tonnes)		
			Constant density	CPUE (all vessels)	CPUE (NZ vessels)
BioRoss – 881H	400–600	**230**	**230 (49)**	**230 (49)**	**230 (49)**
BioRoss – 881H	600–800	**3531**	**3531 (38)**	**3531 (38)**	**3531 (49)**
SSRU 881H west	800–1200		92 (50)	83 (54)	103 (55)
SSRU 881H west	1200–2000		713 (40)	1114 (49)	1038 (47)
IPY – 881H	600–1200	**975**	**975 (50)**	**975 (50)**	**975 (50)**
IPY – 881H	1200–2000	**3356**	**3356 (40)**	**3356 (40)**	**3356 (49)**
SSRU 881I	600–1200		3297 (50)	7883 (51)	5992 (50)
SSRU 881I	1200–2000		4670 (40)	11168 (42)	8576 (41)
SSRU 881K	600–1200		1539 (50)	5027 (51)	2774 (51)
SSRU 881K	1200–2000		2998 (40)	5995 (45)	9111 (43)
SSRUs 882 A, B	600–1200		1404 (50)	1396 (58)	857 (60)
SSRUs 882 A, B	1200–2000		4087 (40)	525 (70)	-
Total			26892 (29)	41823 (28)	36542 (30)

84. Yield estimates for macrourids were calculated using the constant density assumption when extrapolating the biomass estimate across the slope region, noting that this would provide a more precautionary estimate of yield than one based on extrapolations using longline CPUE data. The resulting biomass estimate for SSRUs HIK and small portions of SSRUs JL was 21 401 tonnes which gave a yield estimate of 388.2 tonnes. This yield estimate was then apportioned across the five SSRUs, taking into account maximum historical catches. Yields per SSRU are detailed in Table 19. Existing move-on rules are retained, and macrourid by-catch limits and catches are expected to be reviewed on an annual basis.

Table 19: Proposed catch limits (tonnes) of grenadiers in Subarea 88.1 assuming a CV of 0.5 for the estimate of B_0 and that the grenadier density was constant across the entire slope (WG-FSA-08/32).

SSRU	Current catch limit	Estimated yield	Maximum historic catch	Proposed catch limit
881B, C, G	50	-	34	40
881HIK	271	388 (881HIK, 881J, 881L combined)	390	320
881J	79		46	50
881L	24		6	20
882A–B	0	100	8	0
Total	424	488		430

Rajids

85. WG-SAM-07/04 presented data and a preliminary developmental model for Antarctic skates in SSRUs HIK 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.

86. WG-FSA-10/25 provided a characterisation of skate catches in the Ross Sea region. The paper concluded 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 fish that were tagged. While the size composition of the commercial catch was uncertain before 2009 because of the low numbers sampled each year, data collected in the Year-of-the-Skate resulted in improved estimates of the length frequency of the catch. Tag data from the Year-of-the-Skate were also improved, with a total of about 3 300 *Amblyraja georgiana* and 700 *Bathyraja* cf. *eatoni* tagged and a total of 179 skates recaptured.

5.3 Identification of levels of risk

87. WG-FSA-05/21 presented risk categorisation tables for *M. whitsoni* and *A. georgiana*, which are the major by-catch species in Subareas 88.1 and 88.2 (SC-CAMLR-XXIV, Annex 5, Appendix N, Tables 5 and 6).

5.4 Mitigation measures

88. WG-FSA-05/24 used a standardised CPUE analysis to determine factors affecting by-catch rates of macrourids and rajids in the exploratory fishery for toothfish in Subareas 88.1 and 88.2. The analysis was based on fine-scale haul-by-haul data and observer data from all vessels in the fishery from 1998 to 2005.

89. The analysis suggested that it might be possible to reduce by-catch of macrourids in Subareas 88.1 and 88.2 by avoiding fishing in the depth ranges and areas where by-catch rates are highest. However, the Working Group noted that there is a considerable overlap with the spatial and depth distribution of *Dissostichus* spp., and area and/or depth restrictions would also impact on the ability of the fleet to catch *Dissostichus* spp.

90. Because skates have a reasonable chance of survival, they are released at the surface in accordance with CM 33-03. The current by-catch limits and move-on rules are given in CM 33-03.

6. Incidental mortality of birds and mammals

6.1 Incidental mortality reported

91. Since 1998 the only reported seabird mortality in Subareas 88.1 and 88.2 was a single bird in 2004. There have been no reports of marine mammal mortalities since 1998.

6.2 Assessment of risk

92. The risk levels of seabirds in the fishery in Subarea 88.1 is category 1 (low) south of 65°S, category 3 (average) north of 65°S and overall is category 3 (SC-CAMLR-XXX, Annex 8, paragraph 8.1).

6.3 Mitigation measures

93. CM 25-02 applies to these areas and in recent years has been linked to an exemption for night setting in CM 24-02 and subject to a seabird by-catch limit. Offal and other discharges are regulated under annual conservation measures (e.g. CMs 41-09 and 41-10).

7. Ecosystem implications/effects

94. Developments in evaluating ecosystem effects of the *D. mawsoni* fishery were discussed at the FEMA and FEMA2 Workshops (SC-CAMLR-XXVI/BG/6, paragraphs 45 to 48 and SC-CAMLR-XXVIII, Annex 4) and are summarised below.

95. Two key trophic interactions were identified as being important for *D. mawsoni*. The first concerned the nature of the interaction between toothfish predators (e.g. Type C killer

whales, sperm whales and Weddell seals) and toothfish. Results from the ECOPATH model suggest that toothfish only forms about 6–7% of the diet of its predators (WG-EMM-09/42). However, it was noted that the consumption of toothfish in particular locations, at particular times of the year, or by particular parts of the population may be important to predators, even though the total consumption of toothfish by all individuals of a species is relatively low. This may be more important if there are small sub-populations of predators. WG-EMM-09/42 also noted that a balanced ecosystem model for the Ross Sea provided no support for the hypothesis that depletion of toothfish stocks would greatly change the diet of toothfish predators.

96. The second key trophic interaction was between toothfish and its prey – in particular demersal fish species. Results from the ECOPATH model suggest that toothfish consumes 70% of the annual production of demersal species (WG-EMM-07/18), and so a reduction of the toothfish population could have a large impact on the natural mortality of these species. The FEMA Workshop recognised the additional complex interaction with the fishery, whereby demersal fish are taken as by-catch, so that a reduction in natural mortality may be partially offset by an increase in fishing mortality.

97. The FEMA and FEMA2 Workshops considered that it was important to further develop the ecosystem modelling work in the Ross Sea to specifically address these interactions, including that a scoping exercise be undertaken to determine the complexity of the model. These models would need to be spatially and temporally explicit to take into account the spatio–temporal effects of the predation; a Minimum Realistic Model (MRM) approach was considered to be most appropriate. Given the paucity of data, the model should be as simple as possible, yet complex enough to test the key functional relationships, and modelling results in the first instance would, by necessity, need to be used in a strategic, rather than tactical, sense.

98. The FEMA workshops also noted that the modelling was likely to identify a number of areas requiring extra data collection. These included understanding the 3-D foraging area of toothfish, its predators and its prey and how it may change seasonally and spatially, as well as a better understanding of toothfish movements, spawning dynamics and early life history.

99. In regard to spatial overlap, the FEMA2 Workshop examined information on foraging patterns of marine mammals and concluded that the available evidence suggests that the spatial overlap of Weddell seals and killer whales with the fishery is negligible. However, information currently available addressed the distribution of predators (and toothfish) only during summer. Information on toothfish distribution, and the distribution and behaviour of predators, in winter may assist this analysis of potential overlap. The Working Group noted that models such as the SPM could be used to help evaluate whether this would be important.

100. The FEMA2 Workshop noted that the decision rule to estimate long-term precautionary yield for toothfish to satisfy Article II of the Convention (which relates to maintenance of ecological relationships between harvested, dependent and related species) is the proportion of spawning biomass permitted to escape the fishery to safeguard predators. This is set at 50% for the Ross Sea, as well as all other assessed toothfish fisheries.

101. The FEMA2 Workshop noted that the escapement level in the decision rule for the spawning biomass may need to be modified upwards if the size/age classes of *Dissostichus* spp. that are important prey for predators are reduced below a suitable escapement level for those classes.

102. WG-SAM-10/21 reported on progress towards an MRM for investigating trophic relationships between *D. mawsoni* and four groups of demersal fish in the Ross Sea. The paper outlined an approach that could be taken to investigate potential changes in the trophic relationships between *D. mawsoni* and (i) macrourids (especially *M. whitsoni* and *M. caml*); (ii) icefish (especially *C. dewitti*); (iii) deep-sea cods (especially violet cod, *A. rostrata*); and (iv) eel (moray) cods (*Muraenolepis* spp.). While no results were available as yet, the authors indicated that work was ongoing and would be presented to the Scientific Committee working groups in due course.

103. WG-EMM-12/53 used a balanced ecosystem model to explore biomass and flow of organic matter by trophic level, and mixed trophic impacts to evaluate ecosystem-level characteristics of the Ross Sea shelf and slope. The model used 35 trophic groups, averaged over a typical year. The system was characterised by a high biomass of mesozooplankton and benthic invertebrates. The biomass of top predators (trophic levels > 4.5) was only 0.5% of the total living biomass in the Ross Sea (excluding bacteria). The six groups with the highest 'indices of ecological importance' in the food web were phytoplankton, mesozooplankton, Antarctic silverfish (*Pleuragramma antarcticum*), small demersal fishes, Antarctic krill (*Euphausia superba*) and cephalopods. Crystal krill (*E. crystallorophias*) and pelagic fishes were also likely to be important in the food web. It was suggested that these eight groups could be priorities for further monitoring of ecosystem change in the region. Antarctic toothfish was found to have a moderate index of ecological importance for the wider ecosystem, although it would have a greater impact on 'medium-sized' demersal fish.

104. WG-FSA-12/P04 described the McMurdo Sound vertical longline survey for *D. mawsoni* spanning 1972 to 2011. Catch-per-unit-effort (CPUE) declined beginning in 1997–2001. Analysis of fish length and condition suggested changes in sea-ice conditions were associated with a trend of increasing fish length with the index of September–October ice extent, and a trend of decreasing fish condition with minimum ice area. During the time series, fish condition increased until 1992, and has since decreased to a level similar to that at the start of the series. The change in CPUE was not associated with any of the factors analysed.

105. In relation to this paper WG-FSA:

(i) considered that the apparent decline in toothfish CPUE at McMurdo Sound since 2001 was not consistent with data from the fishery. For example, the standardised catch rates from a research longline survey of pre-recruit toothfish (70–110 cm TL) in the southern Ross Sea in 2012 were similar to those made by the same vessel fishing in the area earlier in the fishery, between 1999 and 2003 (WG-FSA-12/41) (see Figure 10)

(ii) considered that the potential changes in the mean number of killer whales per pod during the past decade (presented in WG-FSA-12/P03) may also be related to these local system effects

(iii) agreed that the time series in McMurdo Sound could be a useful tool to monitor local toothfish abundance and ecology within McMurdo Sound and recommended it be continued. However, it also emphasised the importance of the standardisation of the survey with respect to hook and bait type, time of sampling, fishing depth and fishing location

(iv) noted that, given the spatial scale of the Ross Sea and the location of McMurdo Sound, a local sampling effort would not be expected to provide an index of the status of the stock centred well over 500 km away (Figure 11).

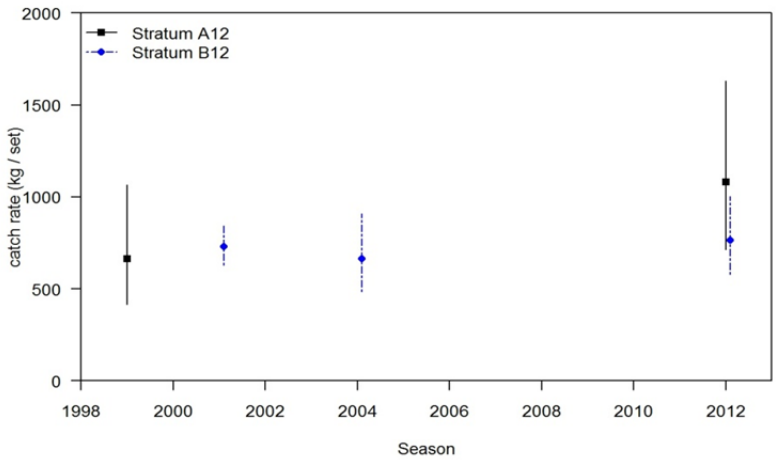

Figure 10: Standardised CPUE indices for New Zealand vessels in stratum A12 (southern part of SSRU 881J) and stratum B12 (southern part of SSRU 881L) for 1999, 2001, 2004 and 2012 (see also WG-FSA-12/41).

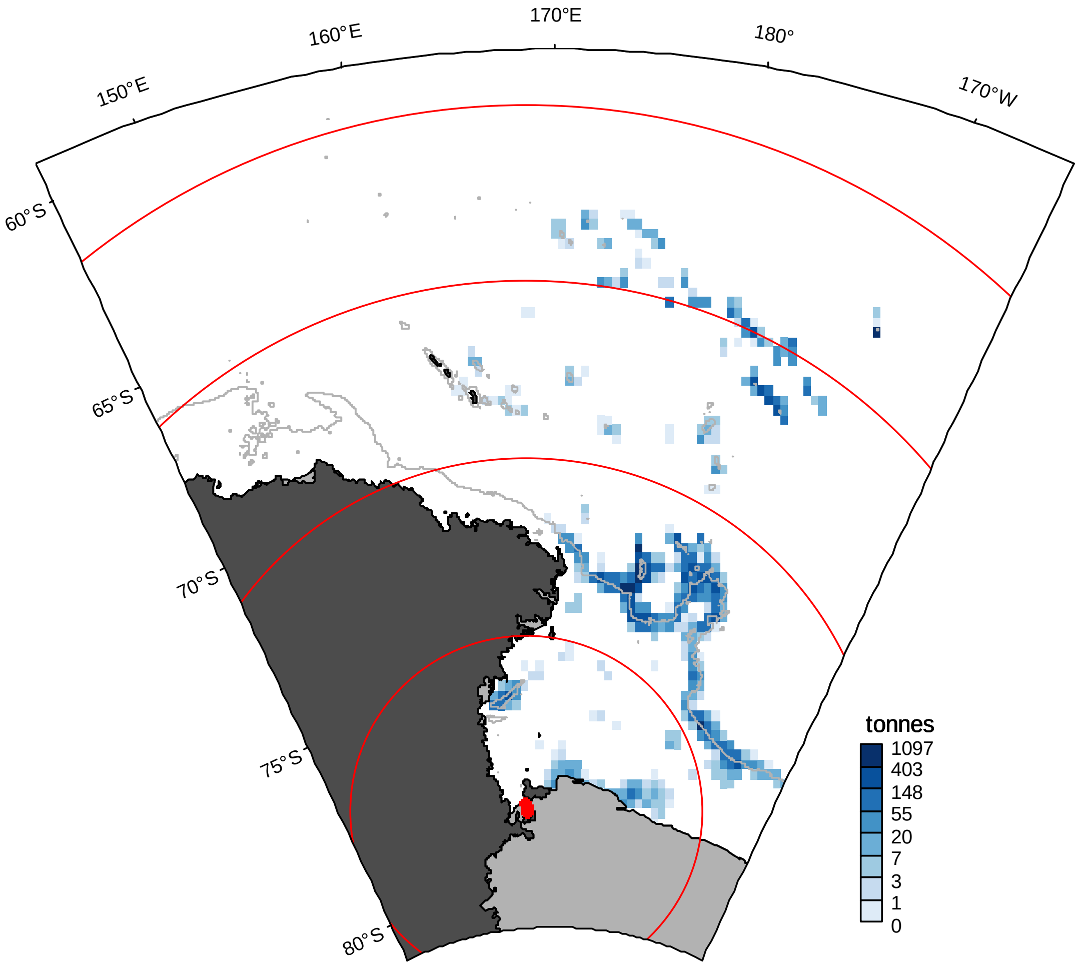

Figure 11: Distribution of total cumulative catch of Antarctic toothfish in the Ross Sea, 1997–2012 in relation to the sampling sites in McMurdo Sound (red dots). Red lines indicate 500 km concentric circles from McMurdo Sound. Gray line indicates the 1 000 m depth contour.

8. Harvest controls and management advice

8.1 Conservation measures

106. The limits on the exploratory fishery for *Dissostichus* spp. in Subareas 88.1 and 88.2 are defined in CMs 41-09 and 41-10 respectively. The limits in force and the Working Group's advice to the Scientific Committee for the forthcoming season are summarised in Tables 20 and 21.

Table 20: Limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 in force (CM 41-09) and advice to the Scientific Committee for 2013.

Element	Limit in force	Advice for 2013
Access (gear)	Limited to notified vessels using longlines.	Carry forward
Catch limit	Precautionary catch limit for *Dissostichus* spp. was 3 282 tonnes for Subarea 88.1 applied as follows: SSRUs A, D, E, F and M – 0 tonnes SSRUs BCG – 428 tonnes total SSRUs HIK – 2423 tonnes total SSRUs JL – 351 tonnes.	Carry forward
Season	1 December to 31 August	Same period
Fishing operations	In accordance with CM 41-01 and the setting of research hauls is not required (Annex B, paragraphs 3 and 4).	Carry forward
By-catch	Regulated by CMs 33-03 and 41-09.	Carry forward
Mitigation	In accordance with CM 25-02, except paragraph 5 if requirements of CM 24-02 are met.	Carry forward
	Daylight setting allowed under CM 24-02, subject to a catch limit of three seabirds per vessel.	Carry forward
Observers	Each vessel to carry at least two scientific observers, one of whom shall be appointed in accordance with the CCAMLR Scheme of International Scientific Observation.	Carry forward
VMS	To be operational in accordance with CM 10-04.	Carry forward
CDS	In accordance with CM 10-05.	Carry forward
Research	Undertake research plan and tagging program as set out in CM 41-01, Annexes B and C.	Carry forward
	Toothfish tagged at a rate of at least one fish per tonne green weight caught.	Carry forward
Data	Daily and five-day catch and effort reporting under CMs 23-01 and 23-07.	Carry forward
	Haul-by-haul catch and effort data under CM 23-04.	Carry forward
	Biological data reported by the CCAMLR scientific observer.	Carry forward
Target species	For the purposes of CMs 23-01 and 23-04, the target species is *Dissostichus* spp. and the by-catch is any species other than *Dissostichus* spp.	Carry forward
Environmental protection	Regulated by CMs 22-06, 22-07, 22-08 and 26-01.	Carry forward
Additional element	Fishing within 10 n miles of Balleny Islands is prohibited.	Carry forward

Table 21: Limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.2 in force (CM 41-10) and advice to the Scientific Committee for 2013.

Element	Limit in force	Advice for 2013
Access (gear)	Limited to notified vessels using longlines.	Carry forward
Catch limit	Precautionary catch limit for *Dissostichus* spp. was 530 tonnes for Subarea 88.2 applied as follows: SSRUs A, B and I – 0 tonnes SSRUs C, D, E, F and G – 124 tonnes total SSRU H – 406 tonnes.	Carry forward
Season	1 December to 31 August	Same period
Fishing operations	In accordance with CM 41-01 and the setting of research hauls is not required (Annex B, paragraphs 3 and 4).	Carry forward
By-catch	Regulated by CMs 33-03 and 41-10.	Carry forward
Mitigation	In accordance with CM 25-02, except paragraph 4 if requirements of CM 24-02 are met.	Carry forward
	Daylight setting allowed under CM 24-02.	Carry forward
Observers	Each vessel to carry at least two scientific observers, one of whom shall be appointed in accordance with the CCAMLR Scheme of International Scientific Observation.	Carry forward
VMS	To be operational in accordance with CM 10-04.	Carry forward
CDS	In accordance with CM 10-05.	Carry forward
Research	Undertake research plan and tagging program as set out in CM 41-01, Annexes B and C.	Carry forward
	Toothfish tagged at a rate of at least one fish per tonne green weight caught.	Carry forward
Data	Daily and five-day catch and effort reporting under CMs 23-01 and 23-07.	Carry forward
	Haul-by-haul catch and effort data under CM 23-04.	Carry forward
	Biological data reported by the CCAMLR scientific observer.	Carry forward
Target species	For the purposes of CMs 23-01 and 23-04, the target species is *Dissostichus* spp. and the by-catch is any species other than *Dissostichus* spp.	Carry forward
Environmental protection	Regulated by CMs 22-06, 22-07, 22-08 and 26-01.	Carry forward

8.2 Management advice

107. Vessels were required to tag and release *Dissostichus* spp. at a rate of one fish per tonne of green weight caught and all vessels achieved the required target rate. In 2012, all vessels fishing in Subareas 88.1 and 88.2 achieved the required tag-overlap statistic, and had a tag-overlap statistic greater than 60%.

108. The Working Group agreed that measures in the research and data collection plans, including the requirement to tag toothfish at the rate of one toothfish per tonne, be retained for the exploratory fisheries in Subareas 88.1 and 88.2. It also encouraged the further development of the data collection plan for these fisheries.

109. In the Ross Sea fishery, the constant catch for which there was median escapement of 50% of the median pre-exploitation spawning biomass level at the end of the 35-year

projection period was 3 282 tonnes. At this yield there is less than a 10% chance of spawning biomass dropping to less than 20% of the initial biomass. Following the third CCAMLR decision rule, the yield of 3 282 tonnes is recommended.

110. For SSRUs 882C–H, the constant catch for which there was median escapement of 50% of the median pre-exploitation spawning biomass level at the end of the 35-year projection period was 530 tonnes. At this yield there is less than a 10% chance of spawning biomass dropping to less than 20% of the initial biomass. Following the third CCAMLR decision rule, the yield of 530 tonnes is recommended. Accordingly, 76% of the yield (406 tonnes) was assigned to the region between 70°50'S and 65°00'S (SSRU 882H) and the remainder (124 tonnes) was assigned to the region south of 70°50'S (SSRUs 882C–G).

References

Hanchet, S.M., G.J. Rickard, J.M. Fenaughty, A. Dunn and M.J. Williams. 2008. A hypothetical life cycle for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region. *CCAMLR Science*, 15: 35–53.

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.

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.