APPENDIX I

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

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

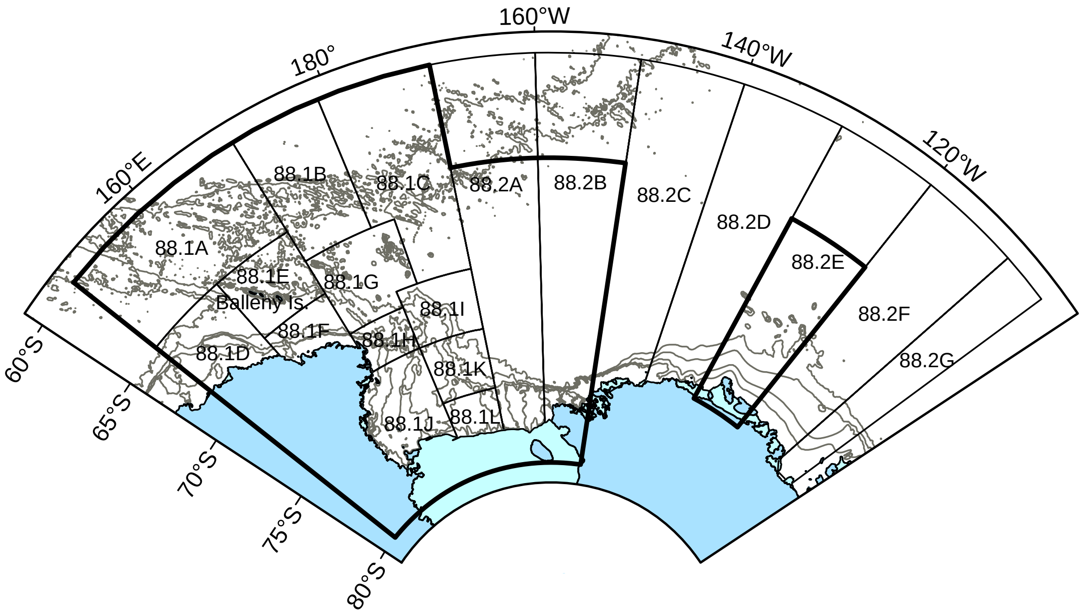

Figure 1: Ross Sea (Subarea 88.1 and SSRUs 882A–B) and SSRU 882E (bounded regions). Depth contours plotted at 500, 1 000, 2 000 and 3 000 m.

1. Details of the fishery

In 2005 the Working Group recommended that Subareas 88.1 and 88.2 be split into two areas for the purposes of stock assessment: (i) the Ross Sea (Subarea 88.1 and SSRUs 882A–B) (WG-FSA-05/4), and (ii) SSRU 882E.

2. The catch limits for the Subarea 88.1 and 88.2 SSRUs in the Ross Sea were changed as part of a three-year experiment starting in 2005/06 (SC-CAMLR-XXIV, paragraphs 4.163 to 4.166). 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. To assist administration of the SSRUs, the catch limits for SSRUs 881B, C and G were amalgamated into a 'north' region and those for SSRUs 881H, I and K were amalgamated into a 'slope' region. Within Subarea 88.2, SSRU 882E was treated as a separate SSRU with its own catch limit, whilst SSRUs 882C, D, F and G were amalgamated with a single catch limit. However, in each of the closed SSRUs, a nominal catch of up to 10 tonnes of *Dissostichus* spp. remained permissible under the research fishing exemption. This nominal catch was not considered as part of the overall catch limit (Conservation Measures 41-09 and 41-10).

3. In 2006/07, the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 was limited to Argentine, Korean, New Zealand, Norwegian, Russian, South African, Spanish, UK and Uruguayan vessels using longlines only (Conservation Measure 41-09). The precautionary catch limit for *Dissostichus* spp. was 3 032 tonnes, of which no more than 356 tonnes total

could be taken in SSRUs B, C and G, 1 936 tonnes total in SSRUs H, I and K, 564 tonnes in SSRU J and 176 tonnes in SSRU L (Figure 1). Four SSRUs (A, D, E and F) were closed to fishing, but had a research allocation of 10 tonnes each. The catch limits for by-catch species were defined in Conservation Measures 33-03 and 41-09. The fishing season was from 1 December 2006 to 31 August 2007.

4. In Subarea 88.2, the exploratory fishery for *Dissostichus* spp. was limited to Argentine, New Zealand, Norwegian, Russian, Spanish, UK and Uruguayan vessels using longlines only (Conservation Measure 41-10). The precautionary catch limit for *Dissostichus* spp. was 547 tonnes south of 65°S, of which no more than 206 tonnes total could be taken in SSRUs C, D and F, and 341 tonnes in SSRU E (Figure 1). Two SSRUs (A and B) were closed to fishing. The catch limits for by-catch species were defined in Conservation Measures 33-03 and 41-10. The fishing season was from 1 December 2006 to 31 August 2007.

5. Details of notifications of intentions to fish in 2007/08 are summarised in CCAMLR-XXVI/12. For Subarea 88.1, notifications were submitted by nine Members (Argentina, Republic of Korea, Namibia, New Zealand, Russia, South Africa, Spain, UK and Uruguay) with a total of 21 vessels. For Subarea 88.2, notifications were submitted by seven Members (Argentina, New Zealand, Russia, South Africa, Spain, UK and Uruguay) with a total of 15 vessels.

1.1 Reported catch

6. In 2006/07, eight Members (Argentina, Republic of Korea, New Zealand, Norway, Russia, South Africa, UK and Uruguay) and 15 vessels fished in the exploratory fishery in Subarea 88.1. The fishery was closed on 2 February 2007 and the total reported catch of *Dissostichus* spp. (excluding research fishing) was 3 093 tonnes (101% of the limit) (CCAMLR-XXVI/BG/17, Table 3). The following SSRUs were closed during the course of fishing:

- SSRUs B, C, G closed on 28 December 2006, triggered by the catch of *Dissostichus* spp. (total catch 584 tonnes; 164% of the catch limit);
- SSRUs H, I, K closed on 2 February 2007, triggered by the catch of *Dissostichus* spp. (total catch 2 080 tonnes; 104% of the catch limit).

7. Five Members (Argentina, Norway, Russia, UK and Uruguay) and seven vessels fished in the exploratory fishery in Subarea 88.2. The fishery closed on 31 August 2007 and the total reported catch of *Dissostichus* spp. was 347 tonnes (63% of the limit) (CCAMLR-XXVI/BG/17). SSRU E was closed on 4 March 2007, triggered by the catch of *Dissostichus* spp. (total catch 325 tonnes; 95% of the catch limit).

8. The number of active fishing vessels and the catch of *Dissostichus* spp. in Subareas 88.1 and 88.2 in 2006/07 are shown in Tables 1 and 2 respectively.

Table 1: Number of vessels authorised in Conservation Measure 41-09, number of vessels that fished, and the catch of *Dissostichus* spp. in Subarea 88.1 in 2006/07, including research fishing (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
Argentina	2	1	157	0	157
Korea, Republic of	3	2	453	11	463
New Zealand	4	4	1 160	1	1 161
Norway	1	1	151	0	151
Russia	2	2	434	0	434
South Africa	1	1	51	0	51
Spain	1	0	-	-	-
UK	2	2	440	0	440
Uruguay	5	2	239	0	239
Total	21	15	3 084	12	3 096

Table 2: Number of vessels authorised in Conservation Measure 41-10, number of vessels that fished, and the catch of *Dissostichus* spp. in Subarea 88.2 in 2006/07, including research fishing (source: catch and effort reports).

Flag State	Vessels authorised in CM 41-10	Number of vessels that fished	Reported catch (tonnes)		
			D. mawsoni	*D. eleginoides*	Total
Argentina	2	1	42	0	42
New Zealand	4	0	-	-	-
Norway	1	1	110	0	110
Russia	2	2	152	0	152
Spain	1	0	-	-	-
UK	2	2	34	0	34
Uruguay	4	1	9	0	9
Total	17	7	347	0	347

9. The Ross Sea fishery saw a steady expansion of effort (number of sets) from 1997/98 to 2000/01, a slight drop in 2001/02, followed by an increase in 2002/03, and an almost three-fold increase in 2003/04. In 2004/05 and 2005/06, overall effort in the Ross Sea dropped, but increased in 2006/07. In 2006/07, ice conditions resulted in some restrictions on fishing in some of the southern SSRUs in January and early February. Thus, in contrast to recent years, no fishing was carried out in SSRUs 881G, K and L. However, vessels fished most of the other available SSRUs in Subareas 88.1 and 88.2 in 2007. Fishing in 2006/07 saw the highest level of effort in SSRUs 881B and 882E, and the second-highest level of effort in SSRU 881H. For the second year, a small amount of fishing was carried out in SSRUs 882D and F.

10. The catch of *D. mawsoni* has shown a steadier increasing trend over the same period, peaking at 3 079 tonnes in Subarea 88.1 for the 2004/05 season, declining to 2 952 tonnes in 2005/06, and increasing to 3 096 in 2006/07, reflecting the annual changes in catch limits.

11. 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 2006/07 are summarised in Table 3 (see CCAMLR-XXVI/BG/17).

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 2006/07 (source: catch and effort reports).

SSRU Groups	*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
881BCG	356	584	57	3	50	0	60	2
881D	0	0	0	0	0	0	0	0
881E	0	0	0	0	0	0	0	0
881F*	0	3	0	0	0	0	0	0
881HIK	1936	2080	310	145	97	31	60	35
881J	564	429	90	4	50	7	20	3
881L	176	0	28	0	50	0	20	0
882A	0	0	0	0	0	0	0	0
882B	0	0	0	0	0	0	0	0
882CDFG	206	22	33	3	50	0	80	<1
882E	341	325	55	51	50	0	20	12

* Catch taken under a research fishing exemption and not considered as part of the catch limit for the subarea.

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

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, WG-FSA-07/10 Rev. 5 and 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		
1996/97	-	1	1980	0	0	0	0	0
1997/98	-	1	1510	1	41	42	0	42
1998/99	2	2	2281	1	296	297	0	297
1999/00	-	3	2090	0	751	751	0	751
2000/01	6	10	2064	34	626	660	0	660
2001/02	10	3	2508	12	1313	1325	92	1417
2002/03	13	10	3760	26	1805	1831	0	1831
2003/04	26	21	3250	13	2184	2197	240	2437
2004/05	21	10	3250	6	3113	3120	23	3143
2005/06	21	13	2964	1	2968	2969	0	2969
2006/07	21	15	3072*	12	3084	3096	0	3096

* Includes 40 tonnes for research fishing (CCAMLR-XXV, paragraph 12.56).

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, WG-FSA-07/10 Rev. 5 and 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		
1996/97	-	0	1 980	0	0	0	-	0
1997/98	-	0	63	0	0	0	-	0
1998/99	-	0	0	0	0	0	-	0
1999/00	-	0	250	0	0	0	-	0
2000/01	2	0	250	0	0	0	-	0
2001/02	7	1	250	0	41	41	0	41
2002/03	9	2	375	0	106	106	0	106
2003/04	18	3	375	0	374	375	0	375
2004/05	10	4	375	0	411	411	0	411
2005/06	17	7	487	0	514	514	15	529
2006/07	16	7	567*	0	347	347	0	347

* Includes 20 tonnes for research fishing (CCAMLR-XXV, paragraph 12.60).

1.2 IUU catch

13. There was no estimated IUU catch in Subareas 88.1 and 88.2 in 2006/07 (WG-FSA-07/10 Rev. 5). The estimated IUU catch in Subarea 88.1 in previous years was 92 tonnes in 2001/02, 240 tonnes in 2003/04 and 23 tonnes in 2004/05 (Table 4).

14. There was an estimated 15 tonnes of IUU catch in Subarea 88.2 (SSRU 882A) in 2005/06 (Table 5). This was the first observed occurrence of IUU fishing in Subarea 88.2.

1.3 Size distribution of the catches

15. *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 2005/06, 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 not apparent in 2006/07, probably as there was no fishing on the shelf in these SSRUs in 2006/07.

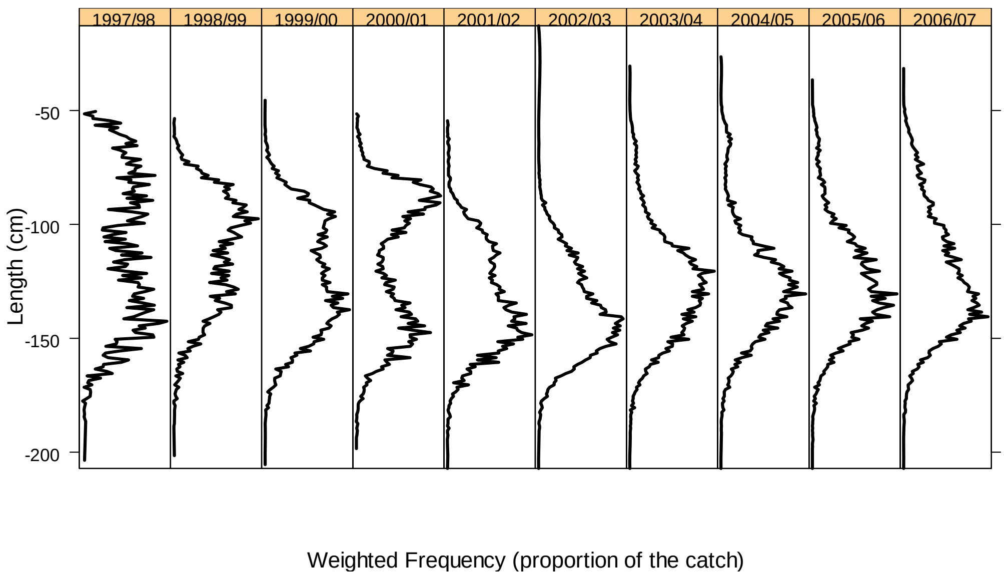

Figure 2: Catch-weighted length frequencies for *Dissostichus mawsoni* in Subarea 88.1 (source: observer, fine-scale and STATLANT data).

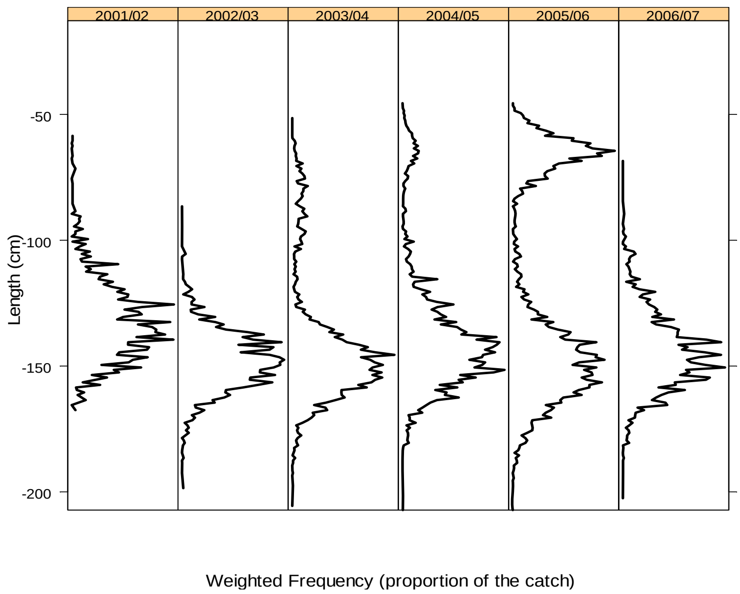

Figure 3: Catch-weighted length frequencies for *Dissostichus mawsoni* in Subarea 88.2 (source: observer, fine-scale and STATLANT data, and the length–weight relationship was taken from observations on *D. mawsoni* in Subarea 88.1).

16. The length-frequency data from the Ross Sea fishery have been very consistent over the past three to four 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-07/28). 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, and there was no evidence for recent strong variation in year-class strength in the fishery (WG-FSA-07/28). It should be noted that the scaled length frequencies only represent the landed part of the *D. mawsoni* catch, and do not include the (often smaller) fish that were selected for tagging before the catch was sampled by observers (WG-FSA-06/34).

2. Stocks and areas

17. 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 (WG-FSA-04/32). This differentiation is supported by oceanic gyres, which may act as juvenile retention systems, and by limited movement of adult tagged fish.

18. Previous research has found that length modal distribution, sex ratio, fish body condition factor and reproductive development of *D. mawsoni* differ between the northern and southern SSRUs in Subarea 88.1, with sampling from the northern SSRUs suggesting that there was a significant higher ratio of males to females that were in poorer condition, and were more advanced in reproductive development (WG-FSA-05/52). Spawning is suspected to occur on isolated geographic features north of the main Antarctic shelf areas, north of 70°S (WG-FSA-06/26).

19. However, 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 (WG-FSA-07/35). 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 (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, 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). The fish gradually move northwards as they mature, feeding in the slope region in depths of 1 000–1 500 m, where they gain condition before moving north onto the Pacific-Antarctic ridge to start the cycle again. Spawning fish may remain in the northern area for up to 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.

3. Parameter estimation

3.1 Observations

<u>Errors in location data held by the Secretariat</u>

20. As in previous years, the C2 data and the CCAMLR observer data used in the analyses and assessments for *D. mawsoni* in Subareas 88.1 and 88.2 were corrected for location and other errors, although the number and nature of these were small when compared to previous years.

Catch history

21. The catch history of *D. mawsoni*, used in the Ross Sea assessment model, is given in Table 6.

Table 6: Total *Dissostichus mawsoni* catch (tonnes) for the Ross Sea for the seasons 1996/97 to 2006/07 (source: C2 data).

Season	Ross Sea			
	Shelf	Slope	North	Total
1996/97	0	0	0	0
1997/98	8	29	4	41
1998/99	14	282	0	296
1999/00	64	689	0	752
2000/01	113	349	143	604
2001/02	10	936	412	1 358
2002/03	2	611	1 161	1 774
2003/04	143	1 663	371	2 177
2004/05	393	2 263	551	3 207
2005/06	251	2 373	343	2 967
2006/07	68	2 443	573	3 084
Total	1 066	11 638	3 558	16 260

Standardised CPUE

22. A standardised CPUE analysis of *D. mawsoni* in the Ross Sea was not updated for 2006/07 or used within the assessment model, as the Working Group considered that CPUE indices were not indexing abundance at the current time.

Catch-at-age

23. Strata for the *D. mawsoni* length- and age-frequency data were determined using a tree-based regression (a post-stratification method) (WG-FSA-SAM-05/8). The analysis used the median length of fish in each longline set, and the explanatory variables SSRU and depth.

24. On average, about 500 *D. mawsoni* otoliths collected by observers were selected for ageing each year, and used to construct an age–length key. The age–length key was applied to the scaled length-frequency distributions for each year to produce catch-at-age distributions (WG-FSA-07/28).

Tag release and recapture

25. Under Conservation Measure 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 catch throughout the season. Vessels may discontinue tagging once 500 fish have been tagged.

26. Tagging rates, by vessel and Flag State since 2004/05, are given in Table 7 for Subarea 88.1 and Table 8 for Subarea 88.2. The tagging rates were determined from tagging data and catch and effort reports submitted to the Secretariat. In 2006/07, four vessels did not achieve a tagging rate of at least one toothfish per tonne of green-weight catch: *Antartic II* (Argentina), *Frøyanes* (Norway), *Argos Georgia* (UK) and *Argos Helena* (UK) in Subarea 88.2.

Table 7: Number of individuals of *Dissostichus* spp. tagged and released and the tagging rate (fish per tonne of green weight caught) reported by vessels operating in the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 since 2004/05. The number of *D. eleginoides* is indicated in brackets. (Source: observer data and catch and effort reports.)

Season	Flag State	Vessel name	*Dissostichus* spp. tagged and released	
			Number of fish	Tagging rate
2004/05	Argentina	*Antartic III*	291 (1)	1.15
	New Zealand	*Janas*	456 (6)	1.05
		San Aotea II	500 (12)	1.00
		San Aspiring	580 (0)	(>500fish)
	Norway	*Frøyanes*	317 (1)	1.53
	Russia	*Volna*	174 (0)	0.74
		Yantar	111 (0)	0.43
	UK	*Argos Helena*	381 (0)	1.46
	Uruguay	*Paloma V*	188 (1)	1.19
		Punta Ballena	223 (1)	1.06
2005/06	Argentina	*Antartic II*	122 (0)	0.83
	New Zealand	*Avro Chieftain*	266 (0)	1.05
		Janas	283 (1)	1.05
		San Aotea II	512 (2)	(>500fish)
		San Aspiring	437 (0)	1.03
	Norway	*Frøyanes*	121 (0)	1.23
	Russia	*Volna*	250 (0)	0.76
		Yantar	246 (0)	0.71
	UK	*Argos Georgia*	50 (0)	1.14
		Argos Helena	275 (4)	1.02
	Uruguay	*Paloma V*	142 (16)	1.33
		Punta Ballena	211 (0)	1.04
		Viking Sur	62 (0)	0.94
2006/07	Argentina	*Antartic II*	228 (0)	1.45
	Korea, Republic of	*Insung No. 22*	352 (20)	1.16
		Jung Woo No. 2	198 (19)	1.24
	New Zealand	*Avro Chieftain*	289 (0)	1.06
		Janas	184 (0)	1.13
		San Aotea II	385 (10)	1.25
		San Aspiring	463 (1)	1.11
	Norway	*Frøyanes*	168 (0)	1.11
	Russia	*Volna*	103 (0)	1.04
		Yantar	371 (0)	1.11
	South Africa	*Ross Mar*	51 (0)	1.00
	UK	*Argos Georgia*	240 (20)	1.01
		Argos Helena	270 (3)	1.36
	Uruguay	*Ross Star*	152 (2)	1.14
		Viking Sur	141 (0)	1.34

Table 8: Number of individuals of *Dissostichus* spp. tagged and released and the tagging rate (fish per tonne of green weight caught) reported by vessels operating in the exploratory fishery for *Dissostichus* spp. in Subarea 88.2 since 2004/05. The number of *D. eleginoides* is indicated in brackets. (Source: observer data and catch and effort reports.)

Season	Flag State	Vessel name	*Dissostichus* spp. tagged and released	
			Number of fish	Tagging rate
2004/05	New Zealand	*Avro Chieftain*	269 (0)	1.01
	Norway	*Frøyanes*	0	0
	Russia	*Volna*	0	0
		Yantar	72 (0)	0.85
2005/06	Argentina	*Antartic II*	16 (0)	0.24
	New Zealand	*Janas*	64 (0)	1.13
	Norway	*Frøyanes*	196 (2)	0.91
	Russia	*Volna*	0	0
		Yantar	0	0
	UK	*Argos Georgia*	76 (0)	1.86
		Argos Helena	92 (1)	1.72
2006/07	Argentina	*Antartic II*	2 (0)	0.05
	Norway	*Frøyanes*	97 (0)	0.89
	Russia	*Volna*	55 (0)	1.03
		Yantar	100 (0)	1.01
	UK	*Argos Georgia*	0	0
		Argos Helena	14 (0)	0.46
	Uruguay	*Viking Sur*	10 (0)	1.07

27. Since 2000/01, more than 15 000 *D. mawsoni* have been tagged in Subareas 88.1 and 88.2. Table 9 gives the number of released and recaptured *D. mawsoni* for the Ross Sea from all vessels and from New Zealand vessels.

Table 9: Number of *Dissostichus mawsoni* with tags released for the 2000/01 to 2006/07 seasons by all (2003/04 to 2006/07) and New Zealand vessels only, and the numbers recaptured in the 2000/01 to 2006/07 seasons by all and New Zealand vessels only.

Group	Tagged fish released		Tagged fish recaptured							
	Season	Number	2001	2002	2003	2004	2005	2006	2007	Total
All	2000/01	259	0	1	1	0	0	0	1	3
	2001/02	684	-	2	5	3	5	7	13	35
	2002/03	858	-	-	5	13	9	2	9	38
	2003/04	2 033	-	-	-	10	23	19	32	84
	2004/05	3 275	-	-	-	-	8	26	29	63
	2005/06	3 040	-	-	-	-	-	11	89	100
	2006/07	3 535	-	-	-	-	-	-	18	18
Total		13 684	0	3	11	26	45	65	191	341
NZL	2000/01	259	0	1	1	0	0	0	1	3
	2001/02	684	-	2	5	3	5	5	4	24
	2002/03	858	-	-	5	7	7	0	5	24
	2003/04	865	-	-	-	3	16	11	8	38
	2004/05	1 518	-	-	-	-	2	12	9	23
	2005/06	1 495	-	-	-	-	-	9	49	58
	2006/07	1 310	-	-	-	-	-	-	9	9
Total		6 989	0	3	11	13	30	37	85	179

28. The Working Group noted that there was considerable uncertainty about the implementation of the tagging program by the fleet fishing in Subareas 88.1 and 88.2. The Working Group also noted that there may be a number of reasons for the differences between observed recapture rates of tags released by vessels from different nations (WG-FSA-07/40). Because of the uncertainty from these differences, the Working Group could not proceed with an assessment based on data from non-New Zealand vessels. Hence, the Working Group has updated the 2006 assessment with data from the most recent fishing year (WG-FSA-07/37).

3.2 Fixed parameter values

29. Natural mortality, length–mass, growth and maturity parameters for *D. mawsoni* in Subareas 88.1 and 88.2 are given in Table 10. The value for the tagging-related growth retardation (TRGR) has been updated from the value used in 2006 (WG-SAM-07/6).

Table 10: 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}	100	100		cm
Range: 5 to 95% maturity		85–115	85–115		cm
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)				0.062	y^{-1}
Instantaneous tag loss rate (double tagged)				0.004	y^{-1}
Tag detection rate				100%	
Tagging-related growth retardation (TRGR)				0.5	y

4. Stock assessment

4.1 Model structure and assumptions

Population dynamics

30. Only the Ross Sea (Subarea 88.1 and SSRUs 882A–B) management areas were assessed using CASAL integrated stock assessment models. No new advice was available for SSRU 882E, and the Working Group recommended that the assessment from 2006 be carried over for the 2007/08 season.

31. 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 11. Various model structures were investigated, and the base-case model and sensitivity models are described below (WG-FSA-07/37). A complete description of the CASAL modelling software was given in WG-FSA-05/P3.

Table 11: 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	CPUE indices	0.5
					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.

32. The Secretariat undertook a validation of the CASAL parameter files, maximum of the posterior density (MPD) outputs, and yield calculations used for the Ross Sea base-case and sensitivity models.

33. The models were run from 1995 to 2007, 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.

34. 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.

35. 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.

36. 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

37. The model parameters were estimated using 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 MCMCs.

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

39. 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

40. The catch proportions-at-age data for the 1997/98–2006/07 seasons were fitted to the modelled proportions-at-age composition using a multinomial likelihood.

41. Tag–release events were defined for the 2000/01–2005/06 seasons. Within-season recaptures were ignored. Tag–release events were assumed to have occurred at the end of the first (summer) time step, following all (summer) natural and fishing mortality.

42. 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 New Zealand vessel observer records (for the base case). Two sensitivity analyses investigated the use of all vessel tag data (all-vessels case), and all vessel data for the 2005/06 releases only (all-vessels-2006 case), plus the numbers of fish tagged and released. 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 100%.

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1 Technically, this is done by minimising, rather than maximising, 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.

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

Process error and data weighting

44. 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.

45. 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

46. 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

47. The parameters estimated by the models, their priors, starting values for the minimisation, and their bounds are given in Table 12. In models presented here, priors were chosen that were relatively non-informative but also that encouraged conservative estimates of B_0.

Table 12: 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	150 000	Uniform-log	$1x10^4$	$1x10^6$
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 (ykm^{-1})	E	3	0.0	Uniform	0.0	50.0
Annual selectivity shift (shelf)	E_f	10	Mean depth	Uniform	–10.0	10.0

Yield calculations

48. 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.

49. 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.

50. 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.

51. 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 2008–2042), for each sample from the posterior distribution.

52. Recruitment from 2001–2042 was assumed to be lognormally distributed with a standard deviation of 0.6 with a Beverton-Holt stock-recruitment steepness h = 0.75. Future catch was assumed to follow the same split between fisheries as that in the most recent four seasons (i.e. based on the distribution of the 2004–2007 catch, 7.4%, 76.5% and 16.1% 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 1998–2007.

53. Note that historically, the catch limit was not always fully taken due to adverse ice conditions in the Ross Sea. 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

54. The likelihood profiles for the 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. 30 000–190 000 tonnes), while estimating the remaining model parameters. The likelihood profiles

for 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 and 2002 suggest very high biomass estimates were less likely. The 2006 tag–release data were the most dominant of the tag data series, and suggested that high biomass values were more unlikely than for previous data.

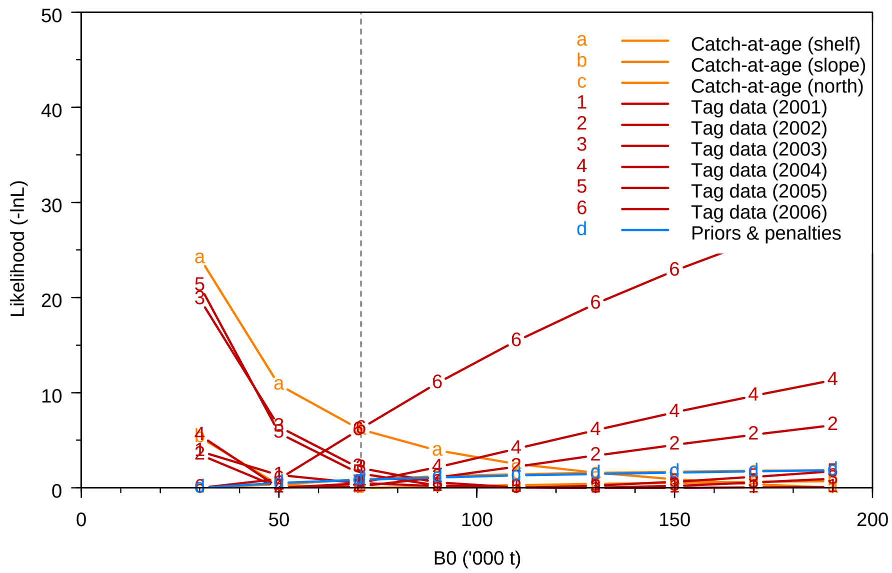

Figure 4: Likelihood profiles for the base-case model for values of B_0. Negative log likelihood values were rescaled to have minimum 0 for each dataset. The dashed vertical line indicates the MPD.

MCMC diagnostics

55. 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

56. Key output parameters for the base case are summarised in Table 13. MCMC estimates of initial (equilibrium) spawning stock abundance (B_0) were 71 200 tonnes (95% credible interval (CI) 59 570–87 900 tonnes), and current (B_{2007}) biomass was estimated as 82% B_0 (95% CI 78–85%). The projected biomass trajectory assuming a future constant catch of 2 700 tonnes is shown in Figure 5.

Table 13: Median MCMC estimates (and 95% CI) of B_0, B_{2007} and B_{2007} as %B_0 for the base-case model.

	Model	B_0	B_{2007}	B_{2007} (%B_0)
1	Base case	71 200 (59 570–87 900)	58 320 (46 700–75 010)	81.9 (78.4–85.4)

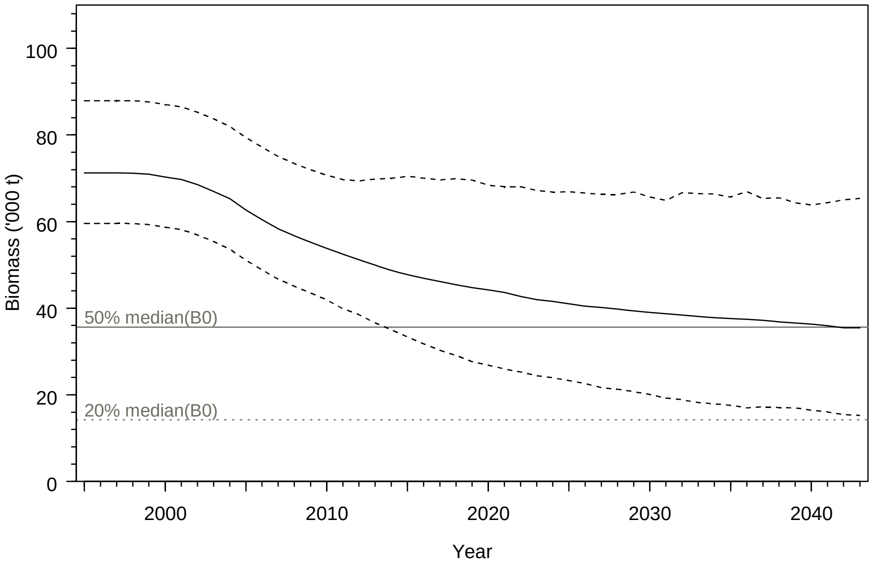

Figure 5: Estimated spawning stock biomass median (solid line) and 95% CI (dashed lines) for the base-case Ross Sea model.

57. Plots of the observed proportions-at-age of the catch versus expected values showed little evidence of inadequate model fit. However, even though the fits to the proportions-at-age were reasonable, there was still some evidence of pattern in the residuals. Estimated selectivity curves for the base-case model (Figure 6) 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 7.

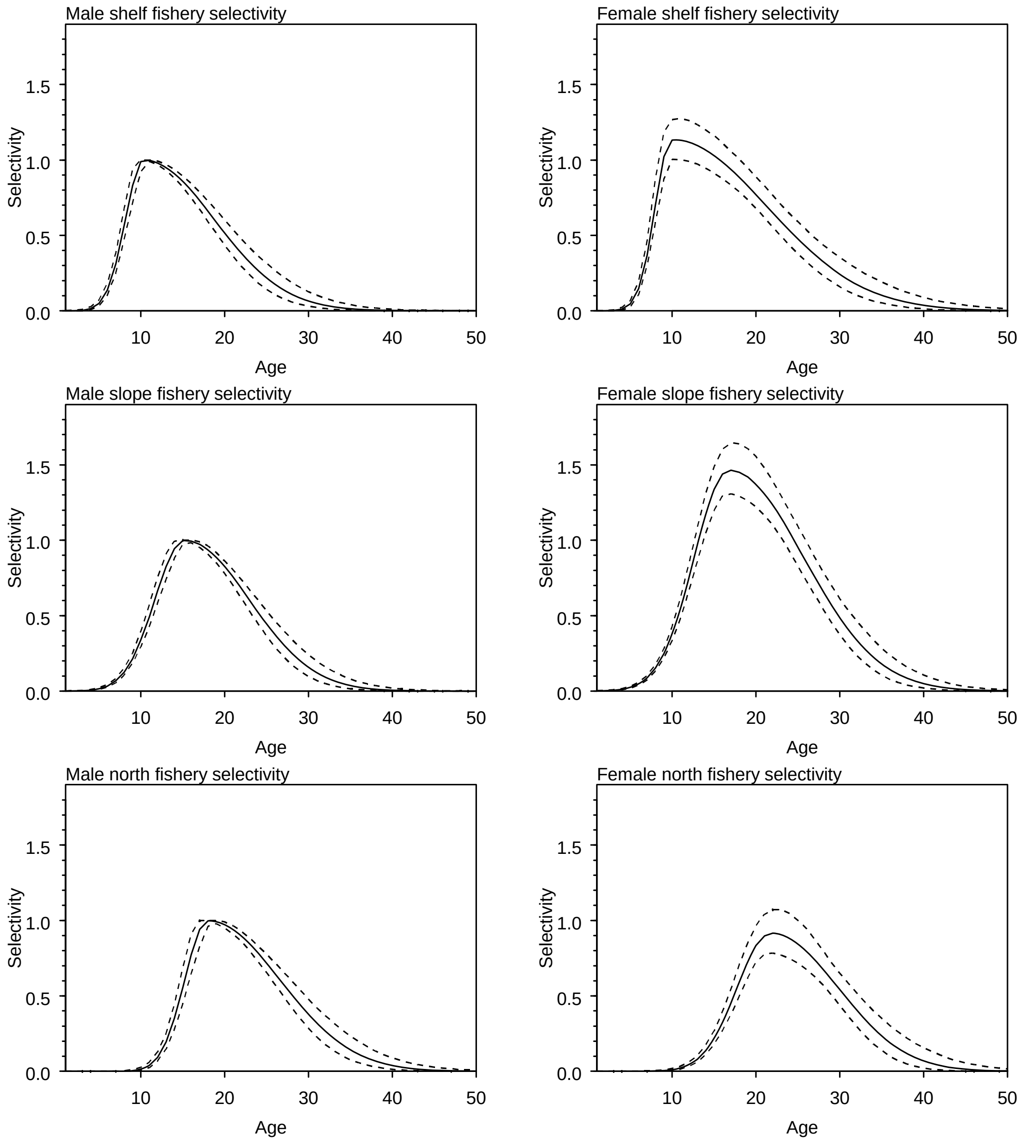

Figure 6: Estimated male and female selectivity ogives for the shelf, slope and north fisheries for the base-case Ross Sea model (solid lines indicate the median, and dashed lines indicate the marginal 95% CI).

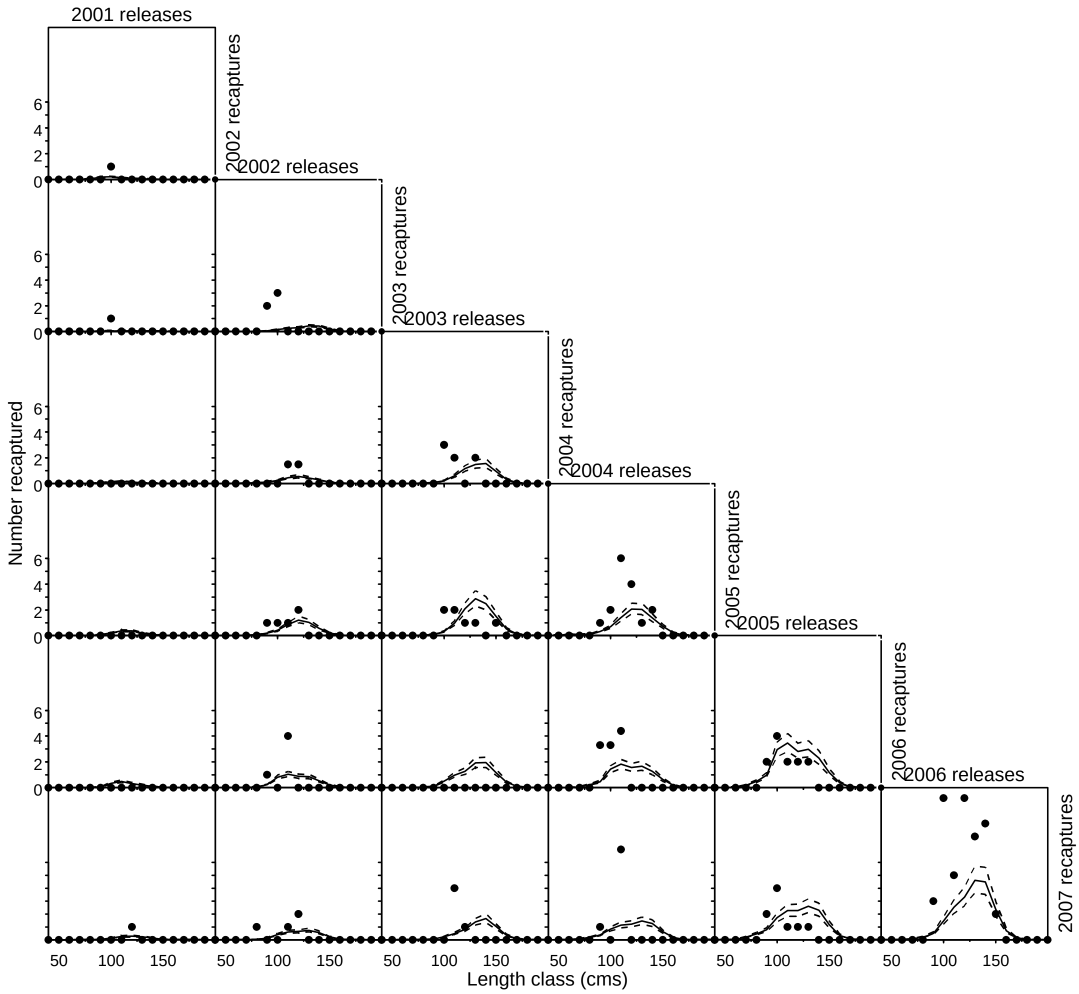

Figure 7: Observed (points) and posterior estimates (lines, MCMC median and 95% CI) of the number of tags recaptured (y-axis) by length class (x-axis), year of release (columns), and year of recapture (rows) for the base-case model.

Sensitivity analyses

58. Model sensitivity runs for the Ross Sea model are described in Table 14. The base-case models included tag–release and recapture data from New Zealand vessels and proportions-at-age of the catch. Sensitivity runs were determined as modifications to the base-case runs, and were chosen to investigate the effect of alternative assumptions or data within the model.

Table 14: Labels and description of the sensitivity runs.

	Model run	Description
1	Base	Base-case run (i.e. 2007 reference case reported in WG-FSA-07/37).
2	Base (2006)	The base-case run as reported in 2006.
3	Logistic north	The base case, but assuming a logistic selectivity for the north fishery.
4	All-vessels	All vessels tag–release and recapture data.
5	All-vessels-2006	Same as the base case, but using tag data from all vessels for 2006 only.

59. The all-vessels run suggested a higher initial biomass, whilst the logistic north and all-vessels-2006 sensitivity runs both suggested an initial biomass about 10% higher than the base case. In all sensitivity cases, current biomass was estimated to be at 84–88% B_0.

4.3 Yield estimates

Ross Sea

60. 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 2 700 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 rule, the yield of 2 700 tonnes is recommended.

SSRU 882E

61. No new advice was available for SSRU 882E. The Working Group recommended that the yields estimated for 2006 be applied for 2007.

4.4 Discussion of model results

62. The Working Group recommended that the model described as the reference case in WG-FSA-07/37 be the base-case assessment model for the Ross Sea. This model used the New Zealand tag data as the tagging observations and was the most conservative of the models considered by the Working Group. However, the Working Group noted that there was considerable uncertainty about the implementation of the tagging program by the fleet fishing in the Ross Sea, and because of this uncertainty, the Working Group updated the 2006 assessment with data from the most recent fishing year.

63. The Ross Sea model is still uncertain. The catch-at-age data are a relatively short time series, and are not very informative for determining current or initial stock size. The tag–recapture data provide the best information on stock size, but the total number of tagged fish recaptured in the Ross Sea is still relatively small.

4.5 Future research requirements

64. The Working Group welcomed the updated assessment of the Ross Sea model, and thanked New Zealand for the work that had gone into it.

65. 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.

66. The Working Group also recommended that alternative assessment methods be reviewed, for application to the Ross Sea assessment, including the CASAL integrated assessment method (WG-FSA-07/37) and the TSVPA method (WG-SAM-07/9).

5. By-catch of fish and invertebrates

5.1 By-catch removals

67. 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 15 and 16 respectively.

Table 15: 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 Conservation Measure 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)
1996/97	-	0	-	0	-	-	0
1997/98	-	9	-	5	-	50	1
1998/99	-	22	-	39	-	50	5
1999/00	-	74	-	41	-	50	7
2000/01	-	61	-	9	-	50	14
2001/02	100	154	-	25	-	50	10
2002/03	610	66	250	11	966	100	12
2003/04	520	319	163	23	1 744	180	23
2004/05	520	462	163	69	4 996	180	24
2005/06	474	258	148	5	14 640	160	18
2006/07	485	153	152	38	7 352	160	43

Table 16: 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 Conservation Measure 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)
1996/97	-	0	-	0	-	-	0
1997/98	-	0	-	0	-	-	0
1998/99	-	0	-	0	-	-	0
1999/00	-	0	-	0	-	-	0
2000/01	-	0	-	0	-	-	0
2001/02	40	4	-	0	-	20	0
2002/03	60	18	-	0	-	140	8
2003/04	60	37	50	0	107	140	8
2004/05	60	21	50	0	-	140	3
2005/06	78	92	50	0	923	100	12
2006/07	88	54	50	0	-	100	13

68. The Working Group noted that the three-year experiment for managing by-catch in Subareas 88.1 and 88.2 had resulted in improved management. The macrourid by-catch limit was exceeded in Subarea 88.2 in 2005/06, but no catch limits were exceeded in either area in 2006/07.

69. Current catch limits for macrourids and rajids in the Ross Sea are proportional to the catch limit of *Dissostichus* spp. in each SSRU based on the following rules from Conservation Measure 33-03:

- the limit for rajids is 5% of the catch limit of *Dissostichus* spp. or 50 tonnes whichever is greater;
- the limit for macrourids is 16% of the catch limit of *Dissostichus* spp. or 20 tonnes whichever is greater.

70. The 16% ratio of the catch limit of macrourids to the catch limit of *Dissostichus* spp. was based on the ratio of the by-catch limit for macrourids to the catch limit for *Dissostichus* spp. in Division 58.5.2 in 2002/03 (CCAMLR-XXI, paragraph 11.53).

71. There were no new assessments of by-catch species or recommendations for revised catch limits by SSRU in 2006/07.

5.2 Assessments of impacts on affected populations

Macrourids

72. The estimate of γ for *M. whitsoni* in Subarea 88.1 in 2003 was 0.01439 (SC-CAMLR-XXII, paragraph 4.132). This indicates that *M. whitsoni* has relatively low productivity and thus may be vulnerable to overexploitation.

73. WG-FSA-05/24 updated the standardised CPUE for *M. whitsoni* in Subareas 88.1 and 88.2 based on an analysis of fine-scale data from all vessels in the exploratory fishery from 1997/98 to 2004/05. Standardised CPUE increased to a peak in 2002 and 2003, dropped in 2004, before increasing again in 2005.

74. WG-FSA-05/22 considered approaches to monitoring and assessing macrourids and rajids in Subarea 88.1 and recommended that a random bottom trawl survey would be the best approach towards obtaining abundance estimates. Tag–recapture experiments for rajids and experimental manipulation of fishing effort are alternative methods which show some promise for monitoring abundance.

Rajids

75. WG-FSA-06/31 reviewed the biological parameters of skates, whilst WG-FSA-06/32 characterised the results of the skate tagging program. Neither can currently be used to estimate total abundance.

76. WG-SAM-07/4 presented data and a preliminary developmental model for Antarctic skates in SSRUs 881H, I, J and K of the Ross Sea. The developmental model attempted to create a catch history of all skates and rays in the Ross Sea, and integrate these data with the available observational data (including tag–recapture data) into a single integrated stock assessment model.

77. 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 tagged or discarded. The size composition of the commercial catch was also very uncertain because of the low numbers sampled each year. Most aspects of the tagging data were also uncertain, including the actual numbers of skates released, the initial mortality of tagged skates, the tag-loss rate and the numbers of skates scanned for tags. While updated summaries of the numbers of skate tag releases and recaptures have been reported, these data are still preliminary and further work is required. Lastly, there is great uncertainty over the biological parameters, including age and growth, natural mortality, steepness and size and age at maturity. However, the paper noted that whilst many aspects of this uncertainty remain, changes to the C2 dataform since 2005 have led to substantial improvements in the landings and release data.

78. The Working Group noted several areas where better data are required, including improving 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, and these were taken up under the appropriate agenda items.

5.3 Identification of levels of risk

79. WG-FSA-05/21 presented risk categorisation tables for *M. whitsoni* and *Amblyraja 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

80. 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 1997/98 to 2004/05.

81. The major factors influencing macrourid by-catch were vessel, area and depth (SC-CAMLR-XXIV, Annex 5, Appendix N, Figures 1 and 2). Catch rates of *M. whitsoni* were highest along the shelf edge (SSRUs 881E, I, K and 882E) in depths from 600 to 1 000 m, and there was an order of magnitude difference in macrourid catch rates between different vessels. Examination of vessel characteristics showed that catch rates of macrourids were lower with the Spanish line system than with the autoline system. This effect was confounded by the bait type, as Spanish line vessels tended to use the South American pilchard as bait, whereas autoline vessels used varying species of squid and/or mackerel. However, the difference in macrourid catch rates between the few Spanish line vessels that

used squid and mackerel for bait, and the majority that used pilchards, was much less than the overall difference between Spanish line and autoline vessels. Russian and Korean vessels had extremely low catch rates compared to other vessels fishing in the same location.

82. It was not possible to reliably determine factors influencing catch rates of rajids in Subareas 88.1 and 88.2 from either fine-scale 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 (SC-CAMLR-XXIV, Annex 5, Appendix N, paragraphs 42 to 53).

83. This 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.

84. The Working Group recommended that further work should be carried out in the intersessional period to compare by-catch levels arising from different gear configurations and to determine whether this information could be used to develop mitigation and avoidance measures for by-catch (SC-CAMLR-XXIV, Annex 5, paragraph 6.22).

85. The current by-catch limits and move-on rules are given in Conservation Measure 33-03.

86. The Working Group recommended that, where possible, all rajids should be cut from the line while still in the water, except on the request of the scientific observer (SC-CAMLR-XXIV, Annex 5, paragraph 6.25). The Commission has been requested to review this mitigation practice (see SC-CAMLR-XXVI, Annex 5, paragraph 5.53).

6. By-catch of birds and mammals

6.1 By-catch removals

87. Details of seabird by-catch are summarised in Table 17.

Table 17: Seabird by-catch limit, observed mortality rate and total estimated mortality of seabird by-catch in Subareas 88.1 and 88.2 (from SC-CAMLR-XXVI, Annex 6, Part II, Table 2).

Season	By-catch limit (number of birds)	Mortality rate (birds per thousand hooks)	Total estimated mortality (number of birds)
1997/98		0	0
1998/99		0	0
1999/00		0	0
2000/01		0	0
2001/02	3*	0	0
2002/03	3*	0	0
2003/04	3*	0.0001	1
2004/05	3*	0	0
2005/06	3*	0	0
2006/07	3*	0	0

* Per vessel during daytime setting.

88. Ad hoc WG-IMAF assessed the risk levels of seabirds in this fishery in Subarea 88.1 as category 1 (low) south of 65°S, category 3 (average) north of 65°S and overall as category 3 (SC-CAMLR-XXVI, Annex 6, Part II, Tables 20 and 21) and recommended (SC-CAMLR-XXVI/BG/31):

- strict compliance with Conservation Measure 25-02 (but with the possibility of exemption to paragraph 4 to allow for daytime setting);
- south of 65°S, no need to restrict longline fishing season;
- north of 65°S, restrict longline fishing to the period outside at-risk species' breeding season where known/relevant unless line sink rate requirement is met at all times;
- daytime setting permitted subject to line sink rate requirements and seabird by-catch limits;
- no offal dumping.

89. Ad hoc WG-IMAF assessed the risk level of seabirds in this fishery in Subarea 88.2 as category 1 (low) (SC-CAMLR-XXVI, Annex 6, Part II, Tables 19 and 20) and recommended:

- strict compliance with Conservation Measure 25-02 (but with exemption to paragraph 4 to allow for daytime setting);
- no need to restrict longline fishing season;
- daytime setting permitted subject to line sink rate requirement;
- no offal dumping.

6.2 Mitigation measures

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

7. Ecosystem implications/effects

91. Developments in evaluating ecosystem effects of the Antarctic toothfish fishery were discussed at the FEMA workshop (SC-CAMLR-XXVI/BG/6, paragraphs 45 to 48) and are summarised below.

92. Two key trophic interactions were identified as being important for Antarctic toothfish. 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 2% of the diet of its predators

(WG-EMM-07/18). 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 especially 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.

93. 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 workshop also 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.

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

95. The workshop 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.

8. Harvest controls and management advice

8.1 Conservation measures

Table 18: Limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 in 2006/07 (Conservation Measure 41-09) and advice to the Scientific Committee for 2007/08.

Element	Limit in 2006/07	Advice for 2007/08
Access (gear)	Limited to vessels from Argentina, Republic of Korea, New Zealand, Norway, Russia, South Africa, Spain, UK and Uruguay using longlines.	Review
Catch limit	Precautionary catch limit for *Dissostichus* spp. was 3 032 tonnes for Subarea 88.1, applied as follows: SSRUs A, D, E and F – 0 tonnes SSRUs B, C and G – 356 tonnes total SSRUs H, I, K – 1936 tonnes total SSRU J – 564 tonnes SSRU L – 176 tonnes	Review
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.	Review
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.	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
	Research fishing under CM 24-01 limited to 10 tonnes of *Dissostichus* spp. green weight and a single vessel in each of SSRUs A, D, E and F. Catches shall not be considered part of the catch limit for the fishery.	Carry forward
	Toothfish tagged at a rate of at least one fish per tonne green weight caught, except in SSRUs A, D, E and F where the rate is three fish per tonne green weight caught (research fishing).	Carry forward
Data	Five-day catch and effort reporting under CM 23-01. Haul-by-haul catch and effort data under CM 23-04. Biological data reported by the CCAMLR scientific observer.	Carry forward Carry forward 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 CM 26-01. No offal discharge.	Carry forward
Additional element	Fishing within 10 n miles of Balleny Islands is prohibited.	Carry forward

Table 19: Limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.2 in 2006/07 (Conservation Measure 41-10) and advice to the Scientific Committee for 2007/08.

Element	Limit in 2006/07	Advice for 2007/08
Access (gear)	Limited to vessels from Argentina, New Zealand, Norway, Russia, Spain, UK and Uruguay using longlines.	Review
Catch limit	Precautionary catch limit for *Dissostichus* spp. was 547 tonnes for Subarea 88.2 south of 65°S, applied as follows: SSRUs A and B – 0 tonnes SSRUs C, D, F and G – 206 tonnes total SSRU E – 341 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.	Review
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.	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
	Research fishing under CM 24-01 limited to 10 tonnes of *Dissostichus* spp. green weight and a single vessel in each of SSRUs A and B. Catches shall not be considered part of the catch limit for the fishery.	Carry forward
	Toothfish tagged at a rate of at least one fish per tonne green weight caught, except in SSRUs A and B where the rate is three fish per tonne green weight caught (research fishing).	Carry forward
Data	Five-day catch and effort reporting under CM 23-01. Haul-by-haul catch and effort data under CM 23-04. Biological data reported by the CCAMLR scientific observer.	Carry forward Carry forward 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 CM 26-01. No offal discharge.	Carry forward

8.2 Management advice

96. 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 for the Ross Sea (Subarea 88.1 and SSRUs 882A–B) was 2 700 tonnes. At this yield, there is a less than 10% chance of spawning biomass dropping to less than 20% of the initial biomass. A yield of 2 700 tonnes is therefore recommended.

97. For SSRU 882E, the Working Group did not have any new information on which to base new advice. The Working Group recommended that the catch limit for 2006/07 be carried forward for 2007/08. A yield of 353 tonnes is therefore recommended for 2007/08.

98. For SSRUs 882C, D, F and G, the Working Group could provide no new advice, but noted that the catches in these areas had provided some useful biological data for toothfish. Therefore, the Working Group recommended the current catch limits in these SSRUs be continued for the 2007/08 season.

99. The Working Group recommended that the allocation method used to set the 2005/06 catch limits for SSRUs in Subarea 88.1 be continued for the 2007/08 season.

100. The Working Group recalled its advice that the current designations of SSRUs in Subareas 88.1 and 88.2 are almost certainly not optimal, but a detailed revision of these would require, at least, a consolidated movement model for fish in these subareas, which is not yet available. Such a revision should take account not only of the principal target species, but also of by-catch species and ecosystem considerations.

101. The Working Group noted that there was considerable uncertainty about the implementation of the tagging program by the fleet fishing in Subareas 88.1 and 88.2 (paragraphs 3.35 and 3.36). The Working Group also noted that there may be a number of reasons for the differences between observed recapture rates of tags released by vessels from different nations. The Working Group requested that the Scientific Committee and the Commission look at the reasons for these differences, and provide advice to the Working Group on how to resolve the observed differences between rates that tags were recaptured from those released by vessels from different nations.