APPENDIX F

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

CONTENTS

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

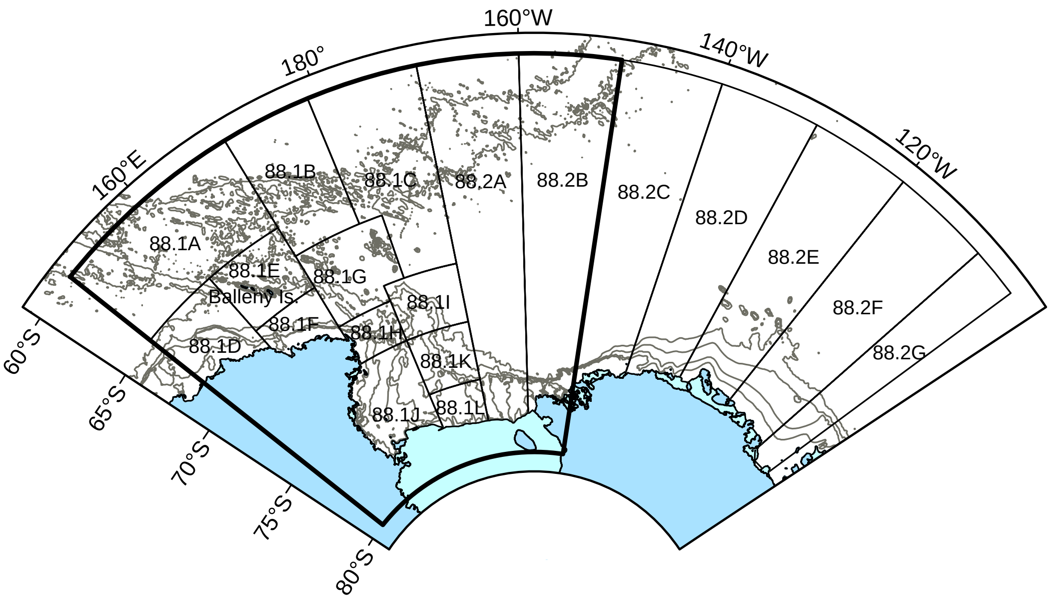

Figure 1: Subareas 88.1 and 88.2, SSRUs and the Ross Sea (bounded region). Depth contours plotted at 500, 1 000, 2 000 and 3 000 m.

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 (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 remained permissible under the research fishing exemption (CCAMLR-XXIV, paragraphs 11.61 and 11.70).

1.1 Reported catch

3. Six Members (Argentina, New Zealand, Norway, Russia, UK and Uruguay) and 13 vessels fished in the exploratory fishery in Subarea 88.1. The precautionary catch limit for

Dissostichus spp. was 2 964 tonnes and the total catch was 2 952 tonnes. The fishery was closed on 6 February 2006 (CCAMLR-XXV/BG/3), and the following SSRUs were closed during the course of fishing:

- SSRUs B, C, G closed on 3 January 2006, triggered by the catch of *Dissostichus* spp. (total catch 343 tonnes; 99% of the catch limit);
- SSRUs H, I, K closed on 19 January 2006, triggered by the catch of *Dissostichus* spp. (total catch 1 976 tonnes; 104% of the catch limit);
- SSRU J closed on 5 February 2006, triggered by the catch of *Dissostichus* spp. (total catch 548 tonnes; 99% of the catch limit);

4. Nine Members (Argentina, Republic of Korea, New Zealand, Norway, Russia, South Africa, Spain, UK and Uruguay) and a total of 21 vessels notified to fish in Subarea 88.1 during the 2006/07 season.

5. Five Members (Argentina, New Zealand, Norway, Russia and the UK) and seven vessels fished in the exploratory fishery in Subarea 88.2. The precautionary catch limit for *Dissostichus* spp. was 487 tonnes and the total catch was 465 tonnes. The fishery was closed on 15 February 2006 (CCAMLR-XXV/BG/3).

6. Seven Members (Argentina, New Zealand, Norway, Russia, Spain, UK and Uruguay) and a total of 16 vessels notified to fish in Subarea 88.2 during the 2006/07 season.

7. The number of vessels active in Subarea 88.1 and 88.2 fisheries for *Dissostichus* spp. during the current year is 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 2005/06 (source: catch and effort reports).

Member	Vessels authorised in CM 41-09	Number of vessels that fished	Reported catch (tonnes)		
			D. mawsoni	*D. eleginoides*	Total
Argentina	2	1	147	0	147
Korea, Republic of	2	0	-	-	-
New Zealand	5	4	1342	1	1343
Norway	1	1	98	0	98
Russia	2	2	673	0	673
South Africa	1	0	-	-	-
Spain	3	0	-	-	-
UK	2	2	315	0	315
Uruguay	3	3	375	0	375
Total	21	13	2951	1	2952

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 2005/06 (source: catch and effort reports).

Member	Vessels authorised in CM 41-10	Number of vessels that fished	Reported catch (tonnes)		
			D. mawsoni	*D. eleginoides*	Total
Argentina	2	1	65	0	65
Korea, Republic of	1	0	-	-	-
New Zealand	5	1	57	0	57
Norway	1	1	215	0	215
Russia	2	2	33	0	33
Spain	3	0	-	-	-
UK	2	2	94	0	94
Uruguay	1	0	-	-	-
Total	17	7	465	0	465

8. 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, effort dropped by 25%, and by another 33% in 2005/06. As in the previous season, ice conditions were very good and allowed vessels access to most of the main fishing grounds in the southern SSRUs (WG-FSA-06/29).

9. 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, but declining to 2 952 tonnes in 2005/06.

10. The catch and catch limits for toothfish, rattails and skates in Subareas 88.1 and 88.2 is given in Table 3.

Table 3: Catches (tonnes) and catch limits (tonnes) by SSRU for the 2006 toothfish fishery in Subareas 88.1 and 88.2. - Not fished. * Limited so the total for the subarea does not exceed 50 tonnes. A catch of up to 10 tonnes was permissible for SSRUs with zero catch limits under a research fishing exemption. (Source: C2 data.)

SSRU	Toothfish		Rattail		Skate	
	Catch	Catch limit	Catch	Catch limit	Catch	Catch limit
881A	1	0	-	0	-	0
881B	10	}	1		0	
881C	333	} 348	1	56	0	50
881D	-	0	-	0	-	0
881E	-	0	2	0	-	0
881F	-	0	-	0	-	0
881G	-	}	-		-	
881H	1012	}	74	}	3	}
881I	373	} 1893	74	} 303	1	} 95
881J	545	551	32	88	1	50
881K	588	}	71	}	0	}
881L	84	172	6	28	0	50
Total 88.1	2945	2964	351	475	5	245

(continued)

Table 3 (continued)

SSRU	Toothfish		Rattail		Skate	
	Catch	Catch limit	Catch	Catch limit	Catch	Catch limit
882A	17	0	8	0	0	0
882B	-	0	-	0	-	0
882C	-	}	-	}	-	}
882D	41	} 214	5	} 34	0	} 50*
882F	65	}	35	}	<1	}
882G	1	}	2	}	<1	}
882E	318	273	42	44	0	50*
Total 88.2	442	487	92	78	<1	50

11. The historical catches for Subareas 88.1 and 88.2 are given in Tables 4 and 5.

Table 4: Catch history for *Dissostichus* spp. in Subarea 88.1 (source: STATLANT data).

Season	Reported catch (tonnes)	Estimated IUU catch (tonnes)	Total (tonnes)	Catch limit
1996/97	<1	0	<1	1980
1997/98	42	0	42	1510
1998/99	297	0	297	2281
1999/00	751	0	751	2090
2000/01	660	0	660	2064
2001/02	1325	92	1417	2508
2002/03	1831	0	1831	3760
2003/04	2166	240	2406	3250
2004/05	3120	28	3148	3250
2005/06	2952	0	2952	2952

Table 5: Catch history for *Dissostichus* spp. in Subarea 88.2 (source: STATLANT data).

Season	Reported catch (tonnes)	Estimated IUU catch (tonnes)	Total (tonnes)	Catch limit
1996/97	0	0	0	1980
1997/98	0	0	0	63
1998/99	0	0	0	0
1999/00	0	0	0	250
2000/01	0	0	0	250
2001/02	41	0	41	250
2002/03	106	0	106	375
2003/04	374	0	374	375
2004/05	411	0	411	375
2005/06	465	15	480	487

1.2 IUU catch

12. There was no estimated IUU catch in Subarea 88.1 in 2005/06 (WG-FSA-06/4). The estimated IUU catch in Subarea 88.1 in previous years was 92 tonnes in 2001/02, 240 tonnes in 2003/04 (WG-FSA-05/6 Rev. 1) and 28 tonnes in 2004/05.

13. There was an estimated 15 tonnes of IUU catch in Subarea 88.2 (SSRU 882A) in 2005/06. This was the first recorded IUU catch in Subarea 88.2.

1.3 Size distribution of the catches

14. *Dissostichus mawsoni* ranged from 50 to 180 cm (Figures 2 and 3). In all years, 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 from fishing at the edge of the continental shelf in SSRUs 882F and G.

15. There was an increased level of fishing on the hills and ridges of the Pacific-Antarctic Ridge in the north of the Ross Sea during the 2001/02 and 2002/03 seasons. This resulted in a greater proportion of larger fish in the catch. This trend has diminished over the last three years as a result of changed SSRU boundaries, reallocation of allowed catch between SSRUs, and the revised management of the SSRUs within the two subareas for the 2006 season (SC-CAMLR-XXIV, Appendix F, paragraph 13). In some years there have been additional modes of smaller fish in Subarea 88.1, reflecting fishing on the Ross Sea shelf (WG-FSA-06/29). 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).

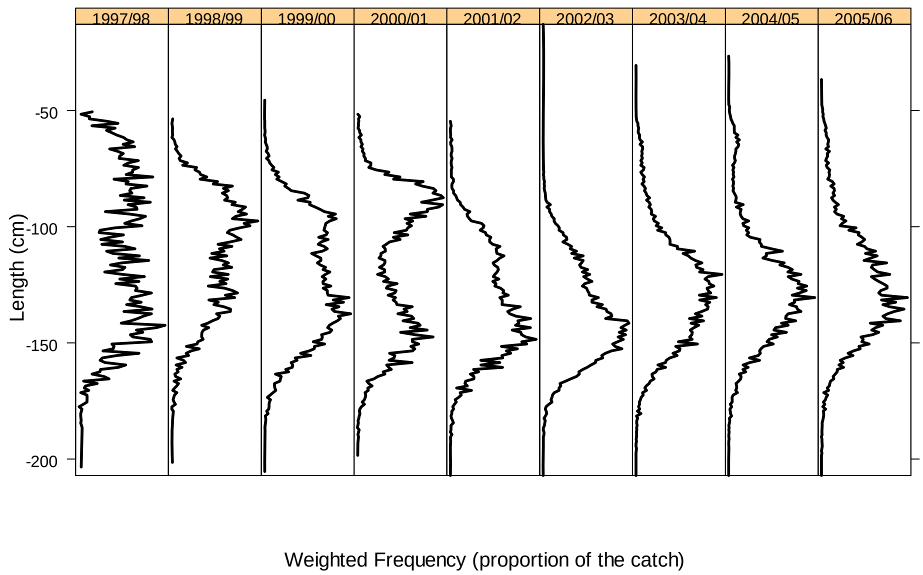

Figure 2: Catch-weighted length frequencies for *Dissostichus mawsoni* in Subarea 88.1 derived from observer, fine-scale and STATLANT data reported by 5 October 2006.

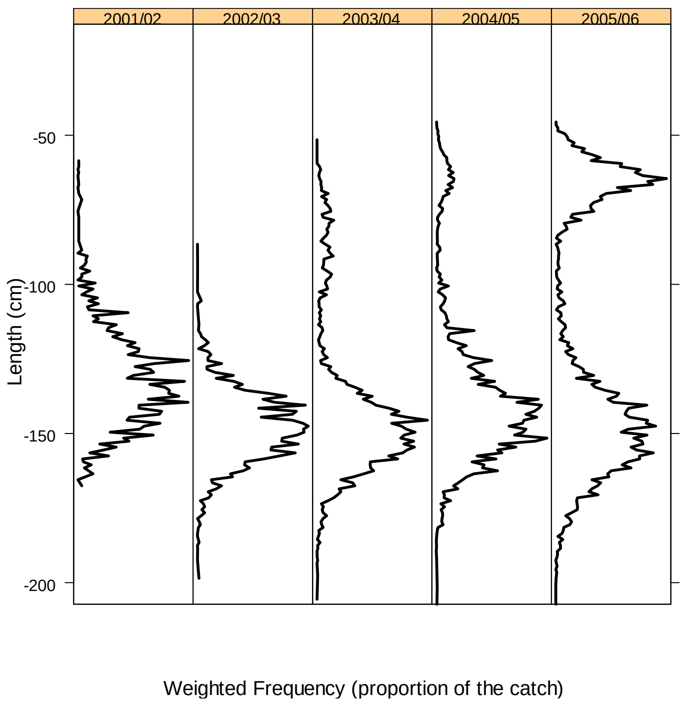

Figure 3: Catch-weighted length frequencies for *Dissostichus mawsoni* in Subarea 88.2 derived from observer, fine-scale and STATLANT data reported by 5 October 2006.

2. Stocks and areas

16. 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.

17. The 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).

3. Parameter estimation

3.1 Observations

Errors in location data held by the Secretariat

18. The CCAMLR Secretariat holds the C2 data and the CCAMLR observer data used in the analyses and assessments for *D. mawsoni* in Subareas 88.1 and 88.2. However, data supplied to the Secretariat contained errors and omissions in the location data (WG-FSA-06/29). Investigations uncovered a range of location errors in both the C2 and observer

databases, of which most were east/west errors (i.e. a location that should have been recorded as degrees west was recorded as degrees east). These errors fell into two general types: (i) errors in formatting of the submitted data, and (ii) errors in the submitted data.

19. Errors in formatting, once discovered, were corrected by the Secretariat. These were predominantly formatting errors in the submitted spreadsheets by CCAMLR observers. Attempts to resolve the remaining errors were made by linking C2 and the observer data, and visually inspecting the location of the C2 sets and the observed sets for each vessel on each trip (WG-FSA-06/29). The corrections resulted in substantive changes to some of the data used as inputs to the stock assessment.

Catch history

20. The catch history of *D. mawsoni*, used in the assessment models, for the Ross Sea and SSRU 882E are given in Table 6.

Table 6: Total *Dissostichus mawsoni* catch (tonnes) for the Ross Sea and SSRU 882E for the years 1997–2006 (source: C2 data).

Year	Ross Sea				SSRU 882E
	Shelf	Slope	North	Total	
1997	0	0	0	0	-
1998	8	29	4	41	-
1999	14	282	0	296	-
2000	64	689	0	752	-
2001	113	349	143	604	-
2002	10	936	412	1 358	-
2003	2	611	1 161	1 774	106.4
2004	143	1 663	371	2 177	362.2
2005	393	2 263	551	3 207	269.7
2006	249	2 372	343	2 964	317.6
Total	996	9 194	2 985	13 173	1 055.9

Standardised CPUE

21. A standardised CPUE analysis of *D. mawsoni* on the three main fishing grounds in Subarea 88.1 showed no significant trend from 1998/99 to 2002/03, a decline in 2003/04, and a sharp increase in 2004/05 and 2005/06 (WG-FSA-06/47). Overall, the indices have increased about 50% since the beginning of the time series. The decline in 2003/04 was thought to be related to a combination of extreme ice conditions and effects from a large number of vessels operating in a confined area. These factors were not present in 2004/05 or 2005/06.

22. The Working Group considered that favourable ice conditions, fisher learning and experience, and improvements in gear were the most likely explanations for the increase in CPUE indices. Hence, the Working Group considered CPUE indices of limited use as indices of abundance at the current time.

23. The lognormal GLM was used in the CPUE with the catch-per-set as the dependant variable. A three-area CPUE analysis (‘shelf’, ‘slope’ and ‘north’) showed more variable indices, increasing to 2001/02, decreasing to 2003/04 and increasing again in 2004/05 and 2005/06. This pattern was similar in all three areas. The significant model terms were year, vessel, number of hooks, soak time, month, depth and fishing code (research or exploratory set). The resulting r^2 was 42.4%.

24. A similar model was used to estimate annual indices for SSRU 882E (WG-FSA-06/48). Significant model terms were number of hooks, soak time, month and vessel. The resulting r^2 was 24.8%.

25. The CPUE indices for the Ross Sea (Subarea 88.1 and SSRUs 882A, B) are given in Table 7, and for SSRU 882E in Table 8.

Table 7: Ross Sea standardised CPUE indices, 95% confidence intervals and CVs for the three fisheries (shelf, slope and north) from 1998/99 to 2005/06.

Season	Shelf			Slope			North		
	Index	95% CI	CV	Index	95% CI	CV	Index	95% CI	CV
1998/99	0.58	0.40–0.84	0.19	0.78	0.68–0.89	0.07	-	-	-
1999/00	1.18	0.95–1.48	0.11	1.13	1.02–1.26	0.05	-	-	-
2000/01	0.68	0.57–0.79	0.08	0.97	0.83–1.13	0.08	0.53	0.44–0.64	0.10
2001/02	-	-	-	1.66	1.47–1.88	0.06	1.74	1.39–2.16	0.11
2002/03	-	-	-	1.10	0.96–1.27	0.07	1.07	0.94–1.21	0.06
2003/04	0.77	0.62–0.94	0.10	0.77	0.70–0.85	0.05	0.48	0.40–0.57	0.09
2004/05	1.73	1.49–2.01	0.08	1.48	1.36–1.62	0.04	0.69	0.60–0.79	0.07
2005/06	1.47	1.19–1.81	0.10	1.70	1.54–1.88	0.05	1.15	0.88–1.49	0.13

Table 8: SSRU 882E standardised CPUE indices, 95% confidence intervals and CVs from 2002/03 to 2004/05.

Season	Index	95% CI	CV
2002/03	1.14	0.62–2.08	0.31
2003/04	0.86	0.62–1.19	0.17
2004/05	0.77	0.55–1.08	0.17
2005/06	1.33	0.72–2.45	0.31

Catch-at-age

26. 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.

27 The Working Group recommended that this analysis be updated in light of the recent discovery of errors in the location data used for that analysis.

28. 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 for the Ross Sea and SSRU 882E (WG-FSA-06/29).

Tag release and recapture

29. 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.

30. Tagging rates, by vessel and Member, are given in Table 9 for Subarea 88.1 and Table 10 for Subarea 88.2. In 2005/06, all but five vessels achieved a tagging rate of more than one toothfish per tonne of toothfish landed. The vessels that failed to achieve the required tagging rate were the *Antartic II* (Argentina), *Volna* (Russia) and *Yantar* (Russia) in Subareas 88.1 and 88.2; the *Viking Sur* (Uruguay) in Subarea 88.1; and the *Frøyanes* (Norway) in Subarea 88.2.

Table 9: Tagging rate (fish tagged and released per tonne of green weight caught) reported for *Dissostichus* spp. in the exploratory fishery in Subarea 88.1 (source: observer data and catch and effort reports to October 2006).

Flag State	Vessel name	Tagging rate per season	
		2004/05	2005/06
Argentina	*Antartic II*		0.83
	Antartic III	1.15	
Korea, Republic of	*Bonanza No. 707*		
	Yeon Seong No. 829		
New Zealand	*Avro Chieftain*		1.05
	Gudni Olafsson		
	Janas	1.05	1.05
	San Aotea II	1.00	1.30
	San Aspiring	1.02	1.03
	San Liberatore		
	Sonrisa		
Norway	*Frøyanes*	1.53	1.23
Russia	*Volna*	0.74	0.76
	Yantar	0.43	0.71
South Africa	*Eldfisk*		
	Isla Graciosa		
	South Princess		
Spain	*Arnela*		
UK	*Argos Georgia*		1.14
	Argos Helena	1.46	1.02
Ukraine	*Mellas*		
	Simeiz		
	Sonrisa		

(continued)

Table 9 (continued)

Flag State	Vessel name	Tagging rate per season	
		2004/05	2005/06
Uruguay	*Isla Alegranza*		
	Isla Gorriti		
	Paloma V	1.19	1.33
	Piscis		
	Punta Ballena	1.06	1.04
	Viking Sur		0.94
USA	*America I*		
	American Warrior		

Table 10: Tagging rate (fish tagged and released per tonne of green weight caught) reported for *Dissostichus* spp. in the exploratory fishery in Subarea 88.2 (source: observer data and catch and effort reports to October 2006).

Flag State	Vessel name	Tagging rate per season	
		2004/05	2005/06
Argentina	*Antartic II*		0.24
New Zealand	*Avro Chieftain*	1.01	
	Janas		1.13
	San Liberatore		
Norway	*Frøyanes*	0	0.91
Russia	*Volna*	0	0
	Yantar	0.85	0
UK	*Argos Georgia*		1.86
	Argos Helena		1.72

31. Since 2000/01, more than 11 000 *D. mawsoni* have been tagged in Subareas 88.1 and 88.2 (WG-FSA-06/34). Table 11 gives the number of released and recaptured *D. mawsoni* for the Ross Sea and for SSRU 882E from all vessels and from New Zealand vessels. The New Zealand vessel data were used as inputs for the base-case model, as complete data (i.e. some release data for 2004) for other vessels were unavailable for the assessment (WG-FSA-06/34).

Table 11: Numbers of *Dissostichus mawsoni* with tags released for the 2000/01 to 2005/06 seasons by all and New Zealand vessels only, and the numbers recaptured in the 2000/01 to 2005/06 seasons by all and New Zealand vessels only.

Area		Tagged fish released		Tagged fish recaptured						
		Season	Number	2001	2002	2003	2004	2005	2006	Total
Ross Sea	All	2000/01	259	0	1	1	0	0	0	2
		2001/02	684	-	2	5	3	5	7	22
		2002/03	952	-	-	5	10	9	2	26
		2003/04	1 926	-	-	-	5	18	18	41
		2004/05	3 544	-	-	-	-	8	26	34
		2005/06	3 401	-	-	-	-	-	11	11
	Total		10 766	0	3	11	18	40	64	136
	NZL	2000/01	259	0	1	1	0	0	0	2
		2001/02	684	-	2	5	3	5	5	20
		2002/03	858	-	-	5	7	7	0	19
		2003/04	864	-	-	-	3	16	11	30
		2004/05	1 518	-	-	-	-	2	12	14
		2005/06	1 495	-	-	-	-	-	9	9
	Total		5 678	0	3	11	13	30	37	94
882E	All	2002/03	94	-	-	0	1	1	2	4
		2003/04	393	-	-	-	16	10	10	36
		2004/05	269	-	-	-	-	5	4	9
		2005/06	251	-	-	-	-	-	12	12
	Total		1 007	0	0	0	17	16	28	61
	NZL	2002/03	94	-	-	0	1	1	0	2
		2003/04	393	-	-	-	16	10	1	27
		2004/05	269	-	-	-	-	5	1	6
		2005/06	41	-	-	-	-	-	0	0
	Total		797	0	0	0	17	16	2	35

3.2 Fixed parameter values

32. Natural mortality, length–mass, growth and maturity parameters for *D. mawsoni* in Subareas 88.1 and 88.2 are given in Table 12. These have been updated from the values used in 2005 (WG-FSA-SAM-06/8).

Table 12: 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)				0.75	y

4. Stock assessment

4.1 Model structure and assumptions

Population dynamics

33. As in 2005, two management areas were assessed using CASAL integrated stock assessment models, the Ross Sea (Subarea 88.1 and SSRUs 882A, B) and SSRU 882E.

34. 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 13. Various model structures were investigated, and the base-case model and sensitivity models are described below (WG-FSA-06/60 and 06/48). A complete description of the CASAL modelling software is given in WG-FSA-05/P3.

35. The Secretariat undertook a validation of the CASAL parameter files, MPD outputs, and yield calculations used for the Ross Sea and SSRU 882E base-case models.

Table 13: 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.

36. The models were run from 1995 to 2006, 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.

37. 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). For the SSRU 882E model, a single fishery was defined. In each case, 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, and for the single fishery in the SSRU 882E model). 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.

38. 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.

39. 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 0.75 of a year.

<u>Model estimation</u>

40. 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 the those parameters and penalties that constrain the parameterisations; and second, by estimating the Bayesian posterior distributions[2] using MCMCs.

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

42. 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

43. The catch proportions-at-age data for the 1997/98–2005/06 seasons were fitted to the modelled proportions-at-age composition using a multinomial likelihood for the Ross Sea, and for the 2002/03–2005/06 seasons for SSRU 882E.

44. CPUE indices were assumed to be relative mid-season vulnerable biomass indices, with an associated catchability constant q. A lognormal likelihood was used for the CPUE indices.

45. Tag–release events were defined for the 2000/01–2004/05 seasons for the Ross Sea, and the 2002/03–2004/05 seasons for SSRU 882E. 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.

46. 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) or all vessels observer records (all-vessels 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 the negative log objective function, rather than maximising.

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.

47. 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

48. 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.

49. 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 CPUE data, one for the age data and one for the tag data).

Penalties

50. 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. Second, a tagging penalty discouraged population estimates that were too low to allow the correct number of fish to be tagged.

Priors

51. The parameters estimated by the models, their priors, starting values for the minimisation, and their bounds are given in Table 14. In models presented here, priors were chosen that were relatively non-informative but also that encouraged conservative estimates of B_0.

Table 14: 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	$1x10^4$	$1x10^6$
CPUE q		3	-	Uniform	$1x10^{-10}$	$1x10^{-1}$
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	8	Mean depth	Uniform	–50.0	50.0

Yield calculations

52. 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.

53. 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.

54. 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.

55. Note that in applying the CCAMLR decision rules for the Ross Sea and SSRU 882E models 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 2007–2041), for each sample from the posterior distribution.

56. Recruitment from 2000–2040 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 season (i.e. based on the distribution of the 2006 catch, 12.2, 76.2 and 11.6% 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 1998–2006 for the Ross Sea, and 2003–2006 for SSRU 882E.

57. 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 exploitation rate rules.

Sensitivity analyses

58. Model runs were conducted for the base case and the sensitivity runs for the Ross Sea model described in Table 15. The base-case models included tag–release and recapture data from New Zealand vessels (main report, paragraph 4.37), proportions-at-age of the catch, and

CPUE indices. A single sensitivity run only was investigated for the SSRU 882E model, which used the tag–release and recapture data for all vessels. Sensitivity runs were determined as modifications to the base-case runs, and were chosen to investigate the effect of alternative assumptions of parameters within the model.

Table 15: Labels and description of the sensitivity runs for the Ross Sea model.

	Model run	Description
1	Base	Base-case run (i.e. the free shift case reported in WG-FSA-06/60).
2	Base (2005)	The base-case run as reported in 2005.
3	All vessels	All vessels tag–release and recapture data (all vessels free shift case in WG-FSA-06/60).
4	2005 parameters[3]	The base case, using the 2005 biological parameters (i.e. mass–length, growth, and natural mortality).
5	No CPUE	The base case, excluding CPUE.
6	No process error	The base case, but ignoring additional process error.

4.2 Model estimates

MCMC diagnostics

59. For the base-case model run for the Ross Sea, 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.

60. For the base-case model for the SSRU 882E model, MCMC convergence tests suggested no evidence of poor convergence in the key output parameters and between-sample autocorrelations were low.

Ross Sea model estimates

61. Key output parameters for the base and sensitivity cases are summarised in Table 16. MCMC estimates of initial (equilibrium) spawning stock abundance (B_0) were 80 510 tonnes (95% credible interval (CI) 59 920–119 920 tonnes), and current (B_{2006}) biomass was estimated as 87% B_0 (95% CI 82–90%). The biomass trajectory is shown in Figure 4.

[3] Note: the 2005 parameters case is not exactly comparable to the 2005 base case (aside from the updated time series), as the new length–weight relationship was used to calculate the catch proportions-at-age and the scanned numbers-at-length. While these will be similar to those used in the 2005 case, their use will result in a different estimate of initial biomass than would have been obtained if these were calculated using the 2005 length–weight relationship.

Table 16: Median MCMC estimates (and 95% CI) for the Ross Sea model of B_0, B_{2006} and B_{2006} as $\%B_0$ for the base-case and sensitivity models.

	Model	B_0	B_{2006}	B_{2006} ($\%B_0$)
1	Base case	80 510 (59 920–119 920)	69 790 (49 210–101 190)	86.7 (82.1–90.4)

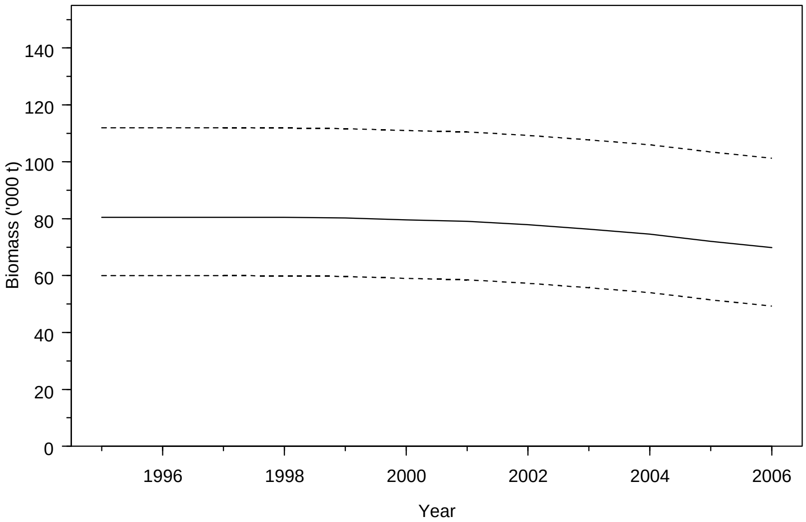

Figure 4: Estimated spawning stock biomass median (solid line) and 95% CI (dashed lines) for the base-case Ross Sea model.

62. Diagnostic plots of the CPUE indices against expected values and quantile-quantile normal diagnostic plots of the normalised residuals suggest that the process error assumed was about the level expected, and that there was no strong evidence of departure from the distributional assumptions (WG-FSA-06/60).

63. Plots of the observed proportions-at-age of the catch versus expected values show some evidence of inadequate model fit, particularly for the single-area scenario and in the most recent year for the shelf fishery. However, even though the fits to the proportions-at-age were reasonable, there was still some evidence of pattern in the residuals (WG-FSA-06/60). Estimated selectivity curves for the base-case model (Figure 5) appeared reasonable, with strong evidence of dome-shaped selectivity in the three fisheries.

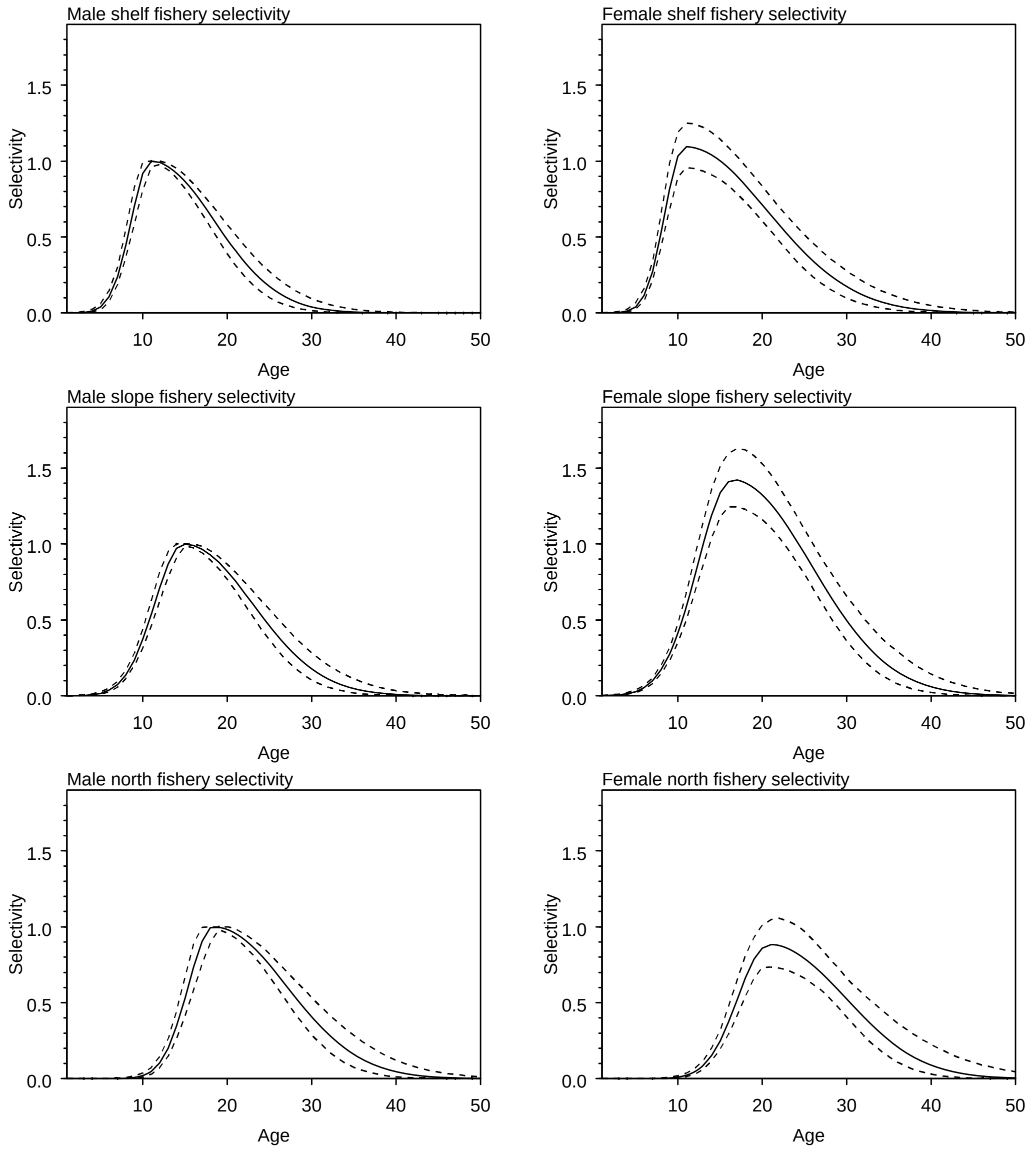

Figure 5: Estimated male and female selectivity ogives for the shelf, slope and north fisheries for the base-case Ross Sea model (solid lines indicate the median, and dashed lines indicate the marginal 95% CI).

64. Results of sensitivity runs are shown in Table 17. The all-vessels and additional process-error cases suggested a higher initial biomass. Running the model with the 2005 biological parameters or removing the CPUE series suggested a slightly lower initial biomass than for the base case. In all sensitivity cases, current biomass was estimated to be above 85% B_0.

Table 17: MPD estimates of B_0, B_{2006} and B_{2006} as $\%B_0$ for the Ross Sea sensitivity models.

Model	B_0	B_{2006}	B_{2006} ($\%B_0$)
Base case	77 200	66 500	86.1
All vessels	115 400	104 600	90.7
2005 parameters	75 400	65 100	86.4
No CPUE	73 200	62 400	85.3
No process error	114 100	103 400	90.6

65. Model runs that included historical IUU catch did not result in any substantive change in estimates of either initial or current biomass (WG-FSA-06/60).

SSRU 882E model estimates

66. Key output parameters for the base-case and sensitivity models are summarised in Table 18. Estimated initial equilibrium mid-season SSB (B_0) was 10 300 tonnes (95% CI 5 300–25 200 tonnes), with current biomass at about 9 420 tonnes (95% CI 4 400–24 330 tonnes). The biomass trajectory is shown in Figure 6.

Table 18: Median MCMC estimates (and 95% CI) for the SSRU 882E model of B_0, B_{2006} and B_{2006} as $\%B_0$ for the base-case and sensitivity models.

Model	B_0	B_{2006}	B_{2006} ($\%B_0$)
Base case	10 300 (5 340–25 210)	9 420 (4 450–24 330)	91.4 (83.4–96.5)
All vessels	9 530 (5 670–18 230)	8 640 (4 880–17 340)	90.7 (84.6–95.2)

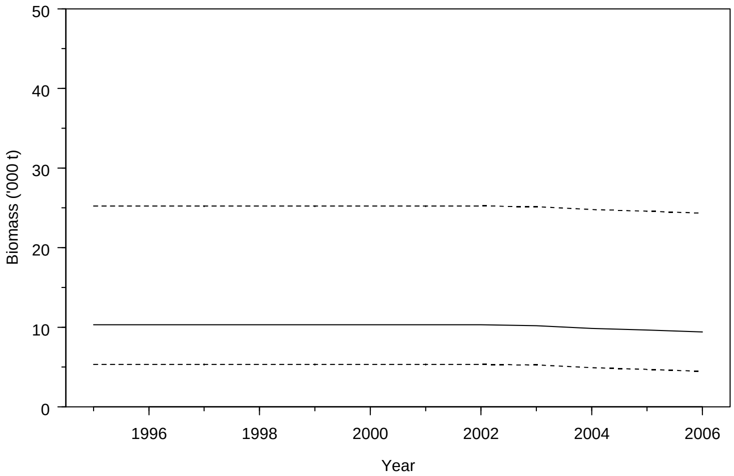

Figure 6: Estimated spawning stock biomass median (solid line) and 95% CI (dashed lines) for the base-case SSRU 882E model.

67. As with the Ross Sea model, the results suggested that the decline in biomass due to fishing has been small, and that current biomass is between 83 and 97% B_0. Diagnostic plots of the CPUE indices against expected values and quantile-quantile normal diagnostic plots of the normalised residuals suggest that the process error assumed was about the level expected, and that there was no strong evidence of departure from the distributional assumptions.

68. Similarly, plots of the observed proportions-at-age of the catch versus expected values show little evidence of inadequate model fit. Estimated selectivity curves (Figure 7) appeared reasonable, with strong evidence of dome-shaped selectivity. The tag–recapture data are reasonably well fitted, but, as for the Ross Sea model, were probably the only data that had any real weight within the model.

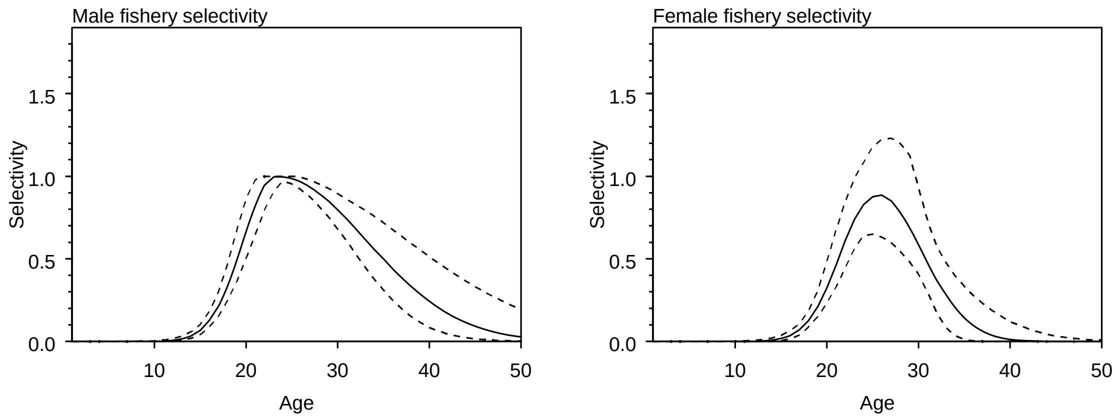

Figure 7: Estimated male and female selectivity ogives for the base-case SSRU 882E model (solid lines indicate the median, and dashed lines indicate the marginal 95% CI).

69. Model estimates for the all vessels sensitivity were very similar (9 530 tonnes, with 95% CI 5 700–18 230 tonnes), but the fits to the proportions-at-age data showed some evidence that dome-shaped selectivity patterns were more likely.

4.3 Yield estimates

Ross Sea

70. 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 3 072 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 3 072 tonnes is recommended.

SSRU 882E

71. In 2005, the Working Group agreed to calculate yields using the assumption that future fishing selectivity was equal to the maturity ogive, because the fishing selectivity was estimated to be to the right of the maturity curve (SC-CAMLR-XXIV, Annex 5, Appendix F, paragraph 58). Using this assumption, the constant catch for which there was a 10% chance of spawning biomass dropping to less than 20% of the initial biomass was 353 tonnes. At this yield, the median escapement of 50% of the pre-exploitation spawning biomass level at the end of the 35-year projection period was 61%.

4.4 Discussion of model results

72. The Ross Sea and SSRU 882E models are highly uncertain. The CPUE indices and the catch-at-age data are a relatively short time series, and are not very informative for determining current or initial stock size.

73. For both models, the tag–recapture data provide the best information on stock size, but the total numbers of fish recaptured in both areas are relatively small.

4.5 Future research requirements

74. The Working Group welcomed the updated assessment of the Ross Sea and SSRU 882E stock models, and thanked New Zealand for the work that had gone into them.

75. The Working Group recommended that future work include:

(i) investigation and inclusion of the tag and recapture data from all nations operating in Subareas 88.1 and 88.2;

(ii) consideration of the movement and stock structure of toothfish;

(iii) evaluation of the robustness of the CASAL assessment to assumptions of constant recruitment and an initial equilibrium population;

(iv) evaluation of the relative importance of tagging data to the assessment;

(v) evaluation of the relative importance of catch-at-age and CPUE data to the assessments.

76. The Working Group also recommended that different assessment methods be reviewed, as appropriate, for application to the Ross Sea assessment, including the CASAL integrated assessment method (WG-FSA-06/60) and the TSVPA method (WG-FSA-06/50).

77. 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

78. Catch histories and limits for managed by-catch species (macrourids, rajids and other species) from fine-scale data were summarised by the Secretariat in WG-FSA-06/4. These are given for Subareas 88.1 and 88.2 in Tables 19 and 20 respectively. Data from observers for the 2005/06 fishing season were provided in WG-FSA-06/4, including tables of the species composition of the observed catch and biological data collected. Data on by-catch in Subareas 88.1 and 88.2 were described and analysed by SSRU in WG-FSA-06/29.

Table 19: Catch history for managed by-catch species (macrourids, rajids and other species) in Subarea 88.1. Rajids cut from the longlines and released are not included in these estimates. Catch limits are for the whole fishery (see Conservation Measure 33-03 for details). (Source: fine-scale data.)

Season	Macrourids		Rajids		Others	
	Limit	Catch	Limit	Catch	Limit	Catch
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	100	12
2003/04	520	319	163	23	180	23
2004/05	520	462	163	69	180	24
2005/06	474	258	148	5	160	18

Table 20: Catch history for managed by-catch species (macrourids, rajids and other species) in Subarea 88.2. Rajids cut from the longlines and released are not included in these estimates. Catch limits are for the whole fishery (see Conservation Measure 33-03 for details). (Source: fine-scale data.)

Season	Macrourids		Rajids		Others	
	Limit	Catch	Limit	Catch	Limit	Catch
2001/02	40	4		0	20	0
2002/03	60	18		0	140	8
2003/04	60	37	50	0	140	8
2004/05	60	21	50	0	140	4
2005/06	78	92	50	0	100	12

79. 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 *Macrourus* spp. by-catch limit was exceeded in Subarea 88.2 (WG-FSA-06/29).

80. Current catch limits for rattails and skates 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:

- skates and rays 5% of the catch limit of *Dissostichus* spp. or 50 tonnes whichever is greater;
- *Macrourus* spp. 16% of the catch limit of *Dissostichus* spp. or 20 tonnes whichever is greater.

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

82. There were no new assessments of by-catch species or recommendations for revised catch limits by SSRU in 2006 (main report, paragraph 6.4).

5.2 Assessments of impacts on affected populations

83. 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.

84. 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.

85. 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.

86. 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.

5.3 Identification of levels of risk

87. 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

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 1997/98 to 2004/05.

89. 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.

90. 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).

91. 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.

92. 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).

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

94. 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).

6. By-catch of birds and mammals

6.1 By-catch removals

95. Details of seabird by-catch are summarised in Table 21.

Table 21: Seabird by-catch limit, reported seabird by-catch, by-catch rate and estimated by-catch for the years 1997/98 to 2005/06 in Subareas 88.1 and 88.2.

Season	By-catch limit	By-catch rate (birds/thousand hooks)	Estimated by-catch
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

* Per vessel during daytime setting.

96. Ad hoc WG-IMAF assessed the risk levels of seabirds in this fishery in Subarea 88.1 as category 1 south of 65°S, category 3 north of 65°S and overall as category 3 (Appendix D, Tables 18 and 19) and recommended (SC-CAMLR-XXV/BG/26):

- 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.

97. Ad hoc WG-IMAF assessed the risk level of seabirds in this fishery in Subarea 88.2 as category 1 (Appendix D, Tables 18 and 19) 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.

98. One southern elephant seal was reported entangled and released alive.

6.2 Mitigation measures

99. 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

100. A carbon budget trophic model for the Ross Sea is currently under development (WG-EMM-06/14). The model consists of 20 functional components, including the following fish components: bentho-pelagic predatory fish (mainly *D. mawsoni*), pelagic and juvenile fish (mainly *Pleuragramma antarcticum*), demersal fish (mainly macrourids, rajids and notothenioids) and cryopelagic fish. This work is part of an ongoing project to examine the effects of the toothfish fishery on the Ross Sea ecosystem. WG-FSA-06/10, 06/17 and 06/27 provided additional details on the diet of *D. mawsoni* in the Ross Sea, which could be usefully incorporated in the ecosystem model.

8. Harvest controls for the 2005/06 season and advice for 2006/07

8.1 Conservation measures

Table 22: Summary provisions of Conservation Measure 41-09 for limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 and advice to the Scientific Committee for the 2006/07 season.

Paragraph and topic	Summary of CM 41-09 for 2005/06	Advice for 2006/07	Paragraph reference
1. Access (gear)	Limited to vessels from Argentina, Republic of Korea, New Zealand, Norway, Russia, South Africa, Spain, UK and Uruguay using longlines.	Review	
2. Catch limit	2 964 tonnes for Subarea 88.1 SSRU limits (tonnes): A, D, E, F – 0 B, C, G – 348 H, I, K – 1893 J – 551 L – 172.	3 072 tonnes update pro rata	
3. Season	1 December 2005 to 31 August 2006	Update	
4. Fishing operations	In accordance with CM 41-01 (except paragraph 6).		
5. By-catch	Regulated in accordance with CM 33-03.		
6. Mitigation	In accordance with CM 25-02 (except paragraph 4 night setting). CM 24-02 to apply. Daylight setting allowed under CM 24-02. No offal discharge.		
7. Observers	Each vessel to carry at least two scientific observers, one of whom shall be a CCAMLR observer.		
8. VMS	To be operational in accordance with CM 10-04.		
9. CDS	In accordance with CM 10-05.		
10. Research	Undertake research plan and tagging program as set out in CM 41-01, Annexes B and C.		
11. Data: catch and effort	(i) Five-day reporting system as in CM 23-01 (ii) Monthly fine-scale reporting system as in CM 23-04 on haul-by-haul basis.		
12. 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.		
13. Data: biological	Monthly fine-scale reporting system as in CM 23-05. Reported in accordance with the Scheme of International Scientific Observation.		
14. Discharge	Prohibition of discharge of: (i) oil (ii) garbage (iii) food waste >25 mm (iv) poultry or parts thereof (v) sewerage within 12 n miles of land.		
15. Additional elements	No live poultry or other living birds to be taken into Subarea 88.1, and any unconsumed dressed poultry is to be removed from Subarea 88.1.		
16. Additional element	Fishing within 10 n miles of Balleny Island is prohibited.		

Table 23: Summary provisions of Conservation Measure 41-10 for limits on the exploratory fishery for *Dissostichus* spp. in Subarea 88.2 and advice to the Scientific Committee for the 2006/07 season.

Paragraph and topic	Summary of CM 41-10 for 2005/06	Advice for 2006/07	Paragraph reference
1. Access (gear)	Limited to vessels from Argentina, New Zealand, Norway, Russia, Spain, UK and Uruguay using longlines.	Review	
2. Catch limit	487 tonnes south of 60°S A, B – 0 C, D, F, G – 214 E – 273	567 tonnes south of 60°S C, D, F, G 214 tonnes E 353 tonnes	
3. Season	1 December 2005 to 31 August 2006	Update	
4. Fishing operations	In accordance with CM 41-01 (except paragraph 6).		
5. By-catch	Regulated in accordance with CM 33-03.		
6. Mitigation	In accordance with CM 25-02 (except paragraph 4 night setting). CM 24-02 to apply. Daylight setting allowed under CM 24-02. No offal discharge.		
7. Observers	Each vessel to carry at least two scientific observers, one of whom shall be a CCAMLR observer.		
8. VMS	To be operational in accordance with CM 10-04.		
9. CDS	In accordance with CM 10-05.		
10. Research	Undertake research plan and tagging program as set out in CM 41-01, Annexes B and C.		
11. Data: catch and effort	(i) Five-day reporting system as in CM 23-01 (ii) Monthly fine-scale reporting system as in CM 23-04 on haul-by-haul basis.		
12. 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.		
13. Data: biological	Monthly fine-scale reporting system as in CM 23-05. Reported in accordance with the Scheme of International Scientific Observation.		
14. Discharge	Prohibition of discharge of: (i) oil (ii) garbage (iii) food waste >25 mm (iv) poultry or parts thereof (v) sewerage within 12 n miles of land.		
15. Additional elements	No live poultry or other living birds to be taken into Subarea 88.2, and any unconsumed dressed poultry is to be removed from Subarea 88.2.		

8.2 Management advice

101. The Working Group recommended that tagging be continued as part of the Research and Data Collection Plan (Conservation Measure 41-01), and urged all Members to continue to tag fish at the required rate.

102. The Working Group also considered that the introduction of more structured research plans for exploratory fisheries may lead to a more effective and efficient collection of research data. It therefore recommended that development of such plans should be considered during the intersessional period.

103. 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 3 072 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 3 072 tonnes is therefore recommended.

104. For SSRU 882E, assuming a future fishing selectivity equal to the maturity ogive, the constant catch for which there was a 10% chance of spawning biomass dropping to less than 20% of the initial biomass was 353 tonnes. At this yield, the median escapement of 50% of the pre-exploitation spawning biomass level at the end of the 35-year projection period was 61%. A yield of 353 tonnes is therefore recommended.

105. 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 2006/07 season.

106. The Working Group recommended that the allocation method used to set 2005/06 catch limits for SSRUs in Subarea 88.1 be continued for the 2006/07 season.

107. The Working Group agreed 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.

108. The Working Group recommended that there should continue to be provision for a 10-tonne research exemption in all SSRUs in Subareas 88.1 and 88.2 having a zero catch limit so as to provide additional opportunities for research and tagging in areas where, often, data are scarce. However, paragraphs 12 and 13 of Conservation Measures 41-09 and 41-10, should be revisited so that:

- it is clear that a 10-tonne research exemption will be granted only for a single vessel in a single SSRU, not one vessel per Member. This will limit the total catch in a closed SSRU to 10 tonnes. On receipt of a notification under Conservation Measure 24-01 Annex A from a Member that it intends to undertake research under the 10-tonne research exemption in a particular SSRU, the Secretariat will notify all Members of this fact and will not allow additional notifications for that SSRU in that season;

- it is clear that paragraphs 12 and 13 of Conservation Measures 41-09 and 41-10 override the normal interpretation of Conservation Measure 24-01 in respect of multiple notifications by Members in a single SSRU;
- it is clear that there is an allowance for the retention of 10 tonnes green weight of *Dissostichus* spp.;
- it is clear that by-catch and *Dissostichus* spp. that are tagged and returned do not count against the 10-tonne limit. The retained catch of toothfish should count against the overall catch limit for the larger area within which the SSRU lies;
- the requirement of tagging rate under the 10-tonne research exemptions will be a minimum of three fish per tonne and a target rate of 10 fish per tonne (paragraph 3.48). This will also require a change to Conservation Measure 41-01, Annex C, paragraph 2(i).