APPENDIX J

FISHERY REPORT: *DISSOSTICHUS ELEGINOIDES* SOUTH GEORGIA (SUBAREA 48.3)

CONTENTS

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1. Details of the fishery

1.1 Reported catch (time series)

At its 2004 meeting, WG-FSA recommended the subdivision of Subarea 48.3 into areas, one containing the South Georgia–Shag Rocks (SGSR) stock and other areas, to the north and west, that do not include the SGSR stock. Within the SGSR area, the Commission defined three management areas (A, B and C) (Conservation Measure 41-02/A).

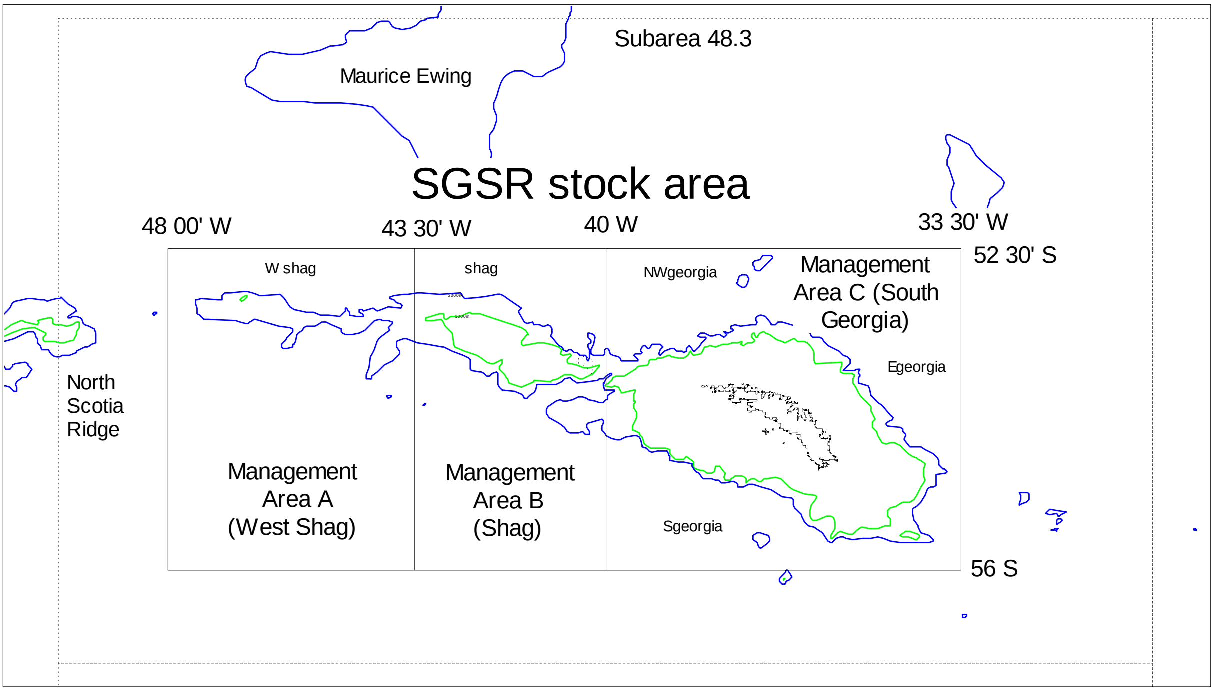

Figure 1: Definition of the SGSR stock area, with its three management areas A, B and C.

2. The catch limits in the 2006/07 season for areas A, B and C were 0 (excepting 10 tonnes for research fishing), 1 066 and 2 488 tonnes, with an overall catch for SGSR of 3 554 tonnes. The total declared catch was 3 535 tonnes. Catches in areas A, B and C were 7 tonnes, 976 tonnes and 2 552 tonnes respectively.

3. Most catch has been taken by longlines, but 66 tonnes were taken by pots in 2001 and 24 tonnes in 2006. These data are included in the total catch. With respect to the distribution of effort, previous reports have displayed the spread of the effort in the fishery over time. Current effort is spread evenly over the fished areas.

1.2 IUU catch

4. There was no evidence of IUU fishing in Subarea 48.3 in 2005/06 and 2006/07 (Table 1).

Table 1: Catch history for *Dissostichus eleginoides* in Subarea 48.3. (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.) SGSR: South Georgia–Shag Rocks stock; West: area outside the SGSR stock area.

Season	Regulated fishery			Estimated IUU catch (tonnes)	Total removals (tonnes)		
	Effort (no. vessels)	*D. eleginoides* catch (tonnes)			SGSR	West	Subarea
		Limit	Reported				
1984/85	1	-	521	0	517	4	521
1985/86	1	-	733	0	733	0	733
1986/87	1	-	1954	0	1954	0	1954
1987/88	2	-	876	0	876	0	876
1988/89	3	-	7060	144	6963	241	7204
1989/90	2	-	6785	437	6838	384	7222
1990/91	1	2500	1756	1775	3531	0	3531
1991/92	23	3500	3809	3066	6864	11	6875
1992/93	18	3350	3020	4019	7039	0	7039
1993/94	4	1300	658	4780	5246	191	5438
1994/95	13	2800	3371	1674	4972	73	5045
1995/96	13	4000	3602	0	3530	72	3602
1996/97	10	5000	3812	0	3808	4	3812
1997/98	9	3300	3201	146	3347	0	3347
1998/99	12	3500	3636	667	4303	0	4303
1999/00	17	5310	4904	1015	5910	9	5919
2000/01	18	4500	4047	196	4232	11	4243
2001/02	17	5820	5742	3	5717	29	5745
2002/03	19	7810	7528	0	7510	18	7528
2003/04	17	4420	4497	0	4460	37	4497
2004/05	8	3050	3039	23	3062	0	3062
2005/06	11	3556	3535	0	3535	0	3535
2006/07	10	3554	3535	0	3535	0	3535

1.3 Size distribution of catches (time series)

5. Catch-weighted length-frequencies for *D. eleginoides* from 1984/85 to 2006/07 are shown in Figure 2.

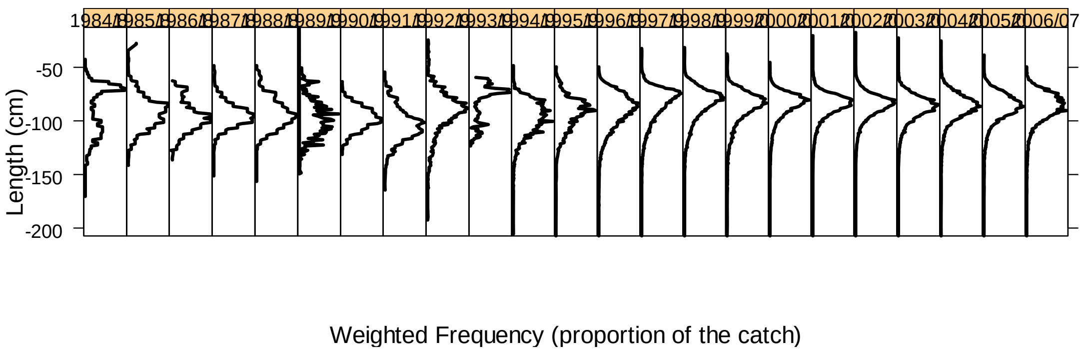

Figure 2: Catch-weighted length frequencies for *Dissostichus eleginoides* in Subarea 48.3 (source: observer, fine-scale and STATLANT data).

6. The mean length of fish caught in the fishery up to 2007 is shown in Figure 3.

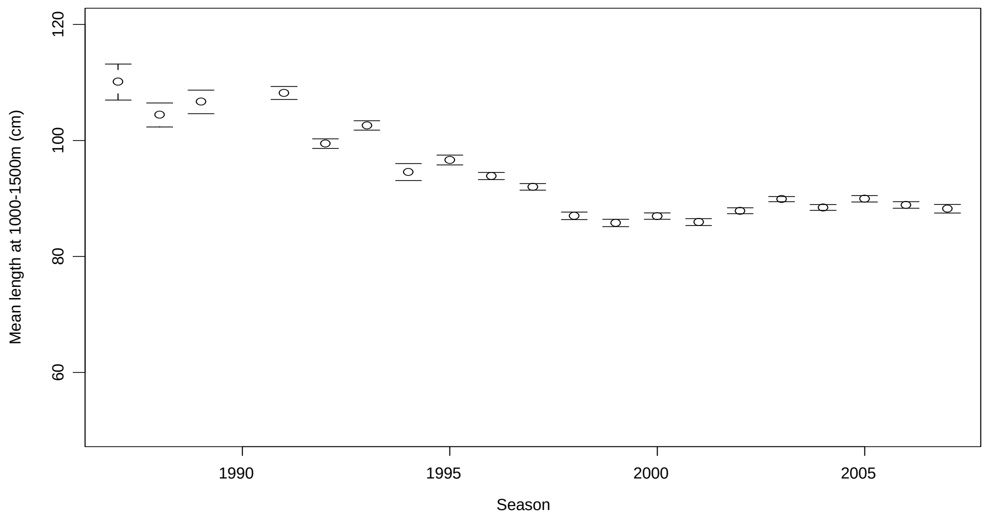

Figure 3: Mean length of fish caught in the fishery up to 2007.

2. Stocks and areas

7. It has been demonstrated that there is genetic separation of those fish present in Subarea 48.3 from those found on the Patagonian Shelf (FAO Area 41). The SGSR stock, occurring within management areas A, B and C (Figure 1), is genetically separate from fish taken in the extreme north and west of Subarea 48.3.

8. All assessments consider only the SGSR stock.

3. Parameters and available data

3.1 Standardised CPUE

9. The GLMM (catch weight as the response variable; season, year, nation of vessel, depth class and an offset for log-hooks as the fixed effects; vessel as the random effect) standardised CPUE analysis was updated. Figure 4 shows that CPUE has remained constant between 2004 and 2007.

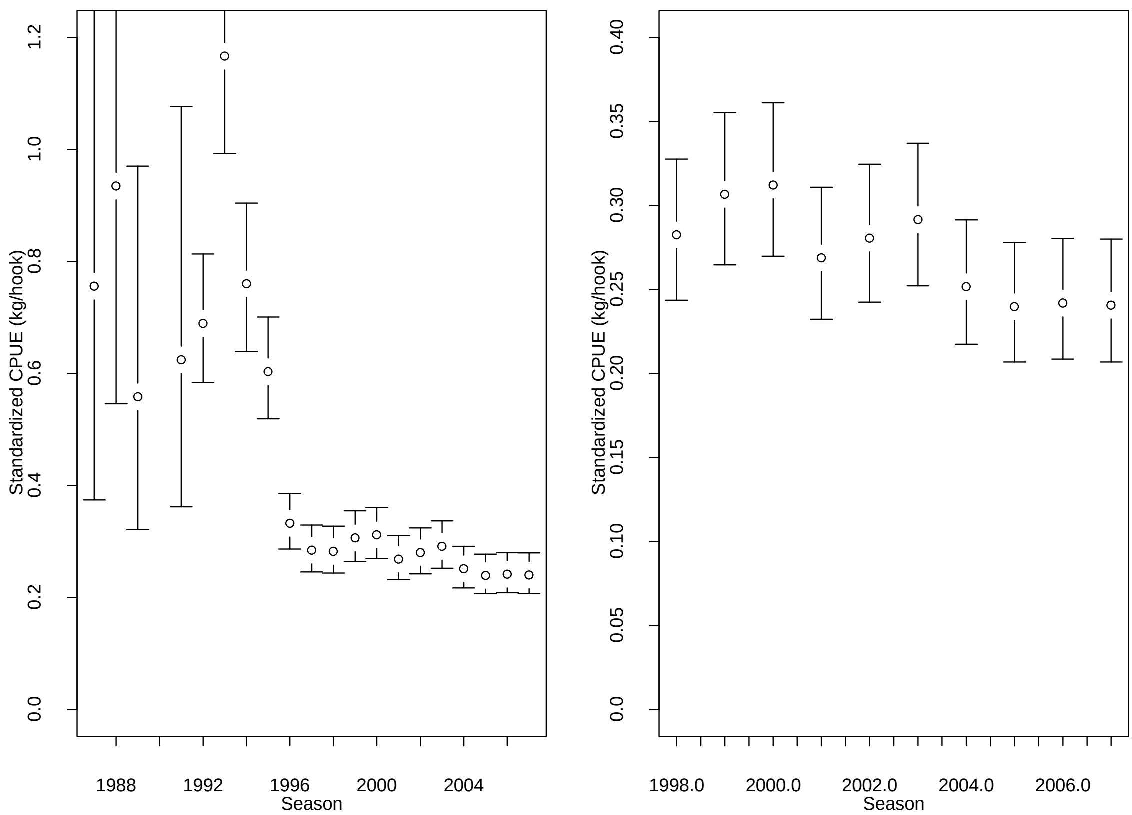

Figure 4: Standardised longline CPUE by fishing season for Subarea 48.3 using the GLMM method with vessel random-effects. The series has been standardised for Chilean vessels fishing in depths between 1 000 and 1 500 m. No data were available for 1990, which is the reason it is absent from the above results. The right-hand plot uses identical data to the left-hand plot, and is provided to reveal more detail in recent trends.

Table 2: Standardised CPUE (kg/hook) calculated during the meeting using the GLMM method. The early/later series qualifiers are to denote the split in the GLMM CPUE series as it is used in the assessment. The early CPUE series relates to the early fleet classification (1985 to 1997) and the later series corresponds to the later fleet (1998 to 2007).

Fishing season	Standardised CPUE using single GLMM	CV (%)
	Early series	
1986/87	0.722	45.0
1987/88	0.896	32.9
1988/89	0.532	33.7
1989/90		
1990/91	0.573	33.3
1991/92	0.633	9.2
1992/93	1.081	9.5
1993/94	0.68	9.5
1994/95	0.564	8.4
1995/96	0.307	8.3
1996/97	0.263	8.2
	Later series	
1997/98	0.262	8.3
1998/99	0.285	8.3
1999/00	0.287	8.2
2000/01	0.249	8.2
2001/02	0.255	8.2
2002/03	0.265	8.2
2003/04	0.228	8.2
2004/05	0.217	8.3
2005/06	0.262	8.6
2006/07	0.229	8.5

3.2 Recruitment

10. The Working Group did not revise its calculation of CMIX estimates of recruitment in Subarea 48.3 (SC-CAMLR-XXIV, Annex 5, Appendix G, Table 4). The primary reason for this was that these data were not being used in the assessment process.

3.3 Mark–recapture data

11. Tagging effort, fishing effort and recaptures were well distributed over the whole of the fishable grounds in Subarea 48.3 this year.

12. In total, 17 815 fish have been tagged in Subarea 48.3 since the program started in 2000 (Table 3). In 2007, 530 tagged animals were recovered; seven of these were tagged in

2000 as juveniles and have shown similar movement to adults providing useful information on recruitment patterns. Fish have moved between each of the areas defined in Figure 1 with the exception of Wshag, which has only exchanged animals with Shag (Table 4).

Table 3: Numbers of marked animals released in different areas in Subarea 48.3. See Figure 1 for area definitions.

Release year	East	NWest	South	Shag	Wshag	Total
2000	37	7		91		135
2001	3	4	16	324		347
2002		99	117	188		404
2003	120	8	134	189		451
2004	601	456	795	1 361	5	3 218
2005	1 110	795	641	1 284	117	3 947
2006	1 273	760	1 442	1 085	100	4 660
2007	1 057	1 159	1 258	1 104	75	4 653
Totals	4 201	3 288	4 403	5 626	297	17 815

Table 4: Movement of animals between areas in Subarea 48.3 (all tag and recapture years)*.

Release area	Recapture area				
	Egeorgia	NWgeorgia	Sgeorgia	Shag	Wshag
Egeorgia	246	17	16	3	
NWgeorgia	18	142	5	6	
Sgeorgia	20	14	327	2	
Shag	9	13	4	344	3
Wshag				7	2
Totals	293	186	353	362	5

* One recapture in 2007 was of a fish tagged in Subarea 48.4 in 2006.

3.4 Biological parameters

13. WG-FSA-06/53 reported a reanalysis of the scientific observer data to estimate age-at-maturity, using the current growth curve (L_∞ = 152.8 cm). The maturity ogive remains unchanged from that used last year, details for the estimation of which can be found in WG-FSA-06/53, and this ogive is presented in Table 5 and the male, female and combined maturity ogives can be seen in Figure 5.

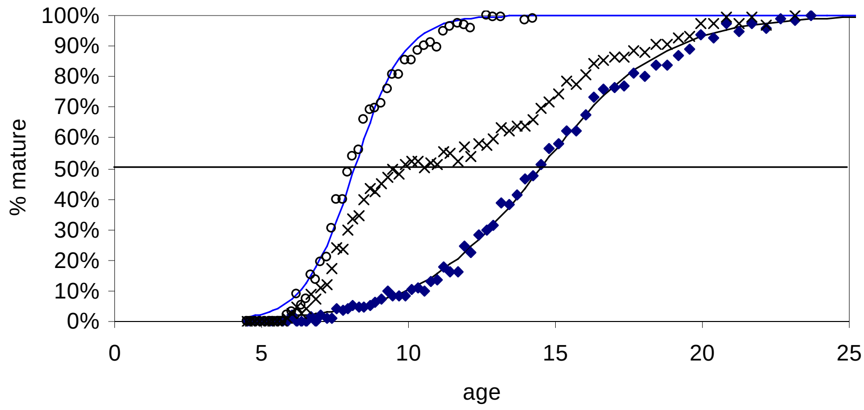

Figure 5: Maturity-at-age for males (open circles), females (diamonds) and all sexes combined (crosses) from observer data 1997–2006. Animals are considered to be mature if they have gonad stages III and above at spawning time (July and August).

Table 5: Maturity ogive used for the SGSR stock.

Age	Maturity ogive
6	0.00
7	0.10
8	0.20
9	0.30
10	0.40
11	0.50
12	0.54
13	0.58
14	0.63
15	0.67
16	0.71
17	0.75
18	0.79
19	0.83
20	0.88
21	0.92
22	0.96
23	1.00

14. Table 6 summarises the parameter values used in the CASAL assessments of Subarea 48.3. The biological parameter values that were estimated from data are the growth, maturity and weight-at-length parameters, as were tag-related growth retardation, tag loss rate and the tag-related mortality rate. Parameters set to values agreed by the Working Group are the steepness, recruitment variability, natural mortality and the tag detection rate.

Table 6: Biological parameter values for *Dissostichus eleginoides* in Subarea 48.3.

Component	Parameter	Value	Component	Parameter	Value
Natural mortality	M	0.13	Tag-related growth retardation		0.5
VBGF	K	0.067	Single tag loss rate		0.06
VBGF	t_0	–1.49	Immediate tagging survivorship		0.9
VBGF	L_∞	152.8	Tag probability of detection		1
Length to mass	a (mm to t)	2.5e-9			
Length to mass	b	2.8	Stock-recruit relationship steepness	h	0.75
Maturity range: 0 to full maturity		1–23	Lognormal recruitment SD		0.6

3.5 Total removals

15. Estimated total removals of *D. eleginoides* are set out in Table 1.

4. Stock assessment

16. WG-FSA-07/29 presented two candidate Subarea 48.3 *D. eleginoides* assessment model structures, both of which use the CASAL software. The first of these proposed assessment models is essentially a data-updated version of the assessment model used to calculate the long-term yield for this stock at last year's Working Group. The data used are the catch-weighted length frequencies, the standardised GLMM CPUE series and the tag–release (2000–2006) and recapture (2004–2007) data. The second model has several new features:

- catch-at-age data from 1998–2007 are used in the model;
- revised tag growth-shock and mortality parameters are used (see WG-FSA-07/29);
- year-class strength is now estimated within the model;
- the growth parameters (k and L_∞; t_0 is kept fixed at the historical value) are also estimated within the model, and the age–length data from 1998–2005 are also used as observations within the estimation scheme;
- GLMM standardised CPUE data from 1998 to 2007 only.

17. The Working Group agreed that the update model was suitable for the setting of the suggested catch limit in Subarea 48.3 this year, and that there was considerable merit in the approach adopted in the secondary model. However, the issues raised at the meeting about estimating new tag growth-shock parameters, how they are incorporated into the model, the estimation of the growth parameters within the model, and the continuing patterns seen in the

fits to the tag–recapture data all suggest that this new model should be brought forward to the next WG-SAM meeting for full review by the members of that group, before any decision is made on whether this new model should be adopted for use at WG-FSA for stock assessment purposes.

4.1 CASAL model structure and assumptions

Population dynamics

18. The CASAL population model used in the assessment of toothfish in Subarea 48.3 was a combined sex, single-area, three-season model. The annual cycle was defined as follows: the first season (1 December to 31 April) is where only recruitment (at the start) and natural mortality occurs; the second season, ranging from the beginning of May to the end of August, includes both natural mortality and fishing and contains the spawning period – half the mortality in that particular season being accounted for before spawning occurs; the final season runs from the beginning of September to the end of November, thus completing the annual cycle, with only natural mortality occurring. It was assumed throughout that the proportions of natural mortality and growth that occurred within each season were equal to that season's length as a proportion of a year. The models were run over the years 1985 to 2007, with an initial unexploited equilibrium age structure, and with a Beverton-Holt stock-recruit relationship with fixed steepness.

Model estimation

19. Exploratory runs and sensitivity analyses were run using a point estimate Bayesian analysis (MPD: maximum posterior density) – akin to maximum likelihood estimation, but with prior beliefs on parameters of interest also accounted for in the objective function. To account for parametric uncertainty in the final runs, CASAL's implementation of the MCMC method for extracting a sample from the parameter's posterior (data updated) probability distribution was used. This allows a full exploration of the model's parameter space, not just the most likely parameter values, as is the case with the exploratory MPD method. The MCMC samples were obtained by first running the sampler for a 'burn-in' period of 500 000 iterations, and a further 1 000 000 iterations of the sampler were obtained, which were then thinned by a factor of 1 000, to yield a parameter sample of length 1 000. Convergence of this chain on the posterior distribution was checked using the methods described in WG-FSA-05 (SC-CAMLR-XXIV, Annex 5).

Observation assumptions

20. The catch proportions-at-length data were fitted to the model-expected proportions-at-length composition, using a multinomial likelihood.

21. CPUE indices were assumed to be lognormally distributed about the model-predicted vulnerable biomass halfway through the fishing season, via a constant catchability *q*. The CPUE series shown in Table 2 was divided into two series corresponding to the time periods of the two fleets. Observation error was accounted for by using the annual CV estimates obtained from the GLMM standardisation. An additional process error CV was also estimated for the first time period, to account for the extra variance required for the population model to interpret the CPUE observations.

22. Tag–release events for 2000, 2001, 2002, 2003, 2004, 2005 and 2006 were incorporated into the model, but given the comparatively low number of returns and spread in return lengths/ages in the recaptures in 2001–2003, only the recapture events in 2004, 2005, 2006 and 2007 were used. Within year/season recaptures were omitted from the observations to allow for possible incomplete mixing in the first few months after release. Tag–release and recapture events occurred during the fishing season (season 2), with a probability of detection of recaptured tags of 1. The estimated numbers of scanned fish for each length class relevant to those in the recapture data, were calculated using the total catch biomass, the catch-at-length proportions and the mean weight of the fish.

23. In each year, the length frequencies of releases and recaptures ranged from 20 to 220 cm in 10 cm length bins.

Process error and data weighting

24. As well as process error being estimated for the CPUE observations, the appropriate effective sample sizes to be used to weight the length-frequency data, and the levels of possible over-dispersion apparent in the estimated tagged populations, were investigated. For both sets of observations, standard formulae were used to estimate these quantities after an initial MPD run of the model with the original sample sizes/dispersion values. The actual effective sample sizes/dispersion values predicted by the model's fit to the relevant dataset were then adopted, and a secondary MPD run was performed. If the implied recalculated sample values/dispersion values were close to those calculated from the first MPD run, then it can be concluded that each dataset was being given the correct weighting in the likelihood.

Penalties

25. Two types of penalties were included within the model. First, a penalty on the catch constrained the estimated harvest rate in any year from exceeding a specified maximum, set at 0.999 (see the *U_max* parameter, in the fishery definition in the population.csl file) in the CASAL assessment models. Second, a tagging penalty discouraged population estimates that were too low to allow the correct number of fish to be tagged.

Priors

26. Within a Bayesian model, all free parameters estimated require both the definition of a prior and bounds that constrain the estimation. Table 7 shows the free parameters estimated in the CASAL models, along with their respective bounds, and prior parameterisations.

Table 7: Free parameters, and their priors and bounds in the CASAL assessment models.

Parameter	Prior	Lower bound	Upper bound
B_0 (virgin SSB)	Uniform-log	20 000	1e+6
q (catchabilities)	Uniform-log	1e-8	1e-1
m (max. sel. age)	Uniform	1	50
l (left sel. decay)	Uniform	0.05	500
r (right sel. decay)	Uniform	0.05	500
CV (CPUE obs.)	Uniform-log	0.01	5

4.2 Selectivity and growth

27. Selectivity-at-age was expressed as a double-normal curve with the following form:

$$s(a) = 2^{-\frac{(a-m)^2}{l^2}} \quad \text{if } a < m \tag{1}$$

$$s(a) = 2^{-\frac{(a-m)^2}{r^2}} \quad \text{if } a \geq m$$

where $s(a)$ is the selectivity at age a, m is the age at maximum selection, l is the left-hand decay term, r is the right-hand decay term. The primary data that inform these selectivities are the annual catch-length frequencies and the tag-returns-at-length. When predicting the annual catch-length frequencies and tag-returns-at-length, the selectivity-at-age curve is interpreted via the specified growth curve, the specified CV of length-at-age (another input parameter to CASAL) and the population dynamics. Consequently, there is a strong interaction between the estimated selectivity curve and the assumed growth curve.

28. In 2005, the Working Group re-estimated the growth curve for the SGSR stock based on new data from the fishery and research surveys. This resulted in a revision of the growth parameters to $L_\infty = 152.8$, $K = 0.067$ and $t_0 = -1.49$. These parameters were used in the 2007 assessment.

4.3 CASAL runs

29. A single assessment model was run for WG-FSA this year, and corresponds to the same mode structure as that used last year. Table 8 details the specific data and key parameters used in the updated model and Table 9 summarises the estimated parameter values.

Table 8: CASAL model structure descriptions.

Feature	The 2006 model	The update model
Model structure	Two-fleets (1985–1997, 1998–2006), fitted to catch-at-length, CPUE and tagging data	No change except the inclusion of the 2007 data for all observation types.
Catches	Revised according to Table 1 (minor revisions only)	As used in 2006, updated with 2007 data.
Catch-at-length	Revised according to the Secretariat calculations in WG-FSA-06/4. Fitted years were [1988, 1989, 1992, 1993, 1995, 1996, 1997] and [1998–2007]. 1990, 1991, 1994 were omitted due to inadequate data or, in the case of 1994, unrepresentative fishing behaviour.	As used in 2006, updated with a single additional 2007 year derived from WG-FSA-07/4.
CPUE	Revised GLMM (Table 2)	No change
Tag releases	Releases 2000–2005	No change with 2006 releases included
Tag recaptures	Recaptures from 2004–2006	No change, with 2007 recaptures used
Scanned population	Recalculated based on the new catch-at-length data from WG-FSA-06/4.	Recalculated based on the new catch-at-length data from WG-FSA-07/4.
Mean weight in the catch	Calculated from haul-by-haul data as total kg catch divided by total numbers caught for all hauls where numbers were recorded.	No change
Maturity ogive	2005 ogive	No change
Steepness, sigma R (σ_R)	0.75, 0.6	No change

Table 9: Review of parameter estimates for the four CASAL models, using the MPD estimation results.

Model	B_0 (1 000 tonnes)	Selectivity 1 parameters (see eq. 1)	Selectivity 2 parameters (see eq. 1)	Process error CV (CPUE)
Update	112.490	11.36, 2.49, 8.59	8.05, 1.15, 9.71	0.406

4.4 Point-estimate (MPD) results

30. Even though MCMC samples are used to calculate the long-term yield, the diagnostics for the reference model are displayed using only the MPD results for clarity. Table 9 shows the MPD summary for the reference model, the update of last year's base-case assessment, and the model used to eventually set the long-term yield at last year's Scientific Committee meeting.

31. The estimates of q for the early and later fleets for the reference model were 0.0091 and 0.0041 respectively.

32. Model-fit diagnostics and goodness-of-fit achieved by the reference model are shown in Figures 6 to 13.

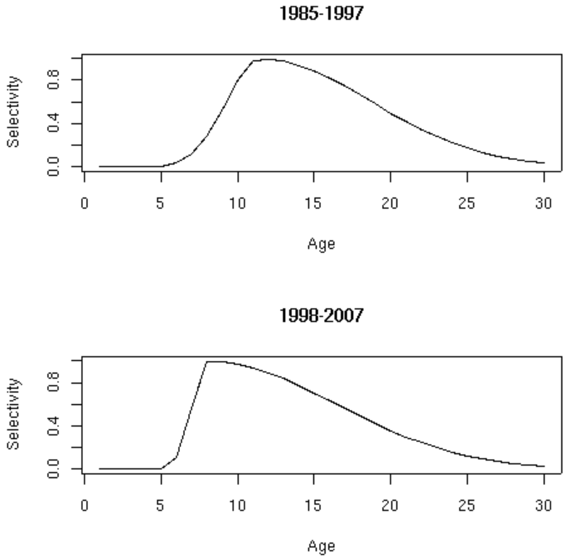

Figure 6: Estimated selectivity curves in the reference model.

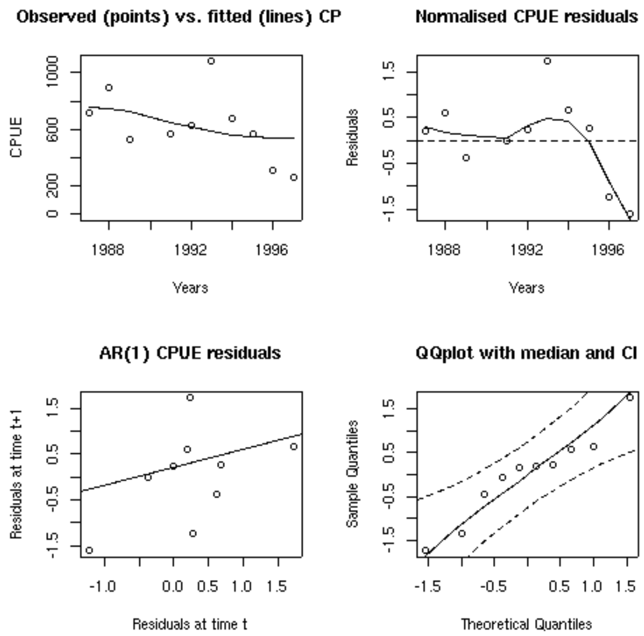

Figure 7: Fit to first-fleet CPUE series in the reference model.

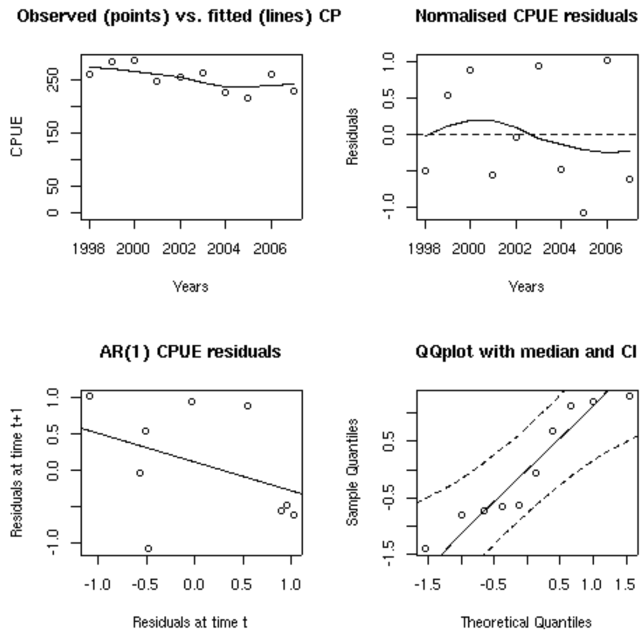

Figure 8: Fit to second-fleet CPUE series for the reference model.

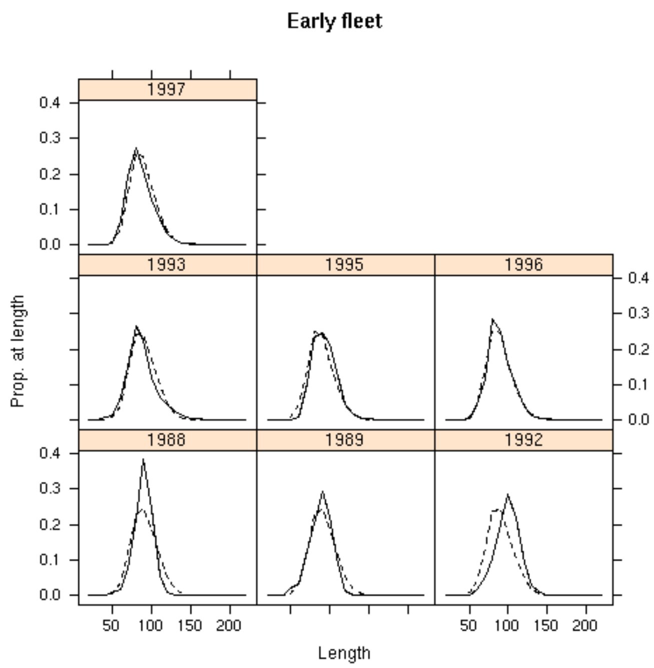

Figure 9: Fit to first-fleet catch-length frequencies for the reference model. The full and dotted lines represent the observed and predicted length frequencies respectively.

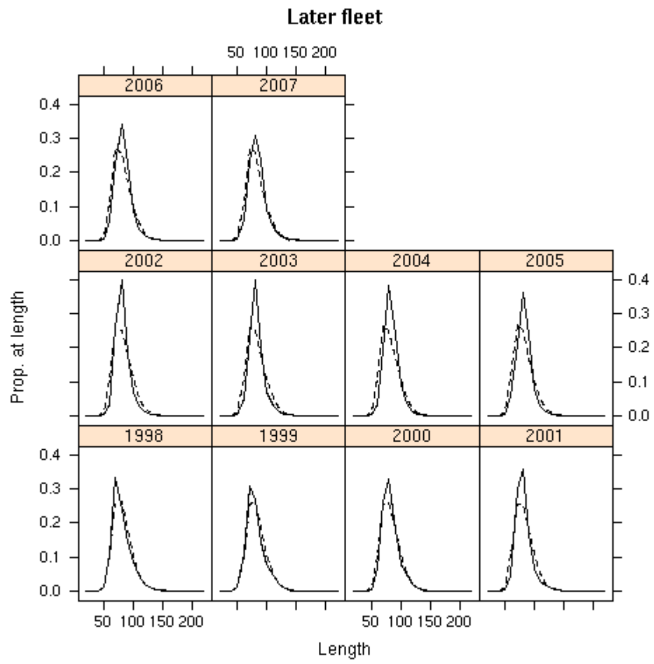

Figure 10: Fit to second-fleet catch-length frequencies for the reference model. The full and dotted lines represent the observed and predicted length frequencies respectively.

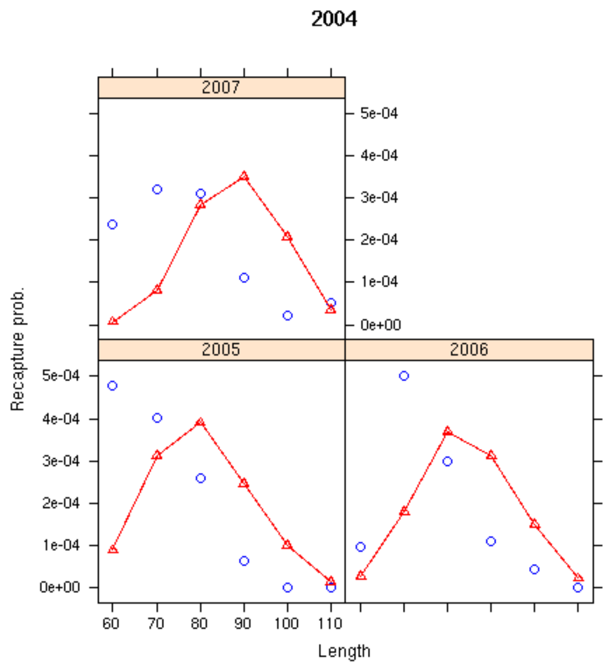

Figure 11: Fits to the 2004 tag–release data – observed recapture probabilities are the circles, expected recapture probabilities are the joined triangles.

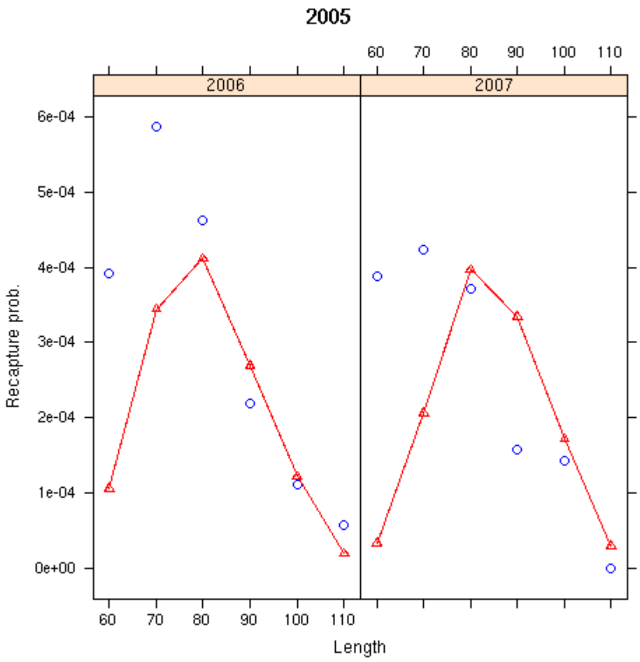

Figure 12: Fits to the 2005 tag–release data – observed recapture probabilities are the circles, expected recapture probabilities are the joined triangles.

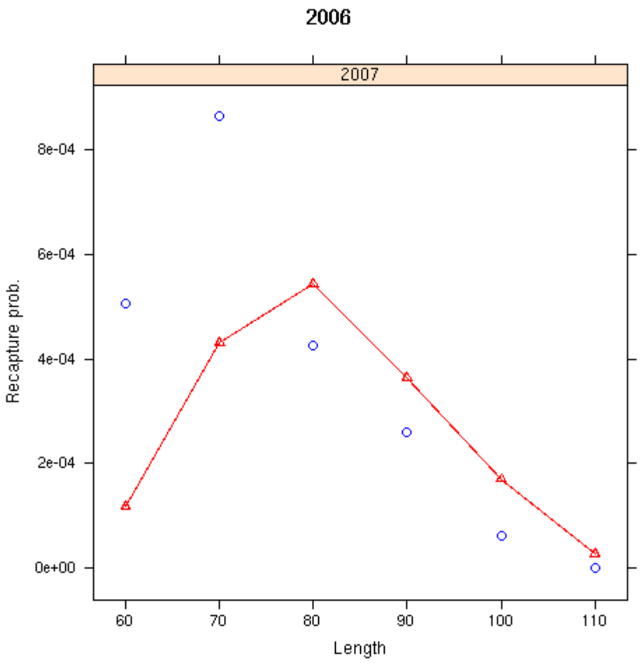

Figure 13: Fits to the 2006 tag–release data – observed recapture probabilities are the circles, expected recapture probabilities are the joined triangles.

33. Stock trajectories and key indices are shown in Figure 14.

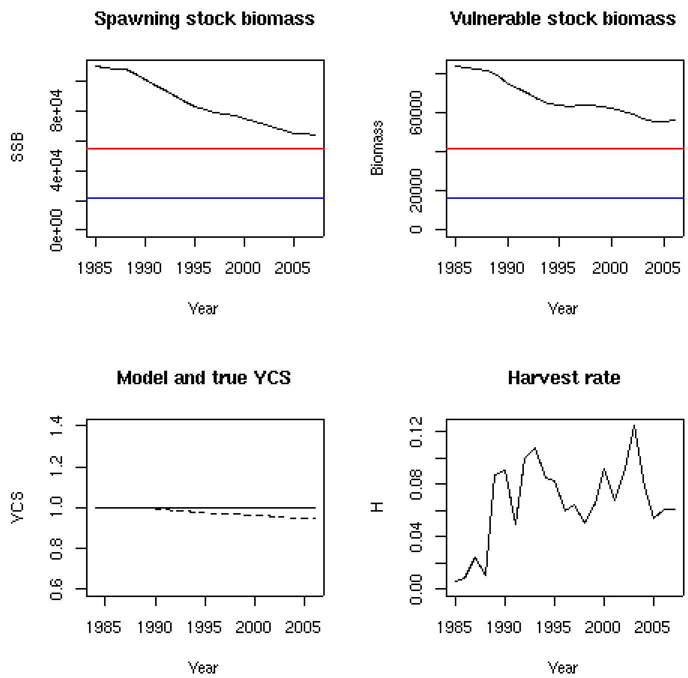

Figure 14: Stock trajectories for the reference model.

34. As can be seen, good fits are achieved to all datasets except the CPUE data for the first fleet, where the fit is poor and a process error with a CV of 0.4 is estimated. The quality of the fit to the early CPUE data, however, must be judged in relation to the high observation errors for most of this series (see Figure 4), and the comments above about the CPUE series (particularly the likely anomalous 1993 CPUE and the abrupt change in the series from 1995 to 1996). With respect to the fits to the tagging data (see Figures 11 to 13), in some cases there is an apparent underestimation of the recaptures of the shorter fish, with some overestimation of the recaptures of larger fish. In a population abundance sense, this suggests that the model is over-estimating the numbers of younger/shorter fish, and under-estimating the numbers of older/longer fish. As to any potential biases in the resultant estimated biomass of fish, given shorter fish are lighter and longer fish are heavier, it is hard to say whether this would introduce a bias in the estimated biomass as well as in the stock numbers.

35. At WG-FSA-06 a number of drivers for this apparent trend were suggested – from recruitment, to growth differences to length-specific tagging reactions to alternate levels of *M* – and the new model in WG-FSA-06/29 ruled out, to some extent, the recruitment and tagging reaction hypotheses, but more work was suggested to look at whether growth changes (beyond the von Bertalanffy paradigm as growth was estimated internally in the model) and/or length-age specific changes in *M* are the root causes of these apparent trends in the fits to the recapture data.

36. Figure 15 shows the likelihood profile for the current assessment model for the virgin biomass parameter. As has been seen in the previous likelihood profiles for this assessment, the length frequencies and the later CPUE possess information on where the minimum levels of B_0 should be, but little if no information on the relative likelihood of higher levels of virgin biomass. This information comes from the tagging data, with the recapture data from the 2004 and 2005 release events giving the strongest such indications – presumably because of a combination of numbers of releases and more recapture events than those from the 2006

release data. As before, the tag-related preferred values of virgin biomass all lie close to each other. Priors and penalties support slightly higher values of virgin biomass, due to an interaction between the two log-uniform priors for the *q* parameters and the log-uniform prior for B_0, and the MPD for B_0 sits slightly to the left (i.e. smaller) than the values the tag data prefer. To make clearer the consistency of the tagging data-predicted estimates of B_0, Figure 16 also has a tag data-specific likelihood profile for the most informative release events – 2004 to 2006. Clearly, the preferred values of the virgin biomass by the three release events are all close, with the 2004 release data preferring a slightly higher value than the 2005 and 2006 release events.

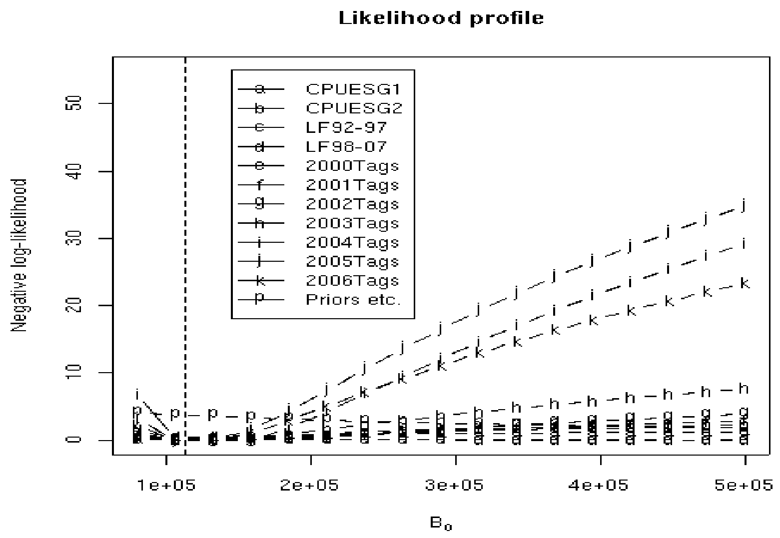

Figure 15: Likelihood profiles for the update model. The legend refers the particular lettered curve in the figure to the relevant dataset etc. used in the assessment.

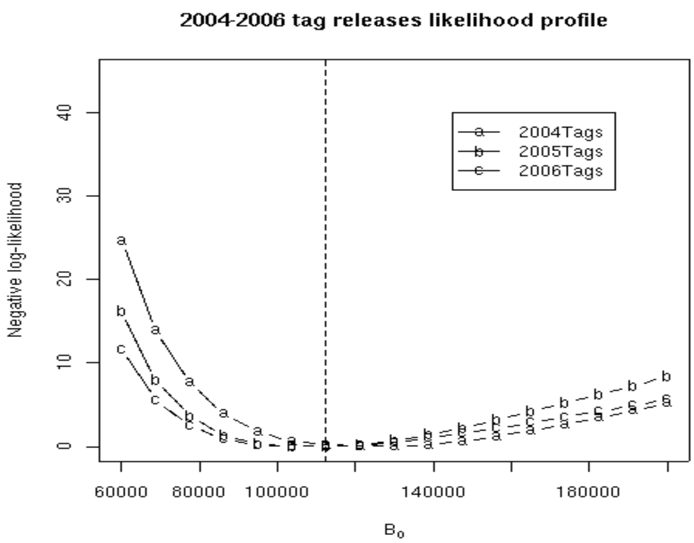

Figure 16: Likelihood profiles for the update model for the tag releases from 2004 to 2006 only.

4.5 MCMC results

37. As can be seen from Table 10, the uncertainty in the MCMC samples about the posterior median is small, due to the continuing precision coming from the tagging data and a similar level of depletion (with associated uncertainty) as was calculated last year – around 59%. The convergence of the MCMC chains was assessed using the methods already outlined in WG-FSA-05 (SC-CAMLR-XXIV, Annex 5).

Table 10: Median biomass and 95% CIs for the initial equilibrium SSB (B_0), the current SSB (B_{2007}), the ratio of current to initial SSB (B_{2007}/B_0), the initial vulnerable biomass (VB_0) and current vulnerable biomass (VB_{2007}) for the reference model.

Model	B_0 (1 000 tonnes)	B_{2007} (1 000 tonnes)	B_{2007}/B_0	VB_0 (1 000 tonnes)	VB_{2007} (1 000 tonnes)
Update	112 (98.7–125)	67.1 (52.9–79.9)	0.59 (0.54–0.64)	85.2 (72.1–97.2)	58.1 (46.5–68.2)

4.6 Sensitivity runs

38. No sensitivity runs were suggested by the Working Group this year. However, the new model presented in WG-FSA-07/29 was presented to the group and there were many suggestions as to future directions for this model, and these are detailed in the future work section.

4.7 Yield calculations

39. CASAL allows the historic stock dynamics to be projected into the future, for a variety of future scenarios. A constant catch projection allows calculation of the long-term yield that satisfies the CCAMLR decision rules:

(i) 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).

(ii) Choose a yield γ_2, so that the median escapement in the SSB over a 35-year period is 50% of the median pre-exploitation level, at the end of the projection period.

(iii) Select the lower of γ_1 and γ_2 as the yield.

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

41. The level of escapement was calculated as the proportion of samples from the Bayesian posterior, where the projected future status of the SSB was below 50% of B_0 in the

respective sample, at the end of the 35-year projection period. For the Subarea 48.3 toothfish CASAL model, the median pre-exploitation spawning biomass was interpreted as the estimate of B_0 for each Monte Carlo sample. This will result in a small downward bias of the status of the stock in each trial, and a small upward 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 constant catches, for each Monte Carlo sample of the Bayesian posterior.

42. Figure 17 shows the historic and future SSB dynamics for a constant yield of 3 920 tonnes projected from 2008 to 2043. As in previous such calculations, it is the escapement rule and not the depletion rule that is invoked.

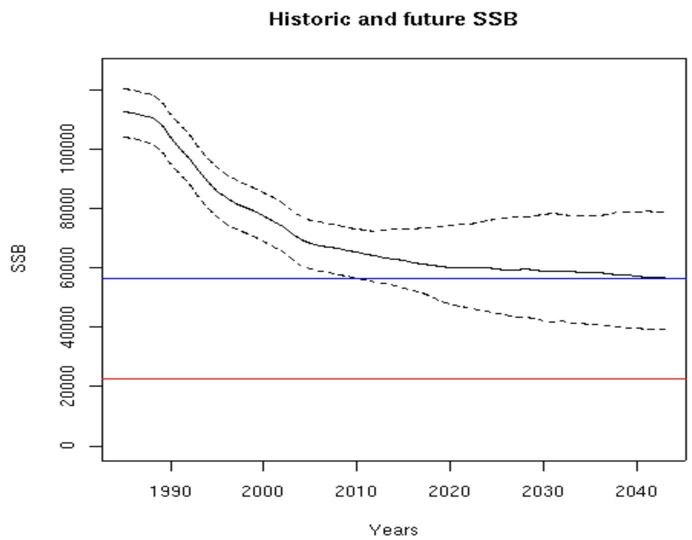

Figure 17: Historic and projected SSB dynamics for a constant future (2008–2043) yield of 3 920 tonnes. The solid line represents the median with the dotted lines representing the 80% credible interval. The blue and red lines are the medians of 50% and 20% of virgin biomass respectively.

4.8 Future work

43. With regards to future developmental work for the stock assessment model used for this stock, the Working Group noted that the new model presented in WG-FSA-07/29 was a marked improvement on the update model used this year for stock assessment purposes. The main features of work suggested for the development of this new model were:

- investigation of the best way to both estimate and include the length-specific trends seen in tag growth-shock and mortality;
- suitable values of future recruitment variability to be used when calculating the yields via projections, given that this model now estimates year-class strength;

- the correct way to estimate the growth parameters within the assessment model, and the potential implications of fixing the t_0 parameter as was done in the paper;
- further investigate the mechanism(s) driving the apparent trends seen in the tag–recapture fits;
- the inclusion of sexual dimorphism within the model.

5. By-catch of fish and invertebrates

5.1 Estimation of by-catch removals

44. The priority by-catch taxa for which assessments of status are required are macrourids and rajids (SC-CAMLR-XXI, Annex 5, paragraphs 5.151 to 5.154). 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 in Table 11.

Table 11: Catch history for by-catch species (macrourids, rajids and other species), catch limits and number of rajids released alive in Subarea 48.3. Catch limits are for the whole fishery (see Conservation Measure 41-02 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)
1987/88	-	0	-	1	-	-	0
1988/89	-	1	-	11	-	-	0
1989/90	-	0	-	1	-	-	0
1990/91	-	1	-	4	-	-	0
1991/92	-	1	-	2	-	-	0
1992/93	-	2	-	0	-	-	0
1993/94	-	0	-	12	-	-	0
1994/95	-	12	-	90	-	-	10
1995/96	-	37	-	54	-	-	0
1996/97	-	34	-	43	-	-	2
1997/98	-	21	-	13	-	-	2
1998/99	-	21	-	19	-	-	9
1999/00	-	18	-	12	-	-	3
2000/01	-	21	-	27	-	-	1
2001/02	291	51	291	25	-	-	29
2002/03	390	75	390	38	-	-	14
2003/04	221	82	221	38	-	-	10
2004/05	152	121	152	9	-	-	20
2005/06	177	137	177	7	21 056	-	38
2006/07	177	131	177	4	9 265	-	27

Estimated cut-off catch

45. Estimates of total mortality for fish cut from longlines in Subarea 48.3 were made in 2003. Sufficient data to repeat these calculations are only available for rajids from 2006/07. An estimate of total mortality was calculated using a linear relationship between full survivorship at depths ≤900 m and zero survivorship at depths >2 000 m.

46. Reported numbers of rajids released were multiplied by the above 'deaths by depth' factor and combined with numbers caught to give an estimate of total mortality by numbers of 5 005 rajids. This number multiplied by an average weight for rajids of 7.42 kg (derived from fine-scale data for Subarea 48.3 for 2006/07) gives an estimate of total rajid mortality by weight of 37 tonnes.

5.2 Assessments of impact on affected populations

47. A preliminary assessment of rajid populations in Subarea 48.3 using a surplus production model implemented in a Bayesian framework was presented at WG-SAM-07 (WG-SAM-07/11). The Working Group noted that there were currently insufficient data to inform the assessment and that the results were strongly dependent on the informative priors for the two catchability parameters, and the intrinsic rate of increase, *r*. However, it also noted that the assessment was likely to be a 'worst-case' scenario, because the *q* for toothfish is likely to be higher than the *q* for rajids. The fits to the CPUE data were generally poor, and the posterior distributions for the two catchability parameters and *r* were very similar to their prior distributions in the base case. When an uninformed prior was used for *K* and the two *q* parameters, the right-hand tail of the posterior distribution of *K* was very wide. It was noted that the assessment should be considered as a risk assessment rather than a stock assessment.

5.3 Mitigation measures

48. By-catch limits and move-on rules are included in the annual conservation measure established for this fishery (Conservation Measure 41-02). In addition, mitigation measures for rajids consist of cutting rajids off lines at the water surface.

6. By-catch of birds and mammals

49. Details of seabird by-catch are summarised in Table 12 (taken from SC-CAMLR-XXVI, Annex 6, Part II, Table 2). Estimated potential seabird removals by IUU fishing are summarised in SC-CAMLR-XXVI/BG/32 and SC-CAMLR-XXVI, Annex 6, Part II, Table 20.

Table 12: Seabird observed mortality rate and total estimated mortality of seabird by-catch in Subarea 48.3 (from SC-CAMLR-XXVI, Annex 6, Part II, Table 2).

Season	Mortality rate (birds per thousand hooks)	Total estimated mortality (number of birds)
1996/97	0.23	5 755
1997/98	0.032	640
1998/99	0.013*	210*
1999/00	0.002	21
2000/01	0.002	30
2001/02	0.0015	27
2002/03	0.0003	8
2003/04	0.0015	27
2004/05	0.0015	13
2005/06	0	0
2006/07	0	0

* Excluding *Argos Helena* line weighting experiment cruise

50. Ad hoc WG-IMAF assessed the level of risk of incidental mortality of seabirds in Subarea 48.3 as category 5 (high) (SC-CAMLR-XXVI/BG/31).

6.1 Mitigation measures

51. Conservation Measure 25-02 applies to this subarea.

6.2 Interactions involving marine mammals with longline fishing operations

52. Interactions with cetaceans continue to be reported by observers in Subarea 48.3. However, there has been a decline in the percentage of sets affected by cetacean interactions from 25% in 2005/06 to 15% in 2006/07.

7. Ecosystem effects

53. The Working Group did not examine the ecosystem effects of the longline fishery for toothfish in Subarea 48.3.

8. Harvest controls and management advice

8.1 Conservation measures

54. The limits on the fishery for *D. eleginoides* in Subarea 48.3 are defined in Conservation Measure 41-02. The limits in force in 2006/07 and the Working Group's advice to the Scientific Committee for the forthcoming 2007/08 season are summarised in Table 13.

Table 13: Limits on the fishery for *Dissostichus eleginoides* in Subarea 48.3 in 2006/07 (Conservation Measure 41-02) and advice to the Scientific Committee for 2007/08.

Element	Limit in 2006/07	Advice for 2007/08
Access (gear)	Longlines and pots only	Carry forward
Subdivision of Subarea 48.3	Definition of area open to the fishery	Carry forward
Closure of other areas of Subarea 48.3	Closure of fishing outside the area of the fishery	Carry forward
Catch limit	Catch limit for *D. eleginoides* was 3 554 tonnes for the subarea, applied as follows: Management Area A: 0 tonnes Management Area B: 1 066 tonnes Management Area C: 2 488 tonnes.	Review
Season: longline	1 May to 31 August Extension possible to 14 September for vessels complying fully with CM 25-02 in 2005/06.	Same period Update
pots	1 December to 30 November	Same period
seabirds	During extension period (1–14 September) any vessel catching three (3) seabirds to cease fishing.	Carry forward
By-catch: crabs	By-catch of crabs to be counted against crab catch limit.	Carry forward
finfish	Total combined catch of skates and rays 177 tonnes. Total catch of *Macrourus* spp. 177 tonnes.	Revise as pro-rata calculation on catch limit
any species	Move-on rule	Carry forward
Mitigation	In accordance with CM 25-02.	Carry forward
Observers	Each vessel to carry at least one CCAMLR scientific observer and may include one additional scientific observer.	Carry forward
Data	Five-day catch and effort reporting under CM 23-01. Haul-by-haul catch and effort data under CM 23-03. 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, *D. eleginoides* is the target species and the by-catch is any species other than *D. eleginoides*.	Carry forward
Jellymeat	Number and weight of *D. eleginoides* discarded, including those with jellymeat condition, to be reported. These catches count towards the catch limit.	Carry forward
Research fishing	Research fishing under CM 24-01 limited to 10 tonnes of *D. eleginoides* green weight and a single vessel in Management Area A.	Carry forward
Environmental protection	Regulated by CM 26-01.	Carry forward

8.2 Management advice

55. The Working Group recommended that the catch limit for toothfish in Subarea 48.3 (SGSR stock) should be 3 920 tonnes for the 2007/08 fishing season.

56. The Working Group noted that the current model had produced a yield of 3 920 tonnes when updated with catch, length-frequency, CPUE and tagging data from 2007. It noted that some uncertainties with the assessment remain, such as the fits to the tag data. A significant revision of the model is under development, which will allow direct estimation of present and future recruiting cohort strength, which is not possible with the current model. The catch limit for 2008/09, if estimated with this new model, may be different from 3 920 tonnes.

57. The catch limits for management areas A, B and C should be adjusted in a pro-rata manner to 0 (excepting 10 tonnes for research fishing), 1 176 and 2 744 tonnes respectively. By-catch limits for skates/rays and macrourids should be similarly revised to 196 and 196 tonnes respectively.