APPENDIX F

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

# CONTENTS

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## 1. Details of the fishery

### 1.1 Reported catch

The number of vessels active in Subareas 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 2004/05 (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 | 253 | 0 | 253 |
| Australia | 1* | 0 | 0 | 0 | 0 |
| New Zealand | 5 | 3 | 1499 | 1 | 1500 |
| Norway | 1 | 1 | 207 | 0 | 207 |
| Russia | 2 | 2 | 487 | 5 | 492 |
| South Africa | 2 | 0 | 0 | 0 | 0 |
| Spain | 2 | 0 | 0 | 0 | 0 |
| Ukraine | 1+ | 0 | 0 | 0 | 0 |
| UK | 1 | 1 | 260 | 0 | 260 |
| Uruguay | 4 | 2 | 367 | 0 | 367 |
| Total | 21 | 10 | 3073 | 6 | 3079 |

* Withdrawn from fishery
\+ Vessel withdrawn from fishery

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 2004/05 (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 | 0 | 0 | 0 | 0 |
| New Zealand | 5 | 1 | 268 | 0 | 268 |
| Norway | 1 | 1 | 4 | 0 | 4 |
| Russia | 2 | 2 | 141 | 0 | 141 |
| Total | 10 | 4 | 412 | 0 | 412 |

2. The catch limit for *Dissostichus* spp. in Subarea 88.1 was 3 250 tonnes, and for Subarea 88.2 was 375 tonnes.

3. The fishery was active from 1 December 2004 to 27 March 2005 for Subarea 88.1, and 1 December 2004 to 5 February 2005 for Subarea 88.2.

4. The 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%.

5. The catch of *D. mawsoni* has shown a steadier increasing trend over the same period, peaking at 3 073 tonnes in Subarea 88.1 and 412 tonnes in Subarea 88.2 for the 2004/05 season. There has been a general trend towards fishing deeper up until 2002/03, with a small decrease in 2003/04, and again in 2004/05 (WG-FSA-05/29).

6. The total catch for Subarea 88.1 was about 95% of the catch limit, with catch limits in SSRUs C and E (see Figure 3) exceeded by 206 and 2 tonnes respectively. Unlike in 2003/04, ice conditions were very good and allowed vessels access to most of the main fishing grounds in the southern SSRUs (WG-FSA-05/29).

7. In Subarea 88.2, the catch limit of 375 tonnes was over-caught (412 tonnes), and was closed on 5 February 2005. Fishing was carried out in SSRUs 882A, B and E. Most of the catch (270 tonnes) was taken in SSRU 882E.

8. It was noted that the catch limit for SSRU 881C was exceeded due to high catch rates within that SSRU and the time delay (including confusion resulting from the SSRU straddling the International Date Line) in the receipt of 5-day catch reports (CCAMLR-XXIV/BG/13). Catch limits were over-run on two other occasions (SSRU 881E and Subarea 88.2). Key factors in these over-runs included rapid changes in fishing effort and/or catches, and the late submission of catch and effort reports (CCAMLR-XXIV/BG/13).

9. The historical catches for Subareas 88.1 and 88.2 are given in Tables 3 and 4.

Table 3: Catch history for *Dissostichus* spp. in Subarea 88.1 (source: STATLANT data to 2003/04, and catch and effort data in 2004/05).

| 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 | 3079 | 144 | 3252 | 3250 |

Table 4: Catch history for *Dissostichus* spp. in Subarea 88.2 (source: STATLANT data to 2003/04, and catch and effort data in 2004/05).

| 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 | 412 | 0 | 412 | 375 |

### 1.2 IUU catch

10. The total estimated IUU catch in Subarea 88.1 was 144 tonnes in 2004/05 (SCIC-05/10 Rev. 2). The estimated IUU catch in Subarea 88.1 in previous years was 92 tonnes in 2001/02 and 240 tonnes in 2003/04 (WG-FSA-05/6 Rev. 1).

11. There was estimated to be no IUU catch in Subarea 88.2 in 2004/05, as was the case for previous years.

### 1.3 Size distribution of the catches

12. *Dissostichus mawsoni* ranged from 50 to 180 cm (Figures 1 and 2). In all years, there was a broad mode of adult fish at about 120–170 cm.

13. 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 two years as a result of changed SSRU boundaries and reallocation of allowed catch. In some years there have been additional modes of smaller fish, reflecting fishing on the Ross Sea shelf (WG-FSA-05/52). 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-05/29).

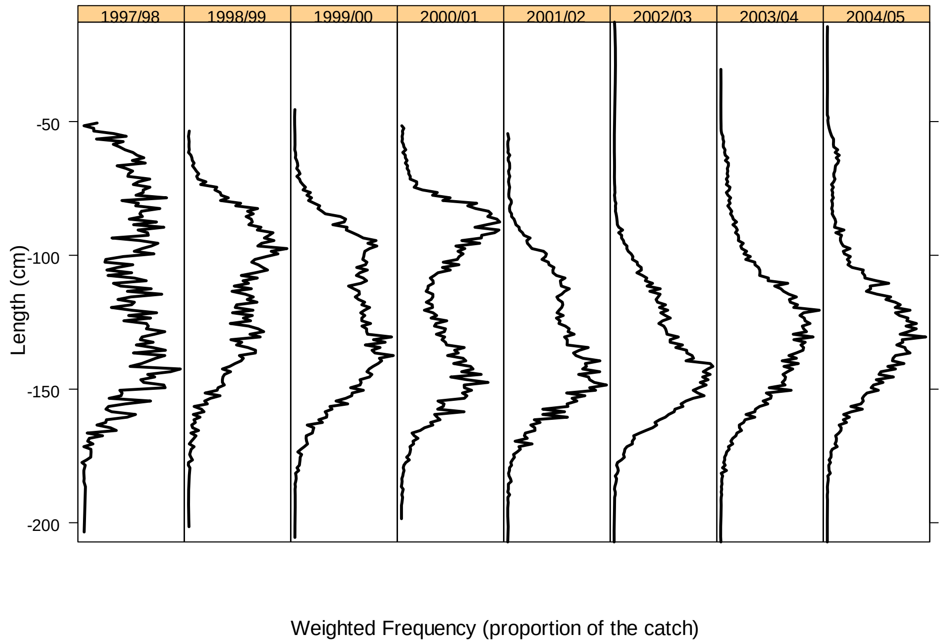


Figure 1: Catch-weighted length frequencies for *Dissostichus mawsoni* in Subarea 88.1 derived from observer, fine-scale and STATLANT data reported by 5 October 2005.

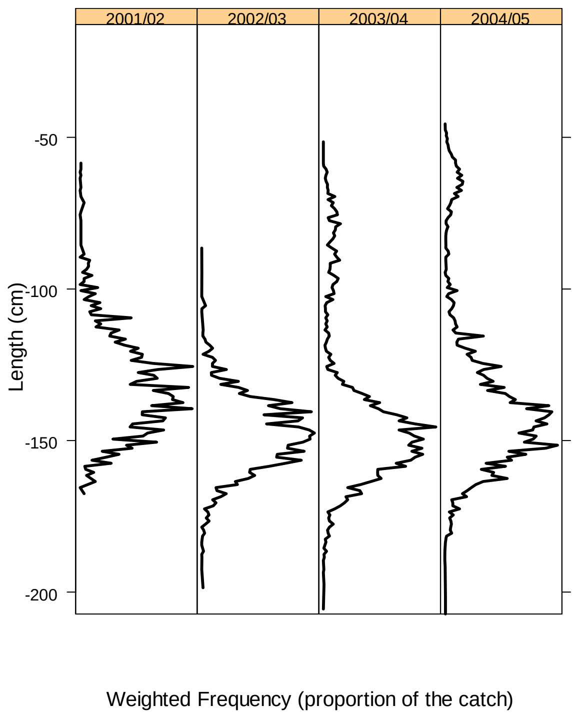


Figure 2: Catch-weighted length frequencies for *Dissostichus mawsoni* in Subarea 88.2 derived from observer, fine-scale and STATLANT data reported by 5 October 2005.

## 2. Stocks and areas

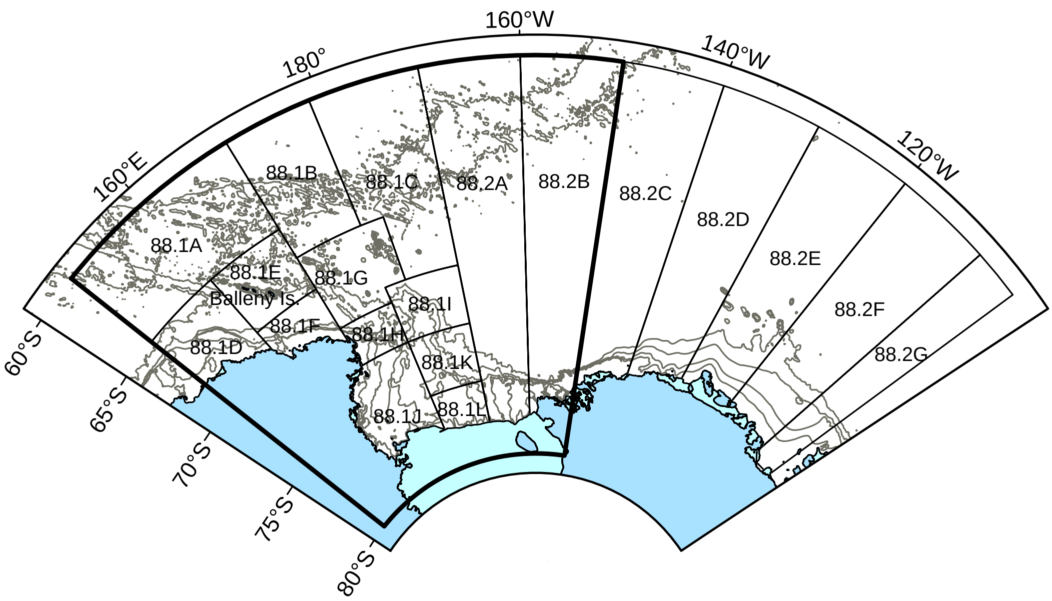


Figure 3: Subareas 88.1 and 88.2, SSRUs and the Ross Sea (bounded region). Depth contours plotted at 500, 1 000, 2 000 and 3 000 m.

14. 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). The weak genetic differentiation is supported by oceanic gyres, which may act as juvenile retention systems, and by limited movement of adult tagged fish.

15. 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-04/35, 04/28 Rev. 1, 05/28, 05/52).

16. 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. The Working Group also recommended that further research be undertaken on the stock structure of *D. mawsoni*.

## 3. Parameter estimation

### 3.1 Observations

Standardised CPUE

17. 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 (WG-FSA-05/32). 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.

18. 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. This pattern was similar in all three areas. The significant model terms were year/area, vessel, hooks, soak time, month, depth and fishing code (research or exploratory set). The resulting $r^2$ was 41.7%.

19. A similar model was used to estimate annual indices for SSRU 882E. Significant model terms were number of hooks, soak time, month and vessel. The resulting $r^2$ was 28.9%.

20. The CPUE indices for the Ross Sea (Subarea 88.1 and SSRUs 882A–B) are given in Table 5, and for SSRU 882E in Table 6.

Table 5: Standardised CPUE indices, 95% confidence intervals and CVs for the three fisheries (shelf, slope and north) from 1998/99 to 2004/05.

| Season | Shelf | | | Slope | | | North | | |
|---|---|---|---|---|---|---|---|---|---|
| | Index | 95% CI | CV | Index | 95% CI | CV | Index | 95% CI | CV |
| 1998/99 | 0.73 | 0.53–1.00 | 0.16 | 0.76 | 0.65–0.88 | 0.07 | - | - | - |
| 1999/00 | 1.24 | 1.01–1.51 | 0.10 | 1.07 | 0.96–1.20 | 0.06 | - | - | - |
| 2000/01 | 0.65 | 0.55–0.76 | 0.08 | 0.94 | 0.81–1.10 | 0.08 | 0.60 | 0.50–0.72 | 0.09 |
| 2001/02 | 2.32 | 1.56–3.44 | 0.20 | 1.66 | 1.45–1.89 | 0.07 | 1.86 | 1.49–2.33 | 0.11 |
| 2002/03 | 0.93 | 0.50–1.70 | 0.31 | 1.16 | 1.00–1.33 | 0.07 | 1.09 | 0.96–1.24 | 0.06 |
| 2003/04 | 0.83 | 0.70–0.97 | 0.08 | 0.75 | 0.68–0.82 | 0.05 | 0.49 | 0.42–0.56 | 0.07 |
| 2004/05 | 1.49 | 1.29–1.72 | 0.07 | 1.44 | 1.30–1.59 | 0.05 | 0.70 | 0.60–0.82 | 0.08 |

Table 6: Standardised CPUE indices, 95% confidence intervals and CVs, 2002/03–2004/05.

| Year | Index | 95% CI | CV |
|---|---|---|---|
| 2002/03 | 1.27 | 0.77–2.08 | 0.25 |
| 2003/04 | 0.94 | 0.71–1.24 | 0.14 |
| 2004/05 | 0.84 | 0.58–1.22 | 0.19 |

### Catch-at-age

21. 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.

22. 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 (Figure 4) and SSRU 882E (Figure 5) (WG-FSA-05/29).

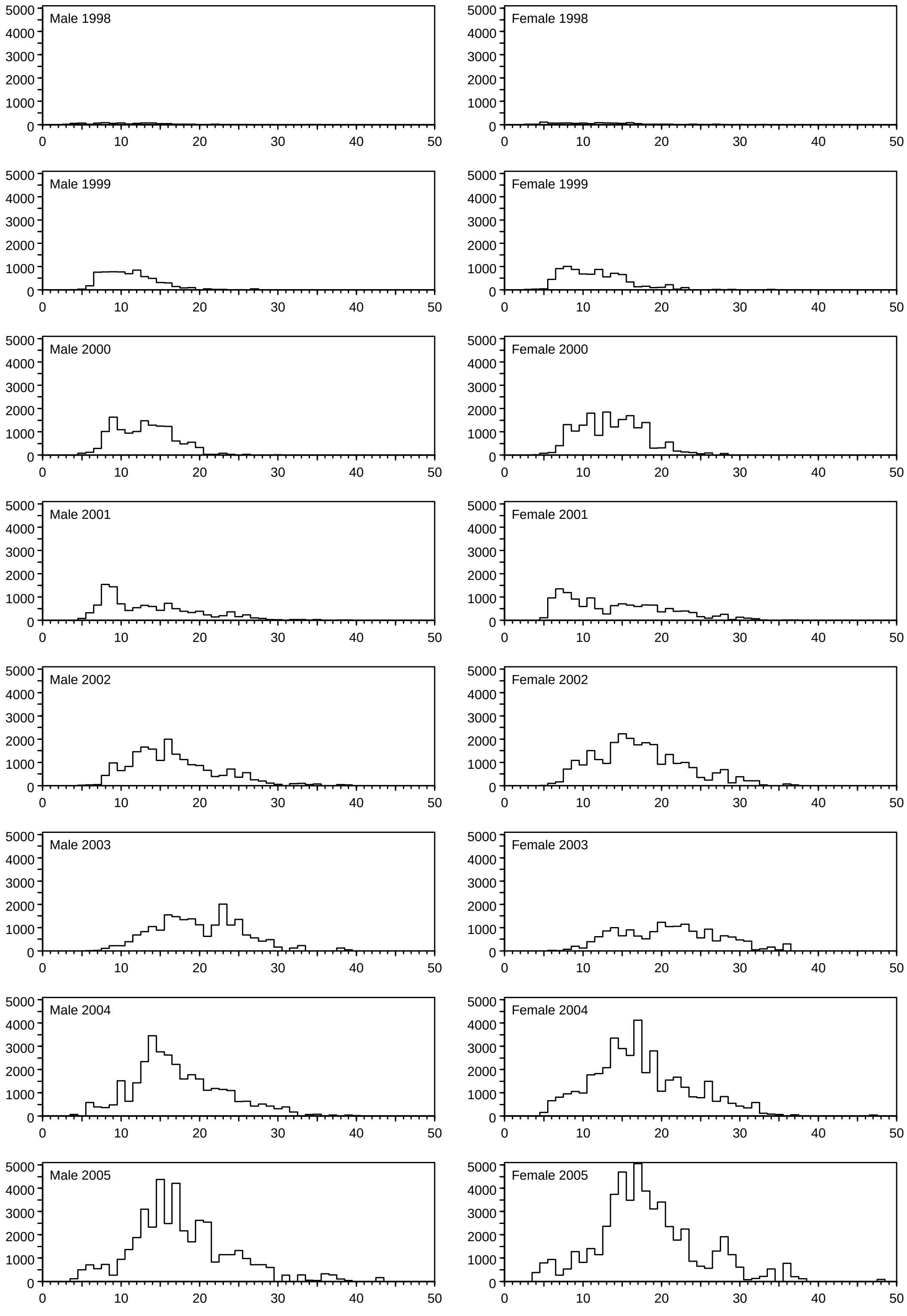


Figure 4: Scaled age-frequency distribution of male and female *D. mawsoni* from 1998 to 2005 from the Ross Sea.

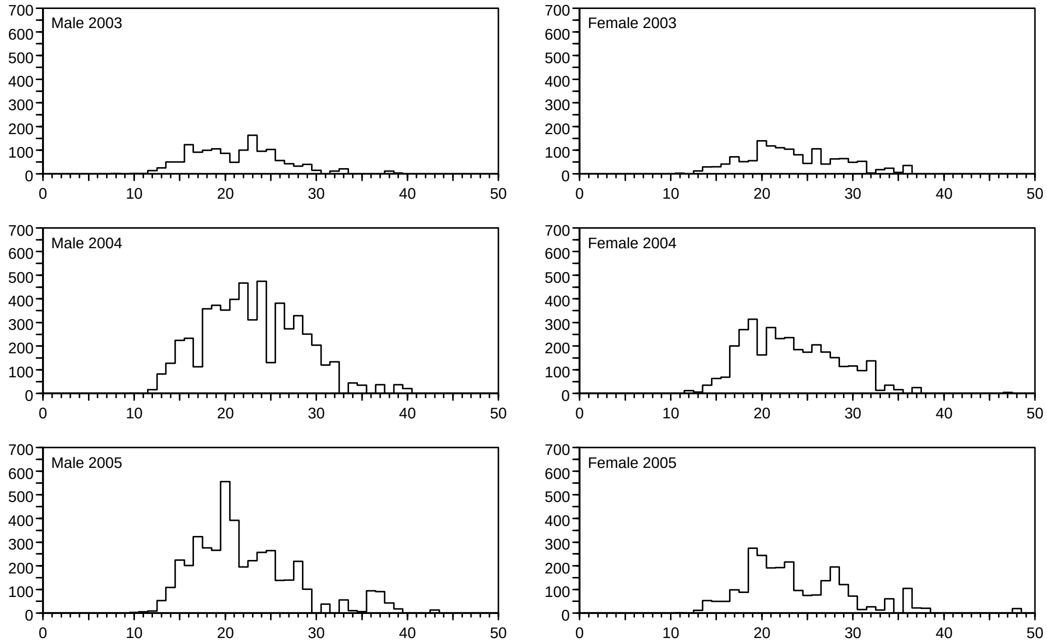


Figure 5: Scaled age-frequency distribution of male and female *D. mawsoni* from 2003 to 2005 from SSRU 882E.

Tag release and recapture

23. The tagging program for *Dissostichus* spp. in the Ross Sea was first initiated in the 2000/01 season in Subarea 88.1 by New Zealand vessels. Since then, the toothfish tagging program has been extended to all vessels participating in the fishery and to Subarea 88.2.

24. In 2004/05, a total of 3 562 *Dissostichus* spp. were tagged in Subareas 88.1 and 88.2 (Table T2). Since 2000/01, a total of 5 346 toothfish have been tagged in Subareas 88.1 and 88.2 by New Zealand vessels (WG-FSA-05/34). Table 7 gives the number of releases and recaptured *D. mawsoni* for the Ross Sea, and Table 8 for SSRU 882E from New Zealand vessels, which were used as inputs for the modelling. Data for other vessels were unavailable for the assessment.

Table 7: Numbers of *Dissostichus mawsoni* with tags released for the years 2001–2005 by New Zealand vessels, and the numbers recaptured in 2001–2005 (ignoring within-season recaptures) by New Zealand vessels.

| Tagged fish released | | Tagged fish recaptured | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Number | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
| 2001 | 259 | - | 1 | 1 | 0 | 0 | 2 |
| 2002 | 650 | - | - | 5 | 3 | 5 | 13 |
| 2003 | 857 | - | - | - | 7 | 7 | 14 |
| 2004 | 863 | - | - | - | - | 16 | 16 |
| 2005 | 1 518 | - | - | - | - | - | - |
| Total | 4 147 | 0 | 1 | 6 | 10 | 28 | 45 |

Table 8: Numbers of *Dissostichus mawsoni* with tags released for the years 2003–2005 by New Zealand vessels, and the numbers recaptured in 2003–2005 by New Zealand vessels.

| Tagged fish released | | Tagged fish recaptured | | | |
|---|---|---|---|---|---|
| Year | Number | 2003 | 2004 | 2005 | Total |
| 2003 | 94 | 0 | 1 | 1 | 2 |
| 2004 | 393 | - | - | 10 | 10 |
| 2005 | 269 | - | - | - | - |
| Total | 756 | 0 | 1 | 11 | 12 |

### 3.2 Fixed parameter values

25. Natural mortality, length–mass, growth and maturity parameters for *D. mawsoni* in Subareas 88.1 and 88.2 are given in Table 9.

Table 9: Parameter values for *Dissostichus mawsoni* in Subareas 88.1 and 88.2.

| Component | Parameter | Value | | | Units |
|---|---|---|---|---|---|
| | | Male | Female | All | |
| Natural mortality | $M$ | 0.15 | 0.15 | | $y^{-1}$ |
| VBGF | $K$ | 0.102 | 0.095 | | $y^{-1}$ |
| VBGF | $t_0$ | 0.31 | 0.50 | | y |
| VBGF | $L_\infty$ | 170.3 | 184.5 | | cm |
| Length to mass | ‘*a*’ | 0.00000986 | 0.00000617 | | cm, kg |
| Length to mass | ‘*b*’ | 3.0335 | 3.1383 | | |
| 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 | $\sigma_R$ | | | 0.7 | |
| 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

26. The CASAL stock models were sex- and age-structured, with ages from 1–50, and where 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 10. Various model structures were investigated, and the base-case model and sensitivity models are described below (WG-FSA-05/31 and 05/33). A complete description of the CASAL modelling software is given in WG-FSA-05/P3.

Table 10: 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.

27. The models were run from 1995 to 2005, 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.

28. The base-case model was implemented as a single-area, three-fishery model. A single area was defined with the catch removed using three concurrent fisheries (slope, shelf and north). Each fishery was parameterised by a sex-based double-normal selectivity ogive (i.e. domed selectivity) and allowed for annual selectivity shifts that shifted left or right with changes in the mean depth of the fishery. 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.

29. 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.

30. 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.

Model estimation

31. 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.

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

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

*Observation assumptions*

34. The catch proportions-at-age data for 1998–2005 were fitted to the modelled proportions-at-age composition using a multinomial likelihood for the Ross Sea, and for 2003–2005 for SSRU 882E.

35. 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.

36. Tag–release events were defined for the years 2001–2004 for the Ross Sea, and 2003–2004 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.

37. 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, 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.

38. 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*

39. 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.

40. 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), and the procedure for calculating the additional process error is described below.

### *Penalties*

41. 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*

42. Within a Bayesian model, all free parameters estimated require both the definition of a prior and bounds that constrain the estimation. The estimated parameters, starting values for the minimisation and bounds are given in Table 11. In models presented here, priors were chosen that were relatively non-informative but also encouraged conservative estimates of $B_0$. However, one sensitivity investigated the use of a uniform-log prior in the CPUE catchability constant $q$ (CPUE priors). Otherwise, priors and bounds for the remaining parameters in the sensitivity runs were as for the base case.

Table 11: 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 | $1 \times 10^4$ | $1 \times 10^6$ |
| CPUE $q$ | | 3 | - | Uniform | $1 \times 10^{-10}$ | $1 \times 10^{-1}$ |
| 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 |
| TRGR period (y) | $g$ | 1 | 0.75 | Uniform | 0.0 | 1.0 |

### Yield calculations

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

1. Choose a yield, $\gamma_1$, so that the probability of the spawning biomass dropping below 20% of its pre-exploitation level over a 35-year harvesting period is 10%, calculated as the proportion of samples from the Bayesian posterior where the predicted future spawning stock biomass (SSB) is below 20% of $B_0$ in any one year, for each year over a 35-year projected period (Rule 1).

2. Choose a yield, $\gamma_2$, so that the escapement in the SSB over a 35-year period is 50% of the pre-exploitation level, calculated as the proportion of samples from the Bayesian posterior where the predicted future SSB is below 50% of $B_0$ at the end of a 35-year projected period (Rule 2).

3. Select the lower of $\gamma_1$ and $\gamma_2$ as the yield (Rule 3).

44. Hence, for each sample from the posterior distribution estimated for each model, the stock status was projected forward 35 years under a scenario of a constant annual catch (i.e. for the period 2006–2040). Recruitment from 1995–2039 was assumed to be lognormally distributed with a standard deviation of 0.7 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 2005 catch, 14.8, 68.0 and 17.2% 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 1998–2005 for the Ross Sea, and 2003–2005 for SSRU 882E.

45. The decision rules were evaluated by estimating the maximum future catch that meets the decision rule criteria. Note that, in previous years, the total catch limit has not often been taken. Ice cover over fishable depths in some SSRUs has meant that fishing vessels were

unable to access some of the available quota. 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

46. Model runs were conducted for the base case and the sensitivity runs for the Ross Sea model described in Table 12. A single sensitivity run was investigated for the SSRU 882E model, where selectivity ogives were assumed to be logistic (i.e. no declining right-hand limb). Sensitivity runs were determined as modifications to the base-case runs, and were chosen to investigate the effect of alternative assumptions of parameters estimated within the model or alternative assumptions to the stock productivity parameters.

Table 12: Labels and description of the sensitivity runs for the Ross Sea model.

| | Model run | Description |
|---|---|---|
| 1 | Base | Base-case run |
| 2 | No tag | Same as the base case, but excluding all tag–recapture observations. |
| 3 | TRGR estimated | Same as the base case, but with the TRGR period estimated. |
| 4 | Constant shift | Same as the base case, but setting the selectivity shift equal across all three fisheries. |
| 5 | No shift | Same as the base case, but excluding any selectivity shift. |
| 6 | No TRGR | Same as the base case, but assuming no TRGR. |
| 7 | Low *M* | Same as the base case, but with *M* assumed to be 0.1 $y^{-1}$. |
| 8 | Maturity | Same as base case, but with the revised maturity ogive (115 ±15 cm). |
| 9 | Single fishery | Same as the base case, but with only one fishery and associated selectivity. |
| 10 | Fixed selectivity | Same as the base case, but with the fishing selectivities fixed at the MPD values. |
| 11 | Three-area | Similar assumptions to the base case, but splitting the Ross Sea into three separate populations based on the definitions of the three fisheries. |

### 4.2 Model estimates

MCMC diagnostics and multi-chain comparison

47. For the base-case model run for the Ross Sea, three sets of MCMC samples from the posterior were estimated. Estimates of $B_0$ and the derived parameters $B_{2005}$ and $B_{2005}$ (%$B_0$) for each chain, and the combined chain, are given in Table 13. MCMC diagnostics between the three chains were similar, with trace plots showing no evidence of poor convergence in the key biomass parameters. Between-sample autocorrelations were also low, but there was some evidence of non-convergence in the right-hand declining limb of both the male and female selectivity curves in each of the three fisheries.

48. No multiple chain comparisons were run for the SSRU 882E model, but MCMC convergence tests suggested that the chains had converged for the key output parameters.

Table 13: Median MCMC estimates (and 95% credible intervals) for the Ross Sea model of $B_0$, $B_{2005}$, and $B_{2005}$ as $\%B_0$ for the three chains for the base-case model.

| Chain | $B_0$ | $B_{2005}$ | $B_{2005}$ ($\%B_0$) |
|---|---|---|---|
| 1 | 69 080 (47 920–109 410) | 60 900 (39 800–101 300) | 88.2 (83.0–92.6) |
| 2 | 70 610 (47 580–112 630) | 62 470 (39 450–104 490) | 88.5 (82.9–92.8) |
| 3 | 68 910 (47 690–112 490) | 60 760 (39 560–104 340) | 88.2 (82.9–92.8) |
| Combined | 69 420 (47 690–111 930) | 61 280 (39 560–103 790) | 88.3 (82.9–92.7) |

Ross Sea model estimates

49. Key output parameters for the base and sensitivity cases are summarised in Table 14. MCMC estimates of initial (equilibrium) spawning stock abundance ($B_0$) were 69 400 tonnes (95% credible intervals 47 700–111 900 tonnes), and current ($B_{2005}$) biomass was estimated as 88% $B_0$ (95% CIs 83–93%). The biomass trajectory is shown in Figure 6.

50. The model suggested that the decline in biomass due to fishing has been slight, and that current biomass is likely to be between 81–94% $B_0$. 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.

51. 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. Estimated selectivity curves for the base-case model (Figure 7) appeared reasonable, with strong evidence of dome-shaped selectivity in two of the three fisheries, but to a lesser extent in the shelf fishery.

52. Without tag–recapture data, model estimates were highly uncertain and MCMC estimates ranged between the model lower and upper bounds (10 000–1 000 000 tonnes). The exclusion of the depth shift parameter on fishing selectivity resulted in a higher estimate of initial and current biomass, as did an assumption of a lower value of natural mortality (although this also implies a lower productivity). Assuming a higher length of maturity, resulted in a lower estimate of initial and current biomass. A sensitivity for the three-area-based models (sensitivity 12) was estimated at the MPD only (Table 15). Estimates from the three-area models were obtained for the slope and north areas. The lack of recapture data from the shelf resulted in a lack of convergence in that model. The combined initial spawning stock biomass from the slope and north areas was 47 260 tonnes. This estimate was lower than the base case, but the reason for this was not clear.

Table 14: Median MCMC estimates (and 95% credible intervals) for the Ross Sea model of $B_0$, $B_{2005}$ and $B_{2005}$ as $\%B_0$ for the base-case and sensitivity models.

| | Model | $B_0$ | $B_{2005}$ | $B_{2005}$ ($\%B_0$) |
|---|---|---|---|---|
| 1 | Base case | 69 420 (47 690–111 930) | 61 280 (39 560–103 790) | 88.3 (82.9–92.7) |
| 7 | Low *M* | 94 140 (64 300–144 650) | 85 080 (55 240–135 610) | 90.4 (85.9–93.8) |
| 8 | Maturity | 60 090 (40 310–94 540) | 52 230 (32 490–86 650) | 86.9 (80.6–91.7) |

Table 15: MPD estimates of $B_0$, $B_{2005}$ and $B_{2005}$ as $\%B_0$ for the three-area-based Ross Sea sensitivity models.

| Area | $B_0$ | $B_{2005}$ | $B_{2005}$ ($\%B_0$) |
|---|---|---|---|
| Shelf | No convergence | - | - |
| Slope | 30 710 | 25 440 | 81.5 |
| North | 16 550 | 14 490 | 86.3 |

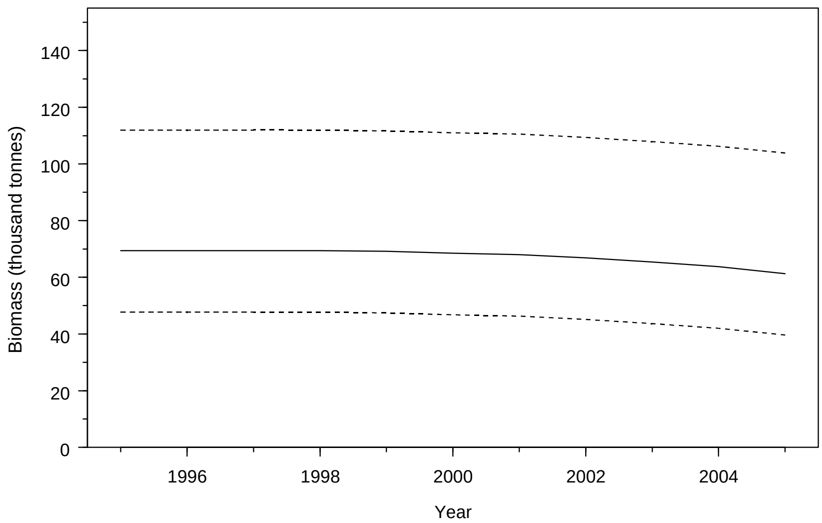


Figure 6: Estimated spawning stock biomass median (solid line) and 95% credible intervals (dashed lines) for the base-case Ross Sea model.

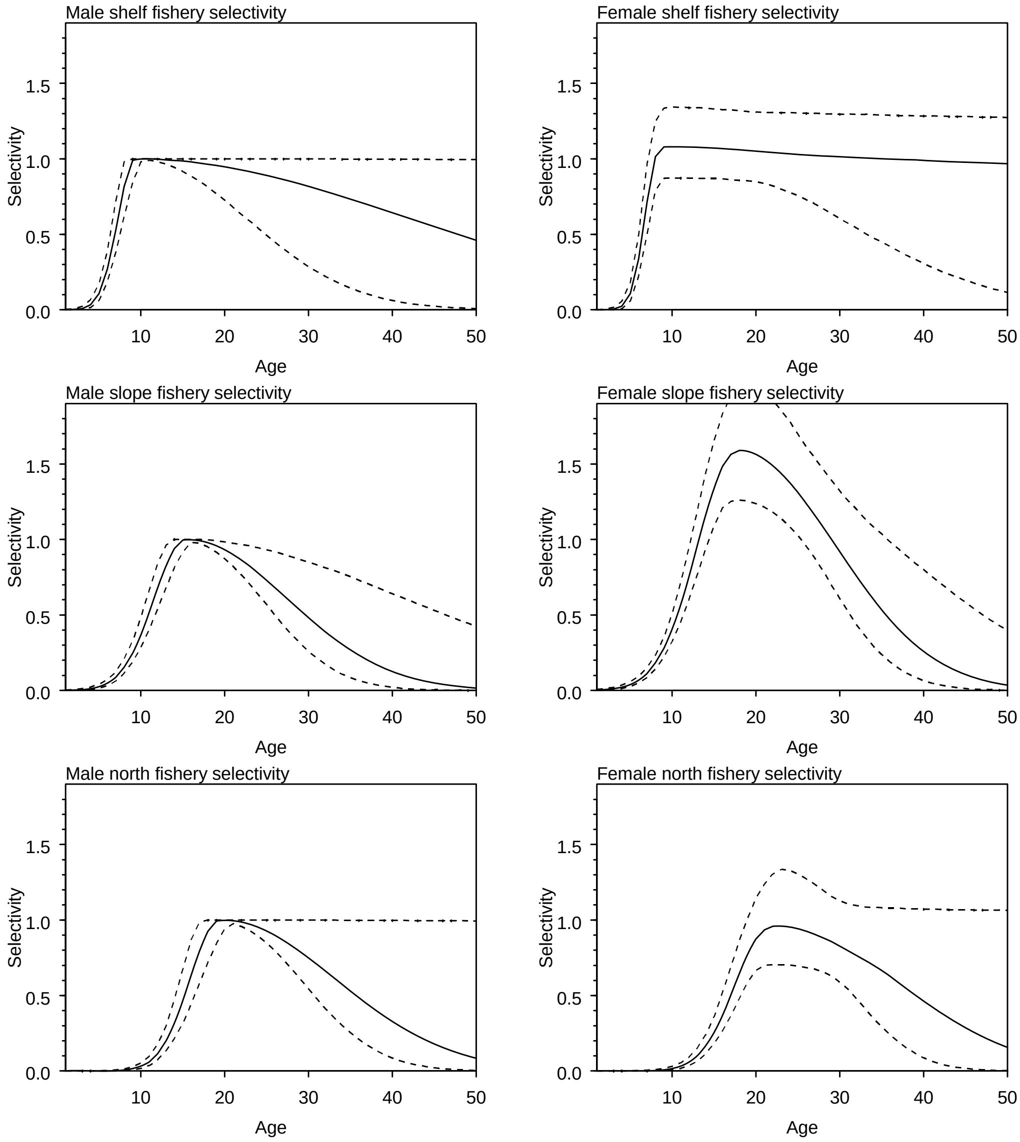


Figure 7: Estimated male and female selectivity ogives for the shelf, slope and north fisheries for the base-case Ross Sea model (solid lines indicate the median, and dashed lines indicate the marginal 95% credible intervals).

<u>SSRU 882E model estimates</u>

53. Key output parameters for the base and sensitivity case are summarised in Table 16. Estimated initial equilibrium mid-season SSB ($B_0$) ranged from 3 600–23 000 tonnes, with current biomass at about 7 720 tonnes (95% CIs 3 760–22 240 tonnes). The biomass trajectory is shown in Figure 8.

54. 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 83–97% $B_0$. 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.

55. 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 9) 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.

56. Model estimates for the logistic sensitivity were slightly more optimistic (8 620 tonnes, with 95% CIs 4 030–23 590 tonnes), but the fits to the proportions-at-age data suggested some evidence that domed selectivity patterns were more likely.

Table 16: Median MCMC estimates (and 95% credible intervals) for the SSRU 882E model of $B_0$, $B_{2005}$ and $B_{2005}$ as $\%B_0$ for the base-case and sensitivity model.

| Model | $B_0$ | $B_{2005}$ | $B_{2005}$ ($\%B_0$) |
|---|---|---|---|
| Base case | 7 720 (3 760–22 240) | 7 090 (3 120–21 610) | 91.8 (83.1–97.1) |
| Logistic | 8 260 (4 030–23 590) | 7 630 (3 400–22 960) | 92.4 (84.4–97.3) |

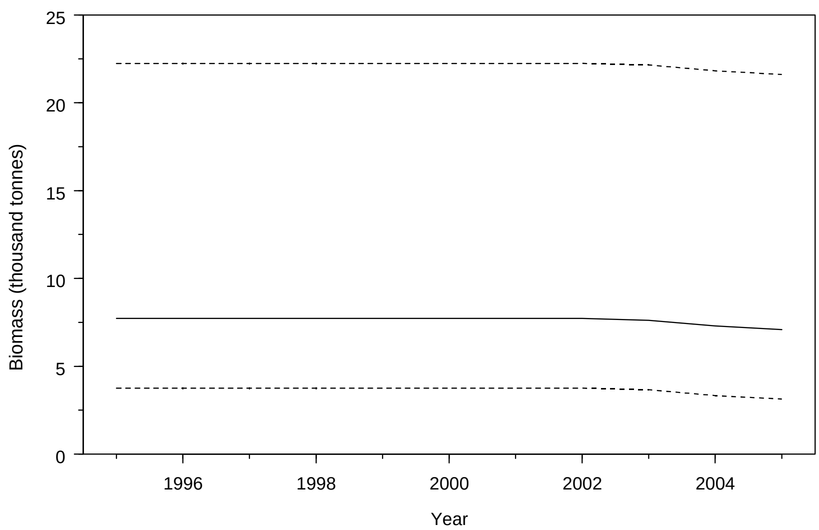


Figure 8: Estimated spawning stock biomass median (solid line) and 95% credible intervals (dashed lines) for the base-case SSRU 882E model.

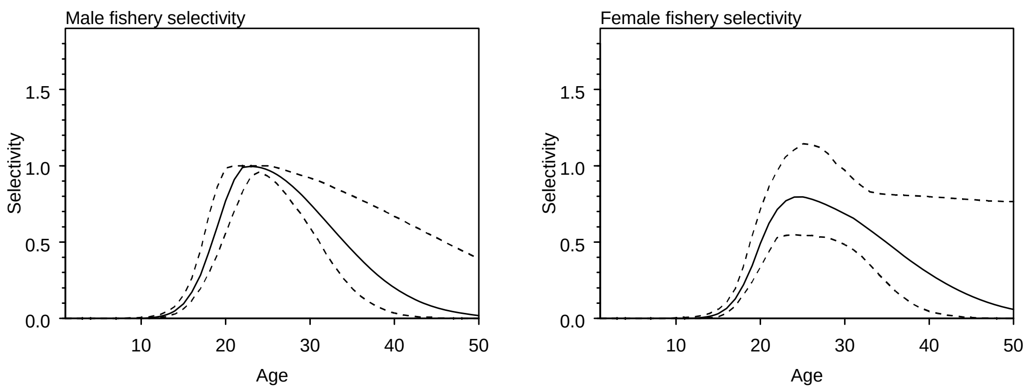


Figure 9: Estimated male and female selectivity ogives for the base-case SSRU 882E model (solid lines indicate the median, and dashed lines indicate the marginal 95% credible intervals).

### 4.3 Yield estimates

Ross Sea

57. The constant catch for which there was median escapement of 50% of the median pre-exploitation spawning biomass level at the end of the 35-year projection period was 2 964 tonnes. At this yield there is a less than 10% chance of spawning biomass dropping to less than 20% of the initial biomass. Following the third CCAMLR rule, the yield of 2 964 tonnes is recommended.

SSRU 882E

58. The constant catch where the median escapement of 50% of the pre-exploitation spawning biomass level at the end of the 35-year projection period was 50%, was 670 tonnes. At this yield there is a less than 10% chance of spawning biomass dropping to less than 20% of the initial biomass. However, at this level of catch, exploitation rates were constrained by the maximum exploitation rate ($U_{max}$ = 1.0) in 86% of runs, and the mean catch achieved was only 454 tonnes. This was because the fishing selectivity was estimated to be to the right of the maturity ogive, there was a significant biomass of mature, but ‘invulnerable’ fish in the projection period.

59. Two revised methods for assessing risk were calculated. The first assumed that the future fishing selectivity was equal to the maturity ogive. The second used the model estimate of the vulnerable biomass, not spawning biomass, as the reference biomass in the risk evaluation.

60. Under the first alternative, the constant catch for which there was a 10% chance of spawning biomass dropping to less than 20% of the initial biomass was 273 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%. The Working Group recommended that, as future fishing selectivity was likely to change as the fishery developed, this was the most reasonable assumption for determining the yield.

61. Under the second alternative, the constant catch for which there was a 10% chance of vulnerable biomass dropping to less than 20% of the initial vulnerable biomass, was 218 tonnes. At this yield, the median escapement of 50% of the pre-exploitation vulnerable biomass level at the end of the 35-year projection period was 66%.

### 4.4 Discussion of model results

62. 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.

63. 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. Model runs without tag–recapture data did not give sensible outputs.

64. Sensitivity analyses were similar to the base case for both the Ross Sea and SSRU 882E models. For the Ross Sea model, the exclusion of the depth shift parameter on fishing selectivity resulted in a higher estimate of initial and current biomass, as did an assumption of a lower value of natural mortality. Assuming a higher length of maturity resulted in a lower estimate of initial and current biomass. The sensitivity for the three-area-based models suggested that the combined initial spawning stock biomass from the slope and north areas was only 47 260 tonnes. This estimate was lower than the base case, but the reason for this was not clear.

### 4.5 Future research requirements

65. The Working Group welcomed the development of the Ross Sea and SSRU 882E stock models, and thanked New Zealand for the work that had gone into the development of the integrated modelling approach for the assessment of toothfish in Subareas 88.1 and 88.2.

66. The Working Group recommended that future work include investigation and inclusion of the tag and recapture data from all nations operating in Subareas 88.1 and 88.2. The Working Group further recommended that future research consider the movement and stock structure of toothfish, and perhaps investigate such issues using simulation and/or multiple-area models.

## 5. By-catch of fish and invertebrates

### 5.1 By-catch removals

67. 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-05/6 Rev. 1. These are given for Subareas 88.1 and 88.2 in Tables 17 and 18 respectively. WG-FSA-05/24 gives the distributions of macrourid and rajid by-catch respectively. Total removals of managed by-catch species from catch and effort reports were tabulated in CCAMLR-XXIV/BG/13 and were similar to the estimates from fine-scale data for Subareas 88.1 and 88.2. Data from observers for the 2004/05 fishing season were provided in WG-FSA-05/7 Rev. 1, 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-05/24 and 05/29.

Table 17: Catch history for managed by-catch species (macrourids, rajids and other species) in Subarea 88.1. 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 | 140# | 66 | 50+ | 11 | 20+ | 12 |
| 2003/04 | 520 | 319 | 163 | 23 | 20+ | 23 |
| 2004/05 | 520 | 462 | 163 | 69 | 20+ | 24 |

\# 50 for SSRU A
\+ For each SSRU

Table 18: Catch history for managed by-catch species (macrourids, rajids and other species) in Subarea 88.2. 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 | 20+ | 8 |
| 2003/04 | 60 | 37 | 163 | 0 | 20+ | 8 |
| 2004/05 | 60 | 21 | 163 | 0 | 20+ | 4 |

\+ For each SSRU

68. The Working Group expressed concern that two by-catch limits were exceeded in Subarea 88.1 during the 2004/05 exploratory fishery (CCAMLR-XXIV/BG/13):

(i) the limit of 124 tonnes for *Macrourus* spp. in SSRU 881I was exceeded by 26 tonnes (29%);

(ii) the limit of 120 tonnes for *Macrourus* spp. in SSRU 881K was exceeded by 81 tonnes (68%).

69. Closures of SSRUs 881G and J during the 2004/05 exploratory fishery were also triggered by the by-catch limits for *Macrourus* spp. (CCAMLR-XXIV/BG/13).

70. 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.

71. 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).

72. There were no new assessments of by-catch species or recommendations for revised catch limits by SSRU in 2005.

### 5.2 Assessments of impacts on affected populations

73. The estimate of $\gamma$ 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.

74. 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.

75. 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.

### 5.3 Identification of levels of risk

76. 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 (Tables N5 and N6).

### 5.4 Mitigation measures

77. 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.

78. The major factors influencing macrourid by-catch were vessel, area and depth (Figures N1 and N2). 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.

79. 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 (paragraphs N42 to 53).

80. 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.

81. 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 (WG-FSA report, paragraph 6.22).

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

83. 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 (WG-FSA report, paragraph 6.25).

## 6. By-catch of birds and mammals

### 6.1 By-catch removals

84. Details of seabird by-catches are reported in paragraph O15 and Table O3, and are summarised in Table 19.

Table 19: Seabird by-catch limit, reported seabird by-catch, by-catch rate and estimated by-catch for the years 1997/98 to 2004/05 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 | |

* Per vessel during daytime setting.

85. Ad hoc WG-IMAF assessed the risk level 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 (Table O20) and recommended:

- 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.

86. Ad hoc WG-IMAF assessed the risk level of seabirds in this fishery in Subarea 88.2 as category 1 (Table O20) and recommended:

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

### 6.2 Mitigation measures

87. 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

88. A carbon budget trophic model for the Ross Sea is currently under development (WG-EMM-05/18). 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-05/71 provides 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 2004/05 season and advice for 2005/06

## 8.1 Conservation measures

Table 20: 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 2005/06 season.

| Paragraph and topic | Summary of CM 41-09 for 2004/05 | Advice for 2005/06 | 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 | 3 250 tonnes for Subarea 88.1<br>Individual SSRU limits (tonnes):<br>A, D, F – 0<br>B – 80<br>C – 223<br>E – 57<br>G – 83<br>H – 786<br>I – 776<br>J – 316<br>K – 749<br>L – 180 | 2 964 tonnes for 88.1 and SSRUs 882A–B<br>Review | 94<br>96–104 |
| 3. Season | 1 December 2004 to 31 August 2005 | 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: seabirds | In accordance with CM 25-02 (except paragraph 4 night setting). CM 24-02 to apply. | | |
| 7. Mitigation | Daylight setting allowed under CM 24-02. | | |
| 8. Mitigation | No offal discharge. | | |
| 9. Observers | Each vessel to carry at least two scientific observers, one of whom shall be a CCAMLR observer. | | |
| 10. VMS | To be operational in accordance with CM 10-04. | | |
| 11. CDS | In accordance with CM 10-05. | | |
| 12. Research | Undertake research plan and tagging program as set out in CM 41-01, Annexes B and C. | | |
| 13. Data: catch and effort | (i) Five-day reporting system as in CM 23-01<br>(ii) Monthly fine-scale reporting system as in CM 23-04 on haul-by-haul basis. | | |
| 14. 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. | | |
| 15. Data: biological | Monthly fine-scale reporting system as in CM 23-05. Reported in accordance with the Scheme of International Scientific Observation. | | |
| 16. Discharge | Prohibition of discharge of:<br>(i) oil<br>(ii) garbage<br>(iii) food waste >25 mm<br>(iv) poultry or parts thereof<br>(v) sewerage within 12 n miles of land. | | |

| | | |
|---|---|---|
| 17. | 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. |
| 18. | Additional element | Fishing within 10 n miles of Balleny Island is prohibited. |

Table 21: 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 2005/06 season.

| | Paragraph and topic | Summary of CM 41-10 for 2004/05 | Advice for 2005/06 | Paragraph reference |
|---|---|---|---|---|
| 1. | Access (gear) | Limited to vessels from Argentina, Republic of Korea, New Zealand, Norway, Russia, Spain, UK and Uruguay using longlines. | Review | |
| 2. | Catch limit | 375 tonnes south of 60°S<br>No individual SSRU limits | 273 tonnes for SSRU882E | 95 |
| 3. | Season | 1 December 2004 to 31 August 2005 | 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: seabirds | In accordance with CM 25-02 (except paragraph 4 night setting). CM 24-02 to apply. | | |
| 7. | Mitigation | Daylight setting allowed under CM 24-02. | | |
| 8. | Mitigation | No offal discharge. | | |
| 9. | Observers | Each vessel to carry at least two scientific observers, one of whom shall be a CCAMLR observer. | | |
| 10. | VMS | To be operational in accordance with CM 10-04. | | |
| 11. | CDS | In accordance with CM 10-05. | | |
| 12. | Research | Undertake research plan and tagging program as set out in CM 41-01, Annexes B and C. | | |
| 13. | Data: catch and effort | (i) Five-day reporting system as in CM 23-01<br>(ii) Monthly fine-scale reporting system as in CM 23-04 on haul-by-haul basis. | | |
| 14. | 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. | | |
| 15. | Data: biological | Monthly fine-scale reporting system as in CM 23-05. Reported in accordance with the Scheme of International Scientific Observation. | | |
| 16. | Discharge | Prohibition of discharge of:<br>(i) oil<br>(ii) garbage<br>(iii) food waste >25 mm<br>(iv) poultry or parts thereof<br>(v) sewerage within 12 n miles of land. | | |
| 17. | 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

89. The Working Group recommended that tagging be continued as part of the Research and Data Collection Plan (Conservation Measure 41-01).

90. The Working Group noted that the aim of requiring research sets with substantial biological sampling in new and exploratory fisheries was to obtain an understanding of the distribution and abundance of target and by-catch species on as wide a geographical scale as possible at an early stage of the fisheries' development. However, the Working Group noted that for Subareas 88.1 and 88.2, the required geographical spread of fishing has already been achieved. Hence, the Working Group agreed that a more effective scheme for collecting biological samples from fisheries in those subareas would be to obtain random samples from catches on all sets carried out.

91. The Working Group recommended that to further this objective the requirement to carry out specific research sets as defined in Annex 41-01/B of Conservation Measure 41-01 within Subareas 88.1 and 88.2 be removed.

92. The Working Group further recommended that there be a requirement that all fish of each *Dissostichus* spp. in a haul (up to 35 fish) be measured and randomly sampled for biological studies (cf. paragraphs 2(iv) to 2(vi) of Annex 41-01/A) from all lines hauled within Subareas 88.1 and 88.2, as proposed and justified in WG-FSA-05/49.

93. 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.

94. The constant catch for which there was median escapement of 50% of the median pre-exploitation spawning biomass level at the end of the 35-year projection period for the Ross Sea (Subarea 88.1 and SSRUs 882A–B) was 2 964 tonnes. At this yield there is a less than 10% chance of spawning biomass dropping to less than 20% of the initial biomass. A yield of 2 964 tonnes is therefore recommended.

95. 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 273 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 273 tonnes is therefore recommended.

96. WG-FSA-05/72 discussed a number of issues relating to the allocation of catch limits amongst SSRUs in Subarea 88.1. These included the small current size of SSRUs, which has led to difficulties with the conduct and management of the fisheries in them due to the sometimes very short fishing seasons, problem with representativeness of data collected in different SSRUs in different times of the year, the effect of poor ice years on southern SSRUs, and the methodology used to determine the allocations. The paper concluded that there is a need to amend the current allocation methods, particularly with a view to having fewer, larger SSRUs and avoiding SSRUs with zero catch limits.

97. In relation to the existing methodology for allocation, it was noted that last year (see SC-CAMLR-XXIII, Annex 5, paragraph 5.6), the analysis to estimate fish density in each SSRU was based on the total catch of *Dissostichus* spp. divided by total effort by all vessels in each SSRU over the history of the fishery, rather than on CPUE in Subarea 48.3 as suggested in WG-FSA-05/72.

98. 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. Also, if expansion of the size of existing SSRUs were to be considered, then ensuring the appropriate spreading of effort within SSRUs and by-catch management may need to be reconsidered. Some Members recommended that these issues be considered intersessionally.

99. Other Members noted that the SSRU definitions that applied in 2002/03 (WG-FSA-03/29) that split Subarea 88.1 into four areas (i.e. four SSRUs formed by the boundaries at latitudes 65°S, 70°S and 76°S, with the central area between 70°S and 76°S split by a boundary at 180°E) might be more appropriate. This proposal could resolve the issues noted in paragraph 96.

100. However, the Working Group recognised that SSRU 882E could be separated from the remaining SSRUs because it has an assessment of its own, and that advice needed to be provided for catch limit allocation amongst the other SSRUs for the coming season. Furthermore, the assessments conducted this year (for the Ross Sea and SSRU 882E) will require a different method of allocation than last year.

101. If a similar method to that used in 2003/04 and 2004/05 for allocating catch limits to SSRUs were applied for 2005/06, then the possible allocations of catch limits for Subarea 88.1 and SSRUs 882A–B are given in Table 22.

Table 22: Estimated fishable seabed areas (km$^2$, 600–1800 m depth range, source: 881A–K from SC-CAMLR-XXII, Annex 5; 882A–B from WG-FSA-05/33), unstandardised CPUE for all vessels from 1997/98 to 2004/05 (kg/hook), proportion of the catch limit by SSRU, and the 2004/05 catch limits, and possible catch limits assuming a total yield of 2 964 tonnes with: (*A*) no minimum SSRU catch limit, and (*B*) a minimum possible SSRU catch limit of 100 tonnes in each SSRU, for the SSRUs in the Ross Sea.

| SSRU | Area (km$^2$) | CPUE (kg/hook) | Proportion (Area*CPUE) | 2004/05 | Allocation | |
|---|---|---|---|---|---|---|
| | | | | | *A* | *B* |
| 881A | 4 908 | 0.09 | 0.01 | 0 | 31 | 0 |
| 881B | 4 318 | 0.20 | 0.02 | 80 | 59 | 0 |
| 881C | 4 444 | 0.55 | 0.06 | 223 | 165 | 184 |
| 881D | 49 048 | – | – | 0 | 0 | 0 |
| 881E | 14 797 | 0.09 | 0.03 | 57 | 90 | 0 |
| 881F | 18 398 | 0.02 | 0.01 | 0 | 25 | 0 |
| 881G | 7 110 | 0.13 | 0.02 | 83 | 63 | 0 |
| 881H | 19 245 | 0.36 | 0.16 | 786 | 467 | 520 |
| 881I | 30 783 | 0.26 | 0.18 | 776 | 535 | 595 |
| 881J | 43 594 | 0.15 | 0.15 | 316 | 455 | 506 |
| 881K | 24 695 | 0.33 | 0.19 | 749 | 558 | 621 |
| 881L | 16 807 | 0.12 | 0.05 | 180 | 142 | 158 |
| Sub-total (88.1) | 238 147 | | 0.87 | 3 250 | 2 590 | 2 584 |
| 882A | 12 478 | 0.40 | 0.12 | – | 341 | 380 |
| 882B | 8 726 | 0.06 | 0.01 | – | 33 | 0 |
| Sub-total (882A–B) | 21 204 | | 0.13 | 375 | 374 | 380 |
| Total | 259 351 | | 1.00 | 3 625 | 2 964 | 2 964 |

102. If the SSRU definitions that were applied in 2002/03 were used, then the catch limits could be separated between four SSRUs in Subarea 88.1.

103. In relation to catch limit allocations, the following issues need to be considered:

- management of the possibly large numbers of vessels that may be fishing simultaneously in an SSRU;
- consideration of compliance issues resulting from the potential for over-runs and under-runs of catch limits for SSRUs;
- the fact that poor sea-ice conditions frequently restricted the ability to fish in the more southerly SSRUs. A discount factor to allow for this may possibly be considered;
- the utility of distribution of catch and research information for assessments should not be diminished as a result of SSRU allocations, e.g. consistency in the location of fishing will provide more reliable CPUE and tag–recapture estimates;
- the desire to retain zero catch limits so that effects of fishing on *Dissostichus* spp. populations can be distinguished from environmental effects;
- allocation of catch limits for by-catch species by SSRU.

104. Dr K. Shust (Russia) indicated that zero catch limits within an SSRU would not provide information on toothfish distribution and abundance in that SSRU.