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BACKGROUND INFORMATION SUPPORTING THE REPORT OF THE MEETING OF WG-FSA 7 to 17 October 2002 (SC-CAMLR-XXI, Annex 5)

Working Group on Fish Stock Assessment

BACKGROUND INFORMATION SUPPORTING THE REPORT OF THE MEETING OF WG-FSA
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AGENDA ITEM 3:

AGENDA ITEM 5:

AGENDA ITEM 3: REVIEW OF AVAILABLE INFORMATION

FISHERIES INFORMATION

Conversion Factors (CFs)

3.1 The matter had been extensively discussed in last year's report (SC-CAMLR-XX, Annex 5, paragraphs 3.69 to 3.91). It underlined the importance of conversion factors and their accuracy in estimating the total catch of the vessel. Special guidelines had been provided to both the scientific observer and the skipper for calculating CFs (SC-CAMLR-XX, Annex 5, paragraph 3.78(i) to (iv)).

3.2 The Working Group encouraged Members last year to undertake detailed analyses of the CFs in the intersessional period to better understand the patterns of differences and what factors may be causing them. With the exception of one paper, WG-FSA-02/71 which updated information on conversion factors of *Dissostichus* spp. in Subareas 88.1 and 88.2 no such analyses have been forthcoming.

3.3 WG-FSA-02/11 summarised information on conversion factors collected during 25 cruises in the commercial longline fishery on *D. eleginoides* in Subareas 48.3, 58.6 and 58.7 and *D. mawsoni* in Subarea 88.1. Data which contained less than 100 observations or which were collected from a very limited length range were omitted from the analysis. Conversion factors presented by the vessel and those collected by the observers were in good agreement. They deviated from each other by (positives indicate that the vessel conversion factor was greater than the observer conversion factor):

(i) South Georgia (Subarea 48.3): -3.9% – + 2.6% (14 out of 16 datasets);

(ii) Crozet and Prince Edward Islands (Subareas 58.6 and 7): 0 – +2.3% (5 out of 6 datasets); and

(iii) Ross Sea (Subarea 88.1): 0 – +4.1% (all 4 datasets).

3.4 WG-FSA-02/71 provided an update from WG-FSA-01/66 on conversion factors reported from *Dissostichus* spp. caught in the Ross Sea. Two different processing states, HAG–S – headed and gutted straight cut and HAG–V – headed and gutted v cut were used. They differed by 8.6–9.5% in weight from each other. HAG–S in *D. eleginoides* had a conversion factor of 1.59 in 2001/02 and 1.56 in 2000/01. Conversion factor in *D. mawsoni* was 1.65 in 2001/02 and thus 5.4 % different from the one of *D. eleginoides*.

3.5 WG-FSA-02/71 further illustrated that if only data from landings were available a reasonable length-frequency distribution from the catch can be generated using length–weight regressions and conversions factors.

3.6 The Working Group welcomed these data and encouraged Members to collect further data on conversion factors and submit them to the Working Group for further consideration at the 2003 meeting.

Conversion of Processed Weight to Green Weight

3.7 Paragraph 3.81 of SC-CAMLR-XX recommended that detailed analysis of conversion factors (CFs) be undertaken in order to better understand the patterns of differences between vessels and observers and what factors may be causing them. It also recommended that theoretical studies be carried out in an effort to derive better estimates of sampling precision.

3.8 A detailed analysis of observer-derived conversion factors for *D. eleginoides* and *D. mawsoni* was undertaken during the course of WG-FSA-02 using data held in the observer database. The analyses were conducted on both trawl and longline fishery data from 1996–2002 from all CCAMLR fisheries.

3.9 Two sources of weight and length data were available for analysis, (a) records for individual fish and (b) records for total haul for which a minimum and maximum length were recorded. In total 10 763 records (24 739 fish) were extracted from the database for longline fisheries along with 339 records (5 607 fish) for trawls in Division 58.5.2. The majority of records were from headed, gutted, and tailed (HGT) *D. eleginoides.*

3.10 In order to assess the influence of fish length, species, processing method, cruise month and fishing area (ASD code) on conversion factors data were modelled using a Generalized Linear Mixed Model (GLMM) (see Appendix 1 for details).

3.11 Results showed that fish length had the most influence on conversion factor (Figure 3.1). Conversion factor was seen to increase in fish greater than 80–90cm. For longline fisheries individual cruise was also shown to have a marked effect upon conversion factor (Figures 3.2a and 3.3). An approximate 95% confidence interval for conversion factors across cruises was estimated at +/-0.28. However the high between-trawl variance was not observed in the trawl fishery data where most of the variability was between hauls.

3.12 The current modelling study has shown that further work is required to investigate the efficiency of the current sampling method and its corresponding estimator of conversion factor (Appendix 2).

Research Surveys

3.13 WG-FSA-02/24 summarised a bottom trawl survey undertaken by Germany in January and February 2002 around Elephant Island and the South Shetland Islands (Subarea 48.1) using the *Polarstern*. The survey was undertaken within the 500 m depth contour to provide biomass estimates for eight species of finfish. A total of 53 valid trawls of the area were made during daylight hours. The biomass estimates derived from this survey for most species were comparable to those results obtained from surveys completed in 1998 and 2001. There was no evidence that stocks of *Notothenia rossii* had recovered to historic levels even in the absence of commercial fishing for the past 20 years. The abundance of finfish determined in this study would not support a reopening of the commercial fishery. It was suggested that a specific survey targeting *N. rossii* be conducted in the near future to properly assess the status of this stock.

3.14 WG-FSA-02/20 presented the results of the biological studies on fish species caught during the German 2002 survey. Information on length–weight relationships, reproductive parameters and food and feeding of *Champsocephalus gunnari* and *Chaenocephalus aceratus* are provided.

3.15 WG-FSA-02/21 investigated the localised abundance of fish in a small area on the shelf off Elephant Island. Twenty trawls were made at random during the *Polarstern* survey mentioned above in February 2002. The abundance of fish within the small area was still very patchy with *C. gunnari* and *Gobionotothen gibberifrons* being the most abundant fish species. Reasons for the patchiness are discussed, and the results have implications for stratification of future surveys.

3.16 WG-FSA-02/70 detailed the results of a random stratified trawl survey conducted in May and June 2002 in Division 58.5.2 to determine the abundance of juvenile *Dissostichus eleginoides*. This survey was conducted at the same time of year and with a similar survey design to that used in previous years. A total of 130 stations (made during day and night) were used to estimate the abundance of *D. eleginoides*. The estimate of biomass of juvenile fish was similar to last year. Year classes corresponding to the age 2 and 3 fish appear to be weaker than those for ages 4 to 8.

3.17 WG-FSA-02/47 presented the results of the random stratified trawl survey mentioned above with respect to *C. gunnari*. A total of 55 trawls made during the day were used to estimate the abundance of *C. gunnari*. The population currently comprises a large mode of fish at about 32 cm comprising mainly 3- and/or 4-year-old fish.

3.18 WG-FSA-02/19 gave a brief summary of the results of the Russian bottom trawl and acoustic survey of South Georgia during January–March 2002. The bottom trawl survey was undertaken within the 500 m depth contour to provide biomass estimates of demersal species (primarily *C. gunnari*). A total of 73 bottom trawls of the area were made during daylight hours. Biomass estimates from the survey were presented in WG-FSA-02/59. Acoustic data were collected during the bottom trawl survey. In addition, a separate acoustic survey of the area was carried out and the results presented in WG-FSA-02/44.

3.19 WG-FSA-02/44 summarised the results of a Russian acoustic survey of icefish at South Georgia carried out during February–March 2002. About 30 acoustic transects were made at right angles to the depth contours during the daytime around the entire South Georgia shelf from 100 m to 500 m depth. Thirty pelagic trawls were made to determine species composition in the pelagic layers. These trawls were used for species decomposition of the acoustic backscatter. Target strength data were collected for several species. The biomass estimate from the acoustic survey was almost double that from the bottom trawl survey. Of this, about 30% of the biomass was in the pelagic region 8–58 m above the bottom. The Working Group agreed that this provided strong evidence that a substantial proportion of the icefish biomass is in the pelagic zone and is unavailable to the bottom trawl survey.

3.20 WG-FSA-02/34 gave a brief summary of the results of the UK bottom trawl survey of Subarea 48.3 during January 2002. The bottom trawl survey was undertaken within the 500 m depth contour to provide biomass estimates of demersal species (primarily *D. eleginoides* and *C. gunnari*). A total of 63 valid bottom trawls of the area were made during daylight hours. Biomass estimates from the survey are summarised in the paper but are considered in more detail in WG-FSA-02/59.

3.21 The data presented in these papers were referred to the subgroups on assessment of *D. eleginoides* and *C. gunnari* to determine how they might be used in assessments for this year.

Subgroup on Icefish Trawl and Acoustic Surveys

3.22 The subgroup considered the problems of combining survey data, such as the Russian and UK data in Subarea 48.3, and how CCAMLR could integrate acoustic data into assessment methods.

3.23 The subgroup recognised the value of acoustic methods and in particular noted the following:

(i) A considerable part of the icefish biomass occurs in the pelagic zone, which suggests that bottom trawl surveys may underestimate biomass. Acoustic methods provide a method of determining the biomass of icefish throughout the water column.

(ii) There are uncertainties in using acoustic methods to determine icefish biomass, particularly mark identification, and target strength measurements of *C. gunnari* and other fish species. These uncertainties should be incorporated when determining confidence limits around acoustic estimates.

(iii) Initially acoustic surveys should be run in parallel with bottom trawl surveys. However running acoustic surveys and bottom trawl surveys has implications regarding cost and ship time. An initial approach would be to follow the methods outlined in WG-FSA-02/56, and conduct acoustic surveys simultaneously with trawl stations and in between stations.

(iv) An intersessional subgroup on acoustics should be initiated, with representation from all interested Members. The objectives of the subgroup would be to evaluate the application of acoustics methods in estimating biomass of exploited fish in the CCAMLR Convention Area. In particular the subgroup would be asked to re-examine the acoustic data from the Russian and UK surveys to provide a robust estimate of biomass, confidence intervals and age composition.

A regression of WG_pf on mean processed weight per fish (WP_pf) was fitted through the origin using the sample size of fish for each record as a statistical weight. A gamma/identity link GLM was fitted with additionally a CRUISE.WP_pf random effect included making the model a Generalised Linear Mixed Model (GLMM) (Breslow and Clayton, 1993). The slope of the regression gives an estimate of the conversion factor (Figure 3.4). Factors that affect conversion can be investigated by fitting their interaction with WP_pf (e.g. MONTH.WP_pf) as fixed effects in the GLMM. Fitting the GLMM and testing fixed effects using Wald tests suggested that fish length, species, processing method and month of the cruise were important predictors of conversion for this dataset. Fish length was calculated as the mid-range value for a subset of the data for which the range in lengths for the second-stage sample was less than or equal to 10 cm. Figure 3.1 shows the relationship between conversion factor, estimated from the GLMM fit, versus length for (a) longline, and (b) trawl fisheries for *D. eleginoides* processed as HGT. Paragraphs 3.82 of the SC-CAMLR-XX discussed the observation that CFs … change according to the maturity of the fish'. For the longline data the estimate of the between-cruise variation in conversion factor (i.e. variation in estimated random regression slopes) was of the order of 0.02 (giving a standard deviation of 0.14) (Figure 3.2a). The between-fish variance for the GLMM was approximately 0.01 (Figure 3.2b) which after scaling by the square of the average CF of approximately 1.7 gives a standard deviation of 0.17 corresponding to the between-fish variance in CF. For the trawl data the between-fish and between-cruise GLMM variances were approximately 0.002 and 0.1 respectively. Analysis of random cruise effects (i.e. random errors in regression slope) revealed a trend with year (Figure 3.3a) which was subsequently modelled using YEAR.WP_pf as a fixed effect with recalculated random cruise effects shown in Figure 3.3b).

Reference

Breslow, N.E. and D.G. Clayton. 1993. Approximate inference in generalized linear mixed models. *Journal of the American Statistical Association,* 88: 9–25.

The data available for estimating conversion factors is provided by observers taking a (sub)sample of fish from each of a sample of haul and either (i) record the green and processed weight for each fish individually or (ii) record the total weights for each sampled haul by accumulating the weights of all fish in the subsample.

From statistical theory for ratio estimators (Cochran, 1977), the conversion factor can be estimated as the ratio of the total of sampled green weights to the total of sampled processed weights. The conversion factor is then used to estimate total green weight caught for each cruise by multiplying the landed product weight by the conversion factor.

Since the sampling method is a two-stage procedure (a first-stage sample of hauls followed by a second-stage subsample of fish from each haul with unequal second-stage sample sizes) the calculation of the precision of the ratio estimator is more complex than for simple random sampling. A number of points should be noted:

Optimising the relative sample sizes of hauls to fish within hauls requires information on the relative variance of the two types of sampling unit.

The conversion factors (ratio estimators in statistical theory) are biased but can be much more efficient than the simple estimator obtained by multiplying the mean sampled green weight per fish by the total number of fish caught and processed. However, the bias and precision of the ratio estimator should be investigated so that adequate first- and second-stage sample sizes can be recommended.

Reference

Cochran, W.G. 1977. *Sampling Techniques*. Third Edition. John Wiley and Sons, New York.

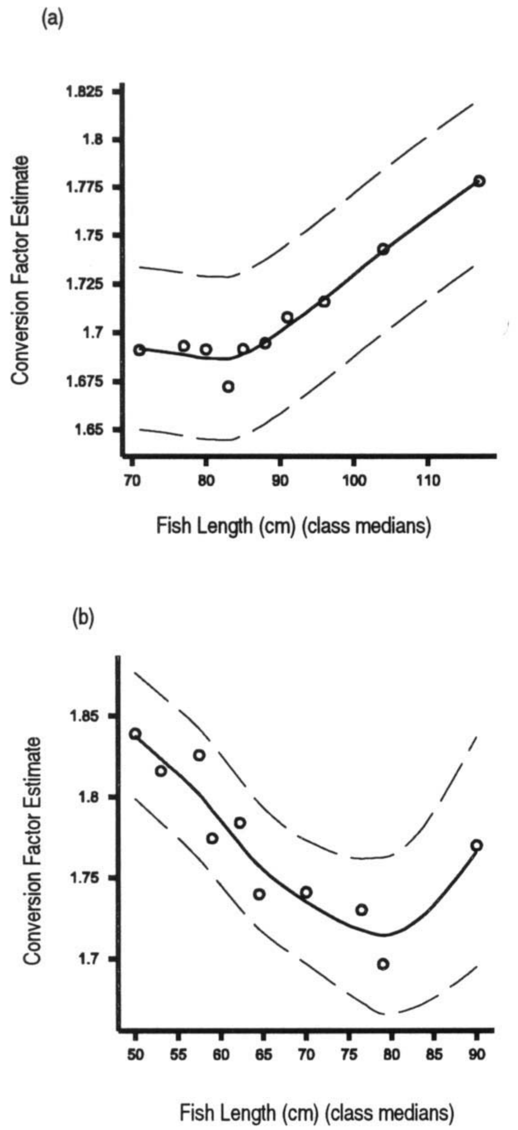


Figure 3.1: Conversion factor estimates obtained from the fit of the GLMM versus length for *D. eleginoides* processes as HGT for: (a) longline and (b) trawl fisheries. (Approximate 95% confidence bounds on estimates shown.)

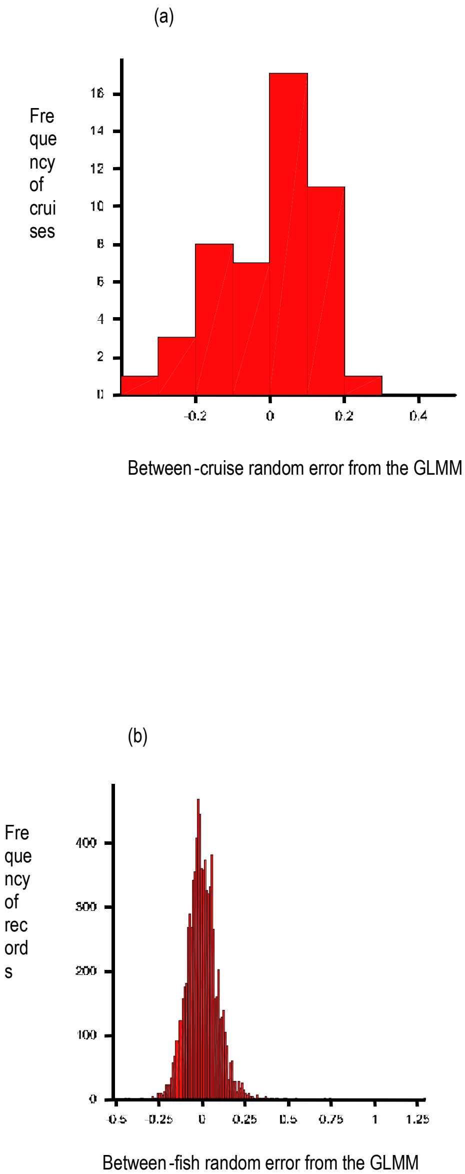


Figure 3.2: Frequency histograms of random error estimates from the fit of the GLMM for headed, gutted and tailed *D. eleginoides* from longline fisheries.

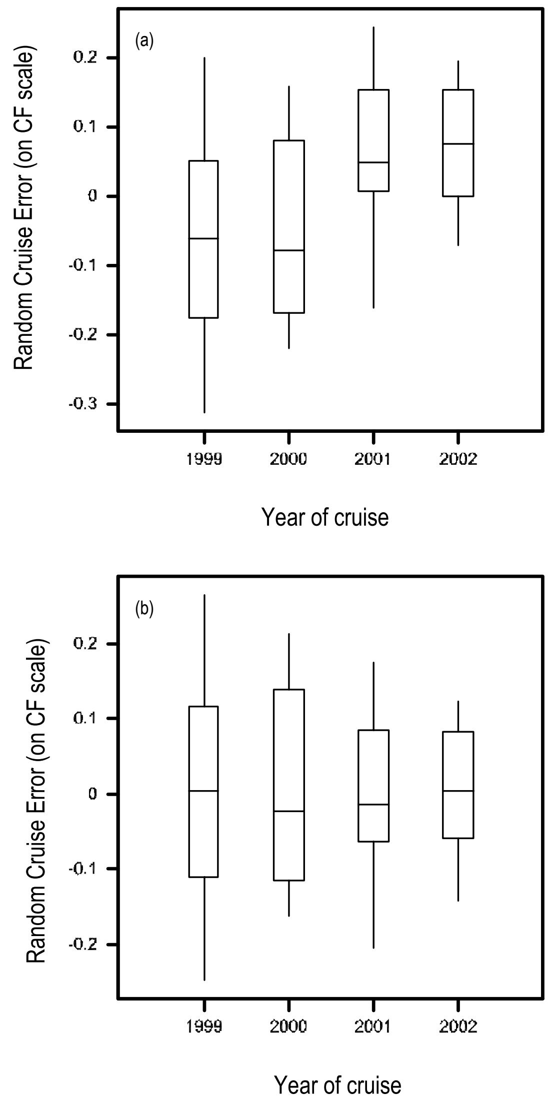
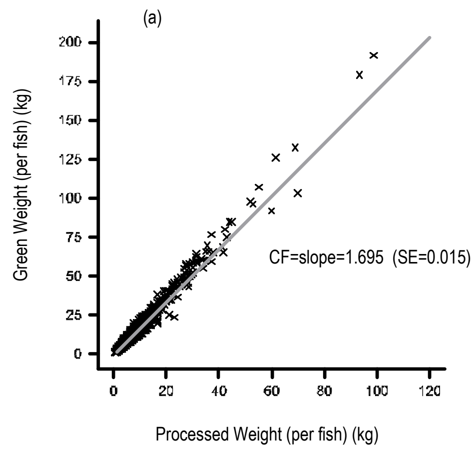


Figure 3.3: Box plots of estimated random cruise errors versus year of cruise for headed, gutted and tailed *D. eleginoides* from longline fisheries for: (a) YEAR.WP_pf fixed term not included in the GLMM, (b) after including the YEAR.WP_pf term.



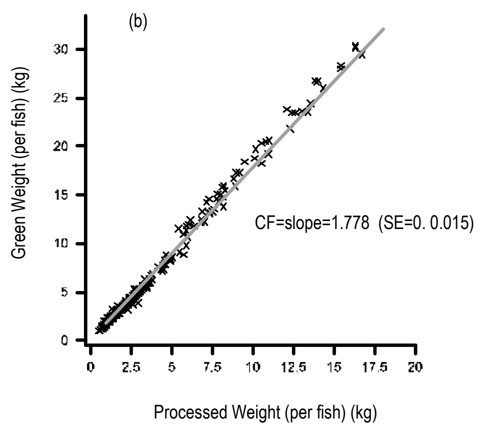


Figure 3.4: Fitted regression using the GLMM for green weight for all samples for headed, gutted and tailed *D. eleginoides* for: (a) longline, and (b) trawl fisheries. The regression slope estimate gives the conversion factor.

AGENDA ITEM 5: ASSESSMENTS AND MANAGEMENT ADVICE

NEW AND EXPLORATORY FISHERIES IN 2001/02 AND FOR 2002/03

Progress towards Assessments of New and Exploratory Fisheries

Precautionary Catch Limits for Subarea 88.1

5.1.1 An exploratory longline fishery by New Zealand for *D. mawsoni* and *D. eleginoides* took place in Subarea 88.1 in 2001/02. The precautionary catch limit of *Dissostichus* spp. in Subarea 88.1 for 2001/02 was 2 508 tonnes, comprising catch limits of 171 tonnes north of 65°S and 584 tonnes in each of the four SSRUs to the south of 65°S (Conservation Measure 235/XX).

5.1.2 Totals of 1 307 tonnes of *D. mawsoni* and 12 tonnes of *D. eleginoides* were caught during 2001/02. The catch limit was almost reached in SSRU C, but was not approached in any of the other SSRUs. All of the catch was taken by New Zealand vessels, which have now been involved in this exploratory fishery for the past five seasons. During that time, the total catches have been 41 tonnes in 1998, 296 tonnes in 1999, 745 tonnes in 2000, 659 tonnes in 2001 and 1 319 tonnes in 2002.

5.1.3 Research activities associated with the New Zealand exploratory fishery are summarised in WG-FSA-02/38, which also includes a comprehensive analysis of data collected by this fishery from 1997/98 to 2001/02.

5.1.4 The exploratory fishery over the last five seasons has seen a widespread distribution of effort. In the 2002 season all five SSRUs were fished and 14 new fine-scale rectangles were fished for the first time. From 28 to 91 fine-scale rectangles have been fished each year, and a total of 171 fine-scale rectangles have been fished overall (WG-FSA-02/38).

5.1.5 Observer length-frequency data for *D. mawsoni* were stratified and scaled up to the catch and year. Most fish in the catch ranged from 70 to 170 cm, with two broad modal peaks at 80–110 cm and 130–140 cm (Figure 5.1.2).

5.1.6 About 500 otoliths have been read from *D. mawsoni* each year and the resulting ages have been compiled into year-specific age–length keys. These were then applied to the scaled length-frequency distributions to produce catch-at-age distributions for each year (WG-FSA-02/38) (Figure 5.1.2). Most *D. mawsoni* in the catch were from 8 to 16 years old (range 3–35 years).

5.1.7 For the last two years the Working Group has used the approach for calculating precautionary catch limits for Subarea 88.1 outlined in SC-CAMLR-XIX, Annex 5, paragraphs 4.20 to 4.33. The Working Group agreed to continue to use this approach for this year's assessment of Subarea 88.1.

5.1.8 The yield in area 88.1 was calculated using the following formula:

$$Y_{881} = \frac{\gamma_{881} f_{881} A_{881}}{\gamma_{483} f_{483} A_{483}} Y_{483}$$

where γ is the precautionary pre-exploitation harvest level for each area, f is the relative density (a function of CPUE and fishing selectivity), A is the seabed area, and Y is the long-term precautionary yield.

5.1.9 As in last year's assessment, separate yield estimates were calculated for each SSRU. Yields for SSRU A were calculated assuming the selectivity patterns and biological parameters for *D. mawsoni*, and the combined CPUE from both *D. mawsoni* and *D. eleginoides*. Last year's yields were updated based on data collected during the 2001/02 fishing year.

5.1.10 The total area fished in Subarea 88.1 increased by about 4% and is now estimated to be 66 674 km^2 (Table 5.1.1).

5.1.11 The estimate of relative fish density for Subarea 88.1 was updated using CPUE data collected during the 2001/02 fishing year. An additional 432 sets were completed making a total of 1 854 research and exploratory sets. The program 'Dataloser' was used to sample this combined dataset. Following last year's assessment, sets were randomly chosen from the combined data, provided they were separated by a minimum distance of 5 n miles. As recommended in last year's assessment (SC-CAMLR-XX, Annex 5, paragraph 4.37) the minimum separation distance criterion was also applied to the Subarea 48.3 data. A total of 2 105 sets were used from Subarea 48.3 covering the period 1987 to 1992.

5.1.12 The CPUE estimates from each SSRU or area were then resampled, averaged and the ratio of CPUE between the SSRU and Subarea 48.3 was calculated. This was repeated 10 000 times and the one-sided lower 95% confidence bound of this ratio was calculated. The CPUE ratios are shown in Table 5.1.1.

5.1.13 A third adjustment was made for differences in fishing selectivity. Estimates of fishing selectivity for each SSRU were revised using the updated length-frequency data (Figure 5.1.3). The corresponding mean fishing selectivities (and ranges) are given for each area in Table 5.1.1.

5.1.14 The final adjustment was made by comparing the precautionary pre-exploitation harvest levels (γ) between the areas. Biological and fishery parameters used for *D. mawsoni* in the GYM calculations were the same as that used in last year's assessment, and are shown in Table 5.1.2. Biological and fishery parameters used for *D. eleginoides* in the GYM calculations were the same as that used in last year's assessment. Estimates of γ from the GYM for each SSRU for *D. mawsoni* and *D. eleginoides* are given in Table 5.1.1.

5.1.15 The pre-exploitation precautionary yield for Subarea 48.3 was calculated using the recruitment parameters from the results of the CMIX analyses, together with the other biological parameters used for the calculations of γ, using zero catches. This yield (7 970 tonnes) was then adjusted by the ratio of γs, densities (a function of CPUE and fishing selectivity), and seabed areas to give estimates of precautionary yield for *D. mawsoni* in Subarea 88.1.

5.1.16 The Working Group noted that the yields for Subarea 48.3 presented here are based on assumptions and parameters which seem appropriate for this assessment in Subareas 88.1 and 88.2 and should not be compared to the actual assessment undertaken for Subarea 48.3.

5.1.17 The resulting estimates of precautionary yields are given by SSRU in Table 5.1.1. Equivalent estimates of yields, the catch limits adopted and the catches actually taken from each SSRU in 2001/02 are shown in Table 5.1.3.

5.1.18 The Working Group noted that whilst the current assessment incorporates several improvements over earlier assessments of this area, there was still considerable uncertainty about the assessments. This stems from uncertainty in biological and fishery parameters for both *Dissostichus* spp., and in particular from the assumed relationship between CPUE and density.

5.1.19 The Working Group noted that there had been a large increase in CPUE in Subarea 88.1 during the 2001/02 fishing year (WG-FSA-02/38). This could be attributed to the good ice conditions encountered in the 2001/02 fishing year, which allowed the vessels access to some of the better fishing grounds, and to the presence of only the two most experienced vessels in the fishery. There is concern that the increased experience in fishing toothfish may have led to an upward bias in CPUE. This is because the high CPUE for one or two smaller grounds is extrapolated over the entire fished area. However, any such bias would be difficult to quantify without a better definition of the main fishing grounds. There was no time to complete a reanalysis of the main fishing grounds, and the Working Group recommended that this be investigated in the intersessional period.

5.1.20 The Working Group also considered that the existing approach could be further improved by treating selectivity differently. The Working Group recommended that estimates of selectivity in next year's assessment should try and take into account depths fished by the vessels, which is currently being used in the Subarea 48.3 assessment of *D. eleginoides*.

5.1.21 Because of the problems outlined above, the Working Group agreed that the revised estimates of yield should be treated with caution and that a discount factor should again be applied to the results of this assessment. In this respect, the Working Group noted that discount factors of 0.3 and 0.5 have been used for *D. mawsoni* in Subarea 88.1 in the last two years.

5.1.22 The Working Group also noted that an analysis of the catch and effort data collected over the past five years would allow the identification of the main fishing grounds in the area. Such an analysis would provide a good basis for designating more appropriate SSRU boundaries.

5.1.23 The Working Group considered that the CPUE series used in the current assessment should not be updated further because of potential biases as the fishers become more experienced. However, revision of this assessment would be appropriate with better information on area boundaries, fishing selectivities and other biological parameters.

Precautionary Catch Limits for Subarea 88.2

5.1.24 The same approach as taken above for Subarea 88.1 was used for calculating precautionary catch limits for *D. mawsoni* in Subarea 88.2.

5.1.25 Only 10 sets were completed in Subarea 88.2 in the 2001/02 fishing year. This was considered too few to carry out a bootstrap analysis. The Working Group therefore assumed the mean CPUE ratio for this area to be the same as that for the whole of Subarea 88.1 (Table 5.1.1).

5.1.26 The adjustment made for fishing selectivity was estimated using the left side of the scaled length-frequency distribution for 2001/02 for Subarea 88.2 (Table 5.1.1).

5.1.27 A final adjustment was made by comparing the precautionary pre-exploitation harvest levels (γ) between Subarea 48.3 and Subarea 88.2. These were calculated from the biological and fishery parameters for each of the areas. The corresponding mean fishing selectivities (and ranges) are given for each area in Table 5.1.1.

5.1.28 The resulting estimate of precautionary yield in Subarea 88.2 is given in Table 5.1.1. Equivalent estimates of yield, the catch limit adopted and the catch actually taken in 2001/02 are shown in Table 5.1.3.

5.1.29 In comparison with the assessment of Subarea 88.1, the Working Group noted that there is even more uncertainty about the assessment for Subarea 88.2. The Working Group agreed that a discount factor again needs to be applied.

Table 5.1.1: Assessment of long-term annual yield for the exploratory fishery by SSRU for *Dissostichus* spp. in Subarea 88.1 and for all SSRUs combined in Subarea 88.2 based on fished seabed area.

	88.1					88.2	48.3
	A	B	C	D	E		
Fished seabed area (km^2)	3 407	10 484	13 041	11 668	28 074	2 384	32 035
Fishing selectivity (mean)	135	115	120	80	80	115	75
Fishing selectivity (range)	30	70	60	20	20	50	20
Ratio total: recruited biomass	2.551	1.683	1.818	1.131	1.131	1.651	1.158
γ	0.048	0.040	0.041	0.037	0.037	0.041	0.034
CPUE ratio	0.578	0.391	0.823	0.495	0.525	0.587	1.0
Estimated yield (tonnes)	1 536	1 772	5 129	1 533	3 912	602	(7 970)

Table 5.1.2: Parameters input to the GYM for evaluation of γ for the exploratory longline fishery for *Dissostichus mawsoni* in Subareas 88.1 and 88.2.

Category	Parameter	Parameter for *D. mawsoni* in Subareas 88.1 and 88.2	Assumed Parameters for *D. eleginoides* in Subarea 48.3
Age structure	Recruitment age	4	4
	Plus class accumulation	35	35
	Oldest age in initial structure	55	55
	Mean (μ)	-	14.965
	SE	-	0.207
Recruitment	SD $\log_e$ (recruits)	0.803	0.773
Natural mortality	Mean annual M	0.15–0.22	0.132–0.198
von Bertalanffy growth	t_0	0.04 years	-0.21 years
	L_∞	1 802 mm	1 946 mm
	k	0.095 year^{-1}	0.066 year^{-1}
Weight at age	Weight–length parameter – A	7.0E-08 kg	3.96E-08 kg
	Weight–length parameter – B	3.0965	2.8
Maturity	L_{m50}	1 000 mm	930 mm
	Range: 0 to full maturity	850–1 150 mm	780–1 080 mm
Spawning season		01/06	01/08
Simulation characteristics	Number of runs in simulation	1 001	1 001
	Depletion level	0.2	0.2
	Seed for random number generator	-24 189	-24 189
Characteristics of a trial	Years to remove initial age structure	1	1
	Observations to use in median SB_0	1 001	1 001
	Year prior to projection	1997	1987
	Reference start date in year	01/12	01/12
	Increments in year	12	12
	Years to project stock in simulation	35	35
	Reasonable upper bound for annual F	5.0	5.0
	Tolerance for finding F in each year	0.000001	0.000001
Fishing selectivity	Length, 50% selected	see Table 5.1.1	see Table 5.1.1
	Range over which selection occurs	see Table 5.1.3	see Table 5.1.3

Table 5.1.3: Summary of catch limits and catches for *Dissostichus* spp. in Subareas 88.1 and 88.2 for the 2000/01 and 2001/02 seasons and precautionary yields for 2002/03.

	2000/01		2001/02		2002/03		
	Catch limit	Catch	Catch limit	Catch	Yield	Yield *0.3	Yield *0.5
Subarea 88.1							
SSRU A	175	67	171	57	1 536	461	768
SSRU B	472	287	584	333	1 772	532	886
SSRU C	472	184	584	565	5 129	1 539	2 564
SSRU D	472	46	584	195	1 533	460	766
SSRU E	472	75	584	179	3 912	1 174	1 956
Total	2 063	659	2 508	1 319	13 882	4 164	6 941
Subarea 88.2[1]	-	-	250	41	602	181	301
Total				41	602	181	301

[1] Note Subarea 88.2 is divided into 7 longitudinal sections each 10° apart, with a maximum 50 tonnes catch in any one SSRU. To date only SSRU A has been fished.

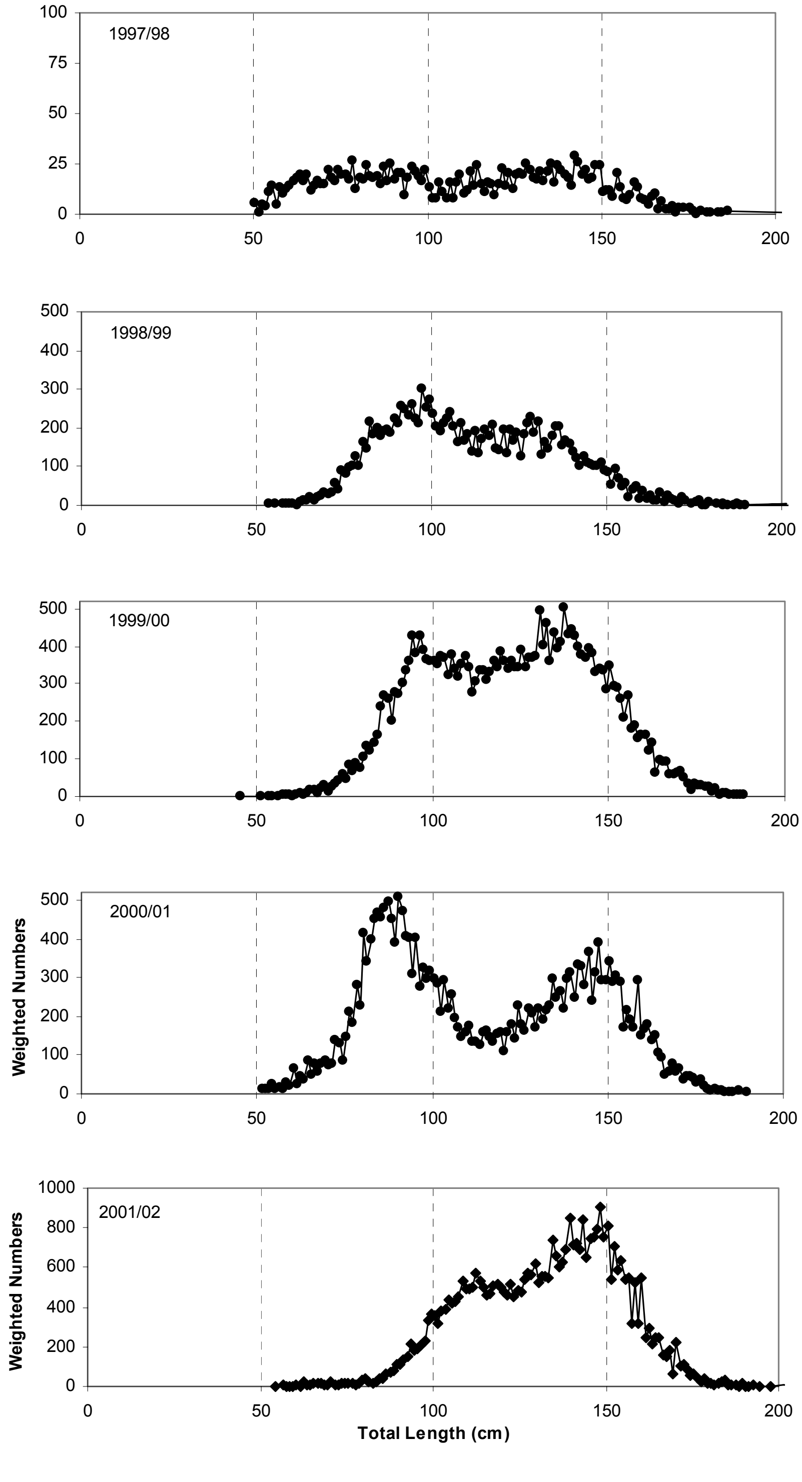


Figure 5.1.1: Catch weighted length-frequency distribution of *D. mawsoni* by year in the exploratory longline fishery in Subarea 88.1.

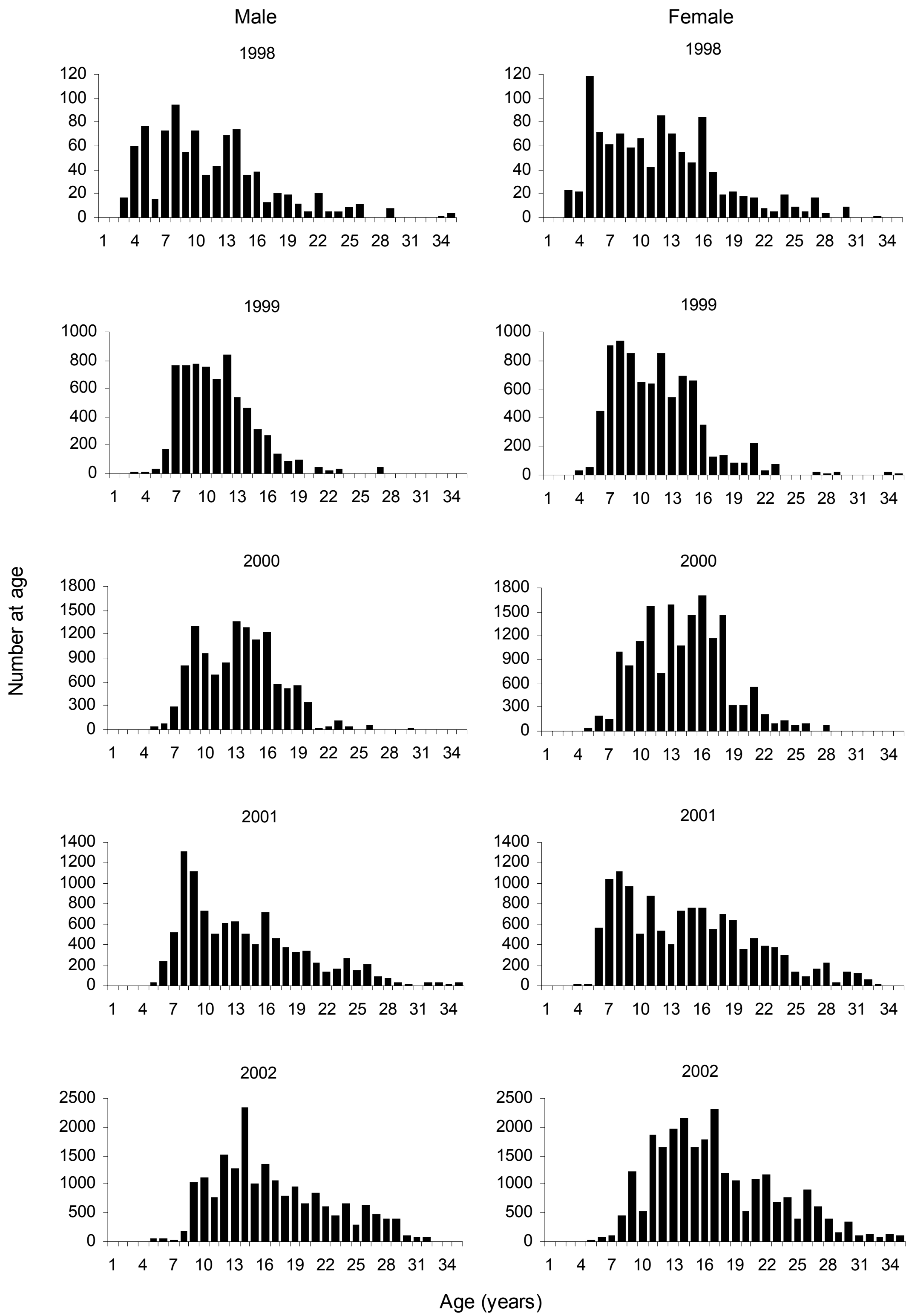


Figure 5.1.2: Estimated numbers at age of *D. mawsoni* by year in the exploratory longline fisheries in Subarea 88.1.

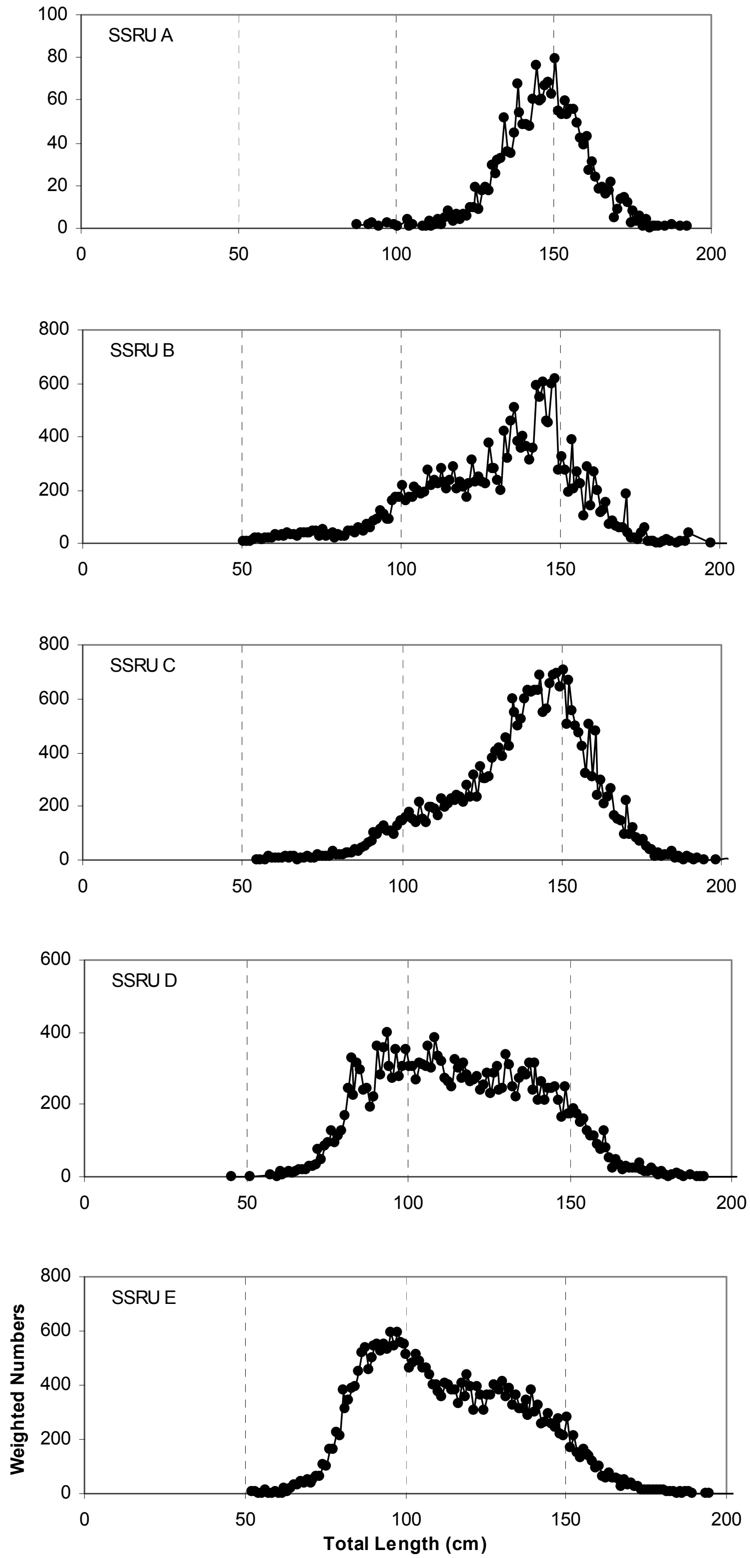


Figure 5.1.3: Catch weighted length-frequency distribution of *D. mawsoni* by SSRU for all years combined in the exploratory longline fisheries in Subarea 88.1.

AGENDA ITEM 5: ASSESSMENTS AND MANAGEMENT ADVICE

ASSESSED FISHERIES

***Dissostichus eleginoides* South Georgia (Subarea 48.3)**

Standardisation of CPUE

5.2.1 Haul-by-haul catch and effort data for Subarea 48.3 (fine-scale data) for the 1985/86 to 2001/02 fishing seasons were examined. GLM analyses were conducted using this dataset (updated to August 2002), except for data for the first season (1985/86), when fishing had been restricted to very shallow depths (mainly less than 300 m). As in the previous year, WG-FSA agreed that data for all months be included in the analyses.

5.2.2 CPUE in kg/hook was used as the response variable, and nationality, season, month, area (East South Georgia, NW South Georgia, South Georgia, West Shag Rocks and Shag Rocks), depth and bait type were considered as predictor variables. Depth information was additionally treated as a categorical variable with four levels (0–500 m, 500–1 000 m, 1 000–1 500 m, 1 500 m and above). GLM analyses were conducted on positive CPUE data only, with an adjustment for zero catches being made afterwards. The results are shown in Figure 5.2.1.

5.2.3 The approach used to fit the GLMs was the same as that used last year, with a square root transformation being applied and a robust quasi-likelihood form of GLM fitted. Models were first fitted using all listed predictor variables as main effects. Of these, the statistically significant predictors were nationality, season and depth class. Models incorporating area, month, and bait, and interactions between predictor variables were not considered, as these factors provided no statistically significant contributions to the GLM. Thus the model form used was cpue ~ season + nationality + depth.class,family = robust(quasi(link = sqrt). A QQ-plot of residuals from the fitted model (Figure 5.2.2) revealed only minor departures from the assumed error model which were not sufficient to reject the fit.

5.2.4 The standardised time series of CPUEs in kg/hook is plotted in Figure 5.2.1 and given in Table 5.2.1. The standardisation is with respect to Chilean vessels fishing at depths of 1 000–1 500 m. This time series has also been adjusted for the presence of hauls with zero catches, by multiplying the standardised CPUEs predicted from the GLMs by the proportions of non-zero catches given in Table 5.2.2. Adjusted, standardised catch rates have fluctuated around a relatively constant level between 1986/87 and 1994/95. The adjusted standardised catch rates declined substantially between 1994/95 and 1996/97. Since this decline, catch rates have demonstrated a slightly increasing trend from 1997/98 until 2001/02.

Table 5.2.1: Standardised series of CPUEs in kg/hook for *Dissostichus eleginoides* in Subarea 48.3.

Season	Std. CPUE	SE
1986/87	0.593	0.023
1987/88	0.744	0.055
1988/89	0.552	0.025
1989/90	-	-
1990/91	0.545	0.021
1991/92	0.630	0.013
1992/93	0.778	0.015
1993/94	0.612	0.024
1994/95	0.616	0.012
1995/96	0.359	0.006
1996/97	0.276	0.006
1997/98	0.274	0.006
1998/99	0.319	0.006
1999/00	0.348	0.006
2000/01	0.325	0.006
2001/02	0.367	0.007

Table 5.2.2: Proportion of non-zero catches by season in the haul-by-haul data for *Dissostichus eleginoides* in Subarea 48.3.

Season	Proportion
1986/87	0.977
1987/88	0.975
1988/89	0.991
1989/90	
1990/91	0.961
1991/92	0.966
1992/93	0.973
1993/94	0.949
1994/95	0.993
1995/96	0.978
1996/97	0.978
1997/98	0.981
1998/99	0.989
1999/00	0.983
2000/01	0.991
2001/02	0.992

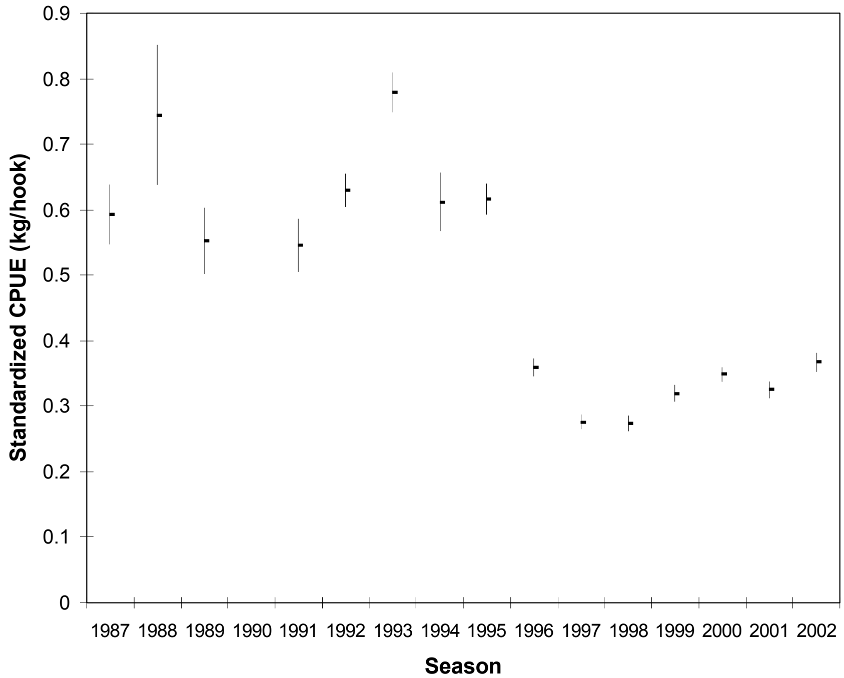


Figure 5.2.1: Standardised CPUEs and 95% confidence intervals in kg/hook for Subarea 48.3.

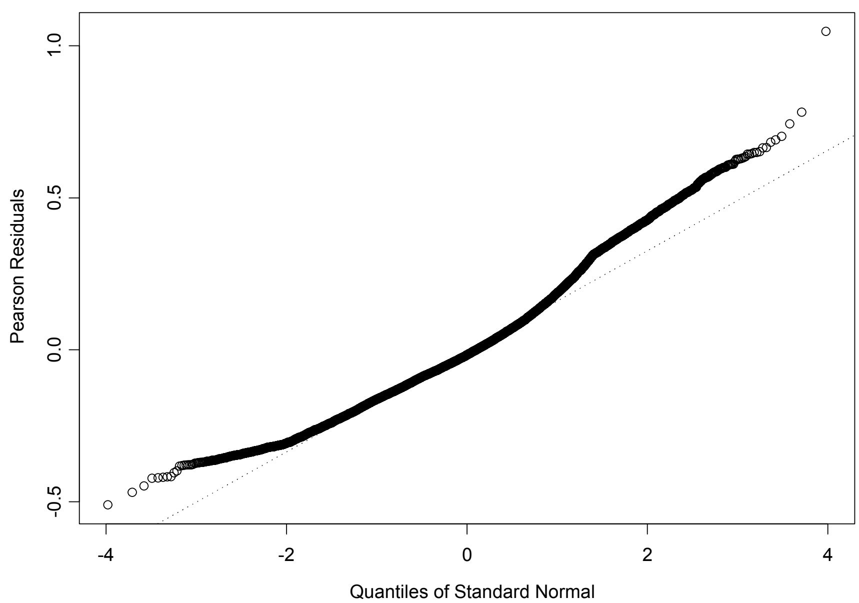


Figure 5.2.2: QQ plot of standardised residuals for the GLM fitted to CPUEs in kg/hook, using a robust GLM with the quasi likelihood family and a square root link.

AGENDA ITEM 5: ASSESSMENTS AND MANAGEMENT ADVICE

OTHER FISHERIES

Crabs (*Paralomis spinosissima* and *P. formosa*) (Subarea 48.3)

General Information about the Fishery

5.3.1 On 15 April 2002 the Japanese fishing vessel *Kinpo Maru No. 58* initiated its first season of participation in the commercial crab fishery in Subarea 48.3 in accordance with Conservation Measure 225/XX. The vessel targeted and retained two species of crabs, *P. spinosissima* and *P. formosa*. Fishing activities ended on 31 May 2002.

5.3.2 The vessel conducted fishery-based research in accordance with the data requirements described in Annex 225/A and completed effort-spreading measures according to the experimental harvest regime for the crab fishery outlined in Conservation Measure 226/XX and Annex 226/A. A total of 112 sets were made, with 51 997 pots deployed for a combined 1.473 million pot hours of fishing effort.

5.3.3 Data from the 2001/02 crab fishing season were submitted to the Secretariat in accordance with the 10-day catch and effort reporting system set forth in Conservation Measure 61/XII. Summary effort information from the 2001/02 crab fishing season by experimental block is provided in Table 5.3.1. Summary catch and effort information by 10-day reporting period is provided in Table 5.3.2.

5.3.4 By-catch from the target crab fishery included two other species of crab (*P. anamerae* and *Neolithodes diomedae*). *N. diomedeae* was retained in small quantities, though was not available in the CCAMLR catch and effort database. All specimens of *P. anamerae* were discarded. There were also four species of finfish reported: *Dissostichus eleginoides*, *Notothenia rossii*, *L. kempi* and *Mancopsetta maculata*. By-catch of *D. eleginoides* during the 2001/02 crab fishing season consisted of 77 fish; considerably lower than by-catch during the 1994/95 and 1995/96 fishing seasons.

Catch and Effort from the 2001/02 Crab Fishing Season

5.3.5 The experimental harvest regime as outlined in Conservation Measure 226/XX specifies that effort be allocated to 12 delineated blocks of 0.5° latitude by 1.0° longitude. The *Kinpo Maru No. 58* successfully completed these experimental hauls. The location of fishing effort (pot hours) is presented in Figure 5.3.1. After the experimental harvest conditions were met, fishing effort was primarily directed in blocks to the north and northwest of South Georgia.

5.3.6 A total of 1 133 989 *P. formosa* (56.1 tonnes) and 767 448 *P. spinosissima* (55.6 tonnes) was caught and retained by the *Kinpo Maru No. 58*. Figures 5.3.2a and 5.3.2b illustrate the catches retained by geographic block. The majority of retained *P. formosa* were taken to the north of South Georgia in blocks C and D, and *P. spinosissima* were taken from the north and northwest of the island in blocks A, B and C. Undersized crabs that were released included 272.3 tonnes of *P. formosa* and 276.0 tonnes of *P. spinosissima*.

5.3.7 The Working Group noted that some of the catch data were incomplete. Counts were present although some weights were missing in the haul-by-haul CCAMLR database. The Working Group stressed the importance of including all data in terms of weight and numbers so that these data are available for assessment.

5.3.8 Average nominal catch rates (numbers/pot) were computed by 10-day reporting period (Table 5.3.2) and for each geographic block for *P. formosa* and *P. spinosissima* (Figures 5.3.3a and 5.3.3b). Catch rates for *P. formosa* were highest to the north of South Georgia in geographic blocks D and EE. Although the highest catch rates were in block EE, there were few pots deployed in this region, and little effort in terms of pot hours. No catches were retained from the 1994/95 and 1995/96 crab fishing seasons, and thus catch rates could not be compared from these seasons.

5.3.9 Catch rates were highest for *P. spinosissima* to the northwest of South Georgia. Overall total nominal CPUE for the 2001/02 season was 14.6 crabs per pot; lower than rates observed for the 1994/95 and 1995/96 fishing seasons (19.1 and 22.8 respectively). However, the fishing season during these years took place from September to January, and is thus poorly suitable for direct comparison of catch rates.

Summary of Biological Data

5.3.10 Biological data for crabs included measurements of carapace width, carapace length, cheliped length, cheliped height, weight, sex, female maturity, presence of rizocephelan parasites and activity. The number of measurements available on the CCAMLR database is summarised in Table 5.3.3.

5.3.11 About 45% of carapace measurements for *P. spinosissima* and 42% of carapace measurements from *P. formosa* were from unsexed individuals. The Working Group recommended that sex is recorded for all measured individuals.

5.3.12 Length, weight, sex and maturity were recorded for fish by-catch species, and some otoliths were collected from *D. eleginoides* (Table 5.3.4).

Size Distribution

5.3.13 Scaled distributions of carapace width for *P. spinosissima* and *P. formosa* were calculated by weighting length measurements by recorded catch weights. These are shown in Figures 5.3.4 and 5.3.5.

Numbers of Undersized Female Crabs Retained

5.3.14 The observer recorded nine male *P. spinosissima* with carapace width less than 94 mm and three females as being retained from a sample of 1 107 individuals. This represented about 1.1% of the total catch of *P. spinosissima*, and 4.5% of the retained catch.

5.3.15 The observer recorded six male *P. formosa* with carapace width less than 90 mm and one female as being retained from a sample of 1 137 individuals. This represented about 0.6% of the total catch, and 6.9% of the retained catch.

Effect of Size Limit

5.3.16 Under the existing size and sex restrictions, only 19.3% of *P. spinosissima* and 8.7% of *P. formosa* caught in the 2001/02 fishery could be retained.

5.3.17 The effect of changing the size limits for *P. spinosissima* and *P. formosa* was investigated by examining the proportion of the observed catch (by number) which were males above a certain size threshold. Results are shown in Figure 5.3.6.

5.3.18 Any reductions in minimum size for male crabs would have a much greater effect on the retained catch of *P. formosa* than of *P. spinosissima*. For example, the proposal of the Japanese Delegation (SC-CAMLR-XXI/BG/19) to reduce the minimum size limit of *P. formosa* to 85 mm would increase the number of *P. formosa* retained by a factor of 2.7 (from 8.7% to 23.8% of the catch). The proposed reduction in the size limit of *P. spinosissima* to 89 mm would only increase the number of *P. spinosissima* retained by a factor of 1.3 (from 19.3% to 25.7%).

Spatial Differences in Mean Size

5.3.19 Mean size of crabs was examined for each of the 11 blocks fished. There were differences in mean size between areas (Table 5.3.5), but the number of crabs measured was small in many areas. Of the blocks with more than 100 individuals measured (blocks A–D for *P. spinosissima* and blocks C–D for *P. formosa*), block C appeared to have the largest mean size of males and the highest proportion of retainable crabs of both species.

Size at Maturity

5.3.20 Female maturity stages for *P. spinosissima* and *P. formosa* are summarised in Table 5.3.6. Following the recommendations in WG-FSA-01/32, females of stages 1–4 were defined as mature, while those of stage 5 were classified as immature.

5.3.21 There were too few immature female *P. formosa* observed (six) to estimate size at maturity. Data on female size at maturity for *P. spinosissima* are plotted in Figure 5.3.7. The fit of the data from 2001/02 was uncertain and the previous estimate of female size at 50% maturity could not be updated

5.3.22 A method for estimating size at maturity for male crabs was described in WG-FSA-01/32. Following this procedure, ln(cheliped height) was plotted as a function of ln(carapace width) for both species (Figure 5.3.8). The inflection point in this relationship is indicative of the onset of maturity. The inflection points were estimated as 65.8 mm (SD = 1.86 mm) for *P. spinosissima* and 62.2 mm (SD = 5.42 mm) for *P. formosa*. These were lower than the estimated size at 50% maturity of 73.4 mm carapace width for *P. spinosissima* and 68.0 mm for *P. formosa* from Shag Rocks (WG-FSA-01/32).

5.3.23 The Working Group expressed concern that the fits of the regression lines in Figure 5.3.8 were poor and considerable weighting was given to a few measurements of small individuals. The Working Group recommended that a more comprehensive analysis of size of male maturity incorporating all available data is required to update estimates of size at maturity in Subarea 48.3.

5.3.24 The Working Group recommended that all existing data on male cheliped height and length be submitted to CCAMLR, and that collection of these data becomes a requirement in future fisheries.

Crab Survival

5.3.25 Almost all crabs were classified as being either lively or limp when captured (Table 5.3.7). Only one *P. formosa* was dead. The proportion of limp crabs was higher for *P. formosa* (7.3%) than for *P. spinosissima* (1.8%).

5.3.26 Results of an experiment to determine survival rates of discarded crabs were summarised in the observer report. A total of 48 *P. spinosissima* and 48 *P. formosa* that would normally be discarded were selected at random and re-immersed in closed pots. Six individuals (three of each species) were lost due to a pot being poorly closed. Of the 90 recovered, two of each species were dead (4.4% mortality). The individuals that died were classified as lively (one *P. spinosissima*) or lively but injured (one *P. spinosissima* and both *P. formosa*) prior to release. The condition of another 20% of *P. spinosissima* and 11% of *P. formosa* deteriorated from lively to limp during the re-immersion. Two *P. formosa* (4.4%) and one *P. spinosissima* (2.2%) recovered from limp to lively after re-immersion.

Table 5.3.1: Effort distribution (number pots and pot hours) for established reference blocks around South Georgia by 10-day reporting period for the 2001/02 crab fishing season.

Block	Start of 10 Day Reporting Period											
	11 April		21 April		1 May		11 May		21 May		Total	
	Pots Fished	Pot Hours	Pots Fished	Pot Hours	Pots Fished	Pot Hours	Pots Fished	Pot Hours	Pots Fished	Pot Hours	Pots	Pot Hours
A					6 250	211 217	2 000	109 617			8 250	320 833
B			2 250	88 417	5 000	136 608					7 250	225 025
C			8 647	210 461	500	9 692	3 500	74 300	1 000	20 583	13 647	315 036
D	800	12 473	400	16 933			1 500	24 975	12 000	257 525	14 700	311 907
E	400	27 627							2 000	40 158	2 400	67 785
EE							1 000	22 658			1 000	22 658
F	400	23 133									400	23 133
G	850	28 816									850	28 816
H	1 150	28 648									1 150	28 648
I	1 200	21 767									1 200	21 767
K	400	13 133									400	13 133
O					250	36 033	500	58 008			750	94 042
Total	5 200	155 597	11 297	315 811	12 000	393 550	8 500	289 558	15 000	318 267	51 997	1 472 783

Table 5.3.2: Catch of *P. formosa* and *P. spinosissima* during the 2001/02 crab fishing season in Subarea 48.3.

Start of 10-Day Period	Pots Fished	Hours Fished	*P. formosa*			*P. spinosissima*		
			Catch (kg)	Catch (Number)	CPUE (Number/Pot)	Catch (kg)	Catch (Number)	CPUE (Number/Pot)
11 April	5 200	385.25	2 306	78 768	15.15	3 752	25 379	4.88
21 April	11 297	774.03	14 403	230 440	20.40	12 347	254 360	22.52
1 May	12 000	949.22	11 772	178 946	14.91	18 394	241 578	20.13
11 May	8 500	579.12	12 457	287 809	33.86	10 312	116 009	13.65
21 May	15 000	636.53	15 194	358 026	23.87	10 771	130 122	8.67
Total	51 997	3 324.15	56 132	1 133 989	21.81	55 576	767 448	14.76

Table 5.3.3: Summary of crab biological data collected by scientific observers.

Number of Measurements	*Paralomis spinosissima*	*Paralomis formosa*	*Paralomis anamerae*	*Neolithodes diomedeae*
Carapace width	2013	1944	97	39
Carapace length	2008	1944	97	39
Cheliped length	1108	1137	59	39
Cheliped height	1108	1137	59	39
Weight	740	616	8	37
Sex	1107	1137	59	39
Female maturity	548	381	15	12
Parasites	1107	1137	59	39
Activity	1031	999	59	15

Table 5.3.4: Summary of biological data on fish by-catch collected by scientific observers.

Number of Measurements	*Dissostichus eleginoides*	*Notothenia rossii*	*Lepidonotothen kempi*	*Mancopsetta maculata*
Length	72	45	3	20
Weight	69	31	0	0
Sex	68	37	0	0
Maturity	68	37	0	0
Otoliths	49	0	0	0

Table 5.3.5: Difference in mean crab size between blocks. *n* values are the numbers of crabs measured. '% retainable' is the percentage of measured crabs that were males exceeding the size limit (94 mm for *P. spinosissima* and 90 mm for *P. formosa*).

Block	*Paralomis spinosissima*					*Paralomis formosa*				
	n	% male	Size (mm)		% retainable	*n*	% male	Size (mm)		% retainable
			male	female				male	female	
A	176	53	84.8	75.9	16	91	78	82.9	66.4	25
B	251	49	89.6	87.4	18	67	94	82.7	91.0	16
C	212	39	93.5	85.8	21	386	60	84.0	71.8	9
D	216	33	91.1	83.0	15	361	63	81.8	71.6	7
E	48	56	88.4	75.4	23	97	75	83.0	71.0	10
EE	2	50	126.0	118.0	50	35	31	87.3	72.5	9
F	17	88	109.6	98.5	88	12	100	89.7		58
H	54	65	98.3	78.8	39	2	100	94.5		100
G	79	97	110.2	81.5	94	2	100	87.0		50
I	33	58	91.5	75.9	24	56	75	79.9	70.6	7
O	19	63	79.2	70.9	21	28	68	84.5	74.3	29

Table 5.3.6: Observed female maturity stages for *Paralomis spinosissima* and *P. formosa*. Maturity was assessed on a 5-point scale: 1 = eggs uneyed; 2 = eggs eyed; 3 = dead eggs; 4 = empty egg cases; 5 = non-ovigerous.

Stage	*Paralomis spinosissima*		*Paralomis formosa*	
	Number	%	Number	%
1	190	34.7	283	74.3
2	210	38.3	57	15.0
3	9	1.6	6	1.6
4	84	15.3	29	7.6
5	55	10.0	6	1.6

Table 5.3.7: Observed activity states of *Paralomis spinosissima* and *P. formosa* captured during the fishery in Subarea 48.3.

State	*Paralomis spinosissima*		*Paralomis formosa*	
	Number	%	Number	%
Lively	1012	98.2	925	92.6
Limp	19	1.8	73	7.3
Dead	0	0	1	0.1
Dead and eaten	0	0	0	0

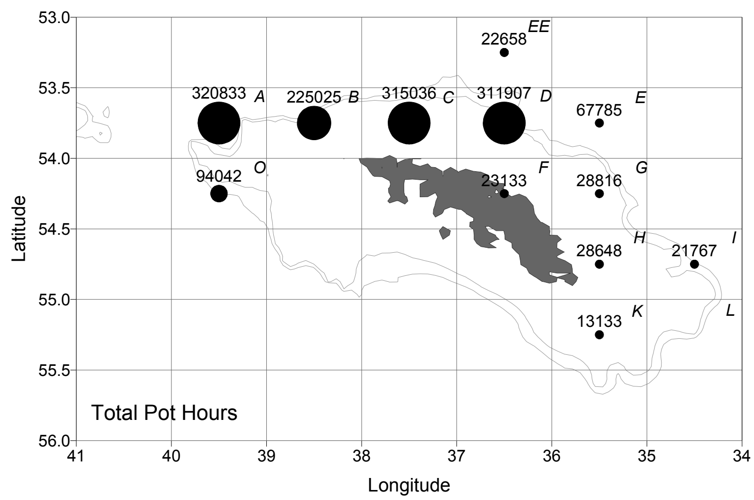
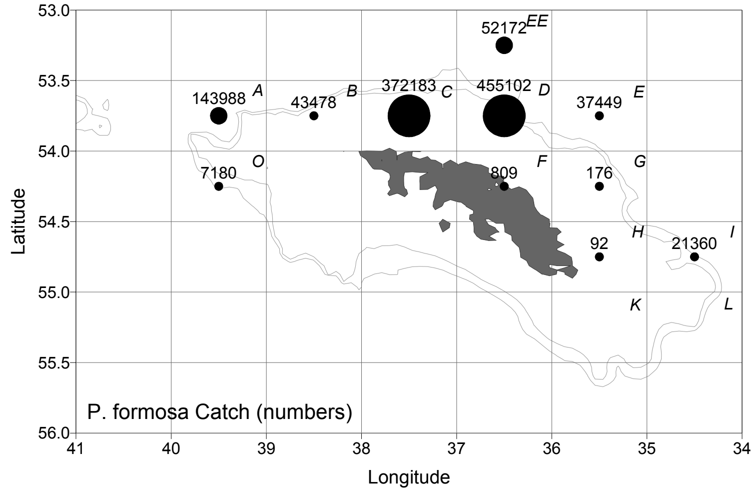


Figure 5.3.1: Effort (pot hours) allocated to each block of the experimental harvest regime for the 2001/02 crab fishing season.

(a)



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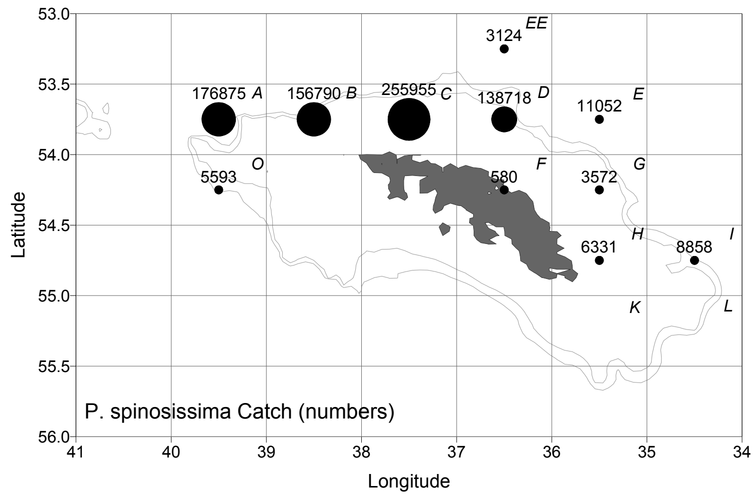
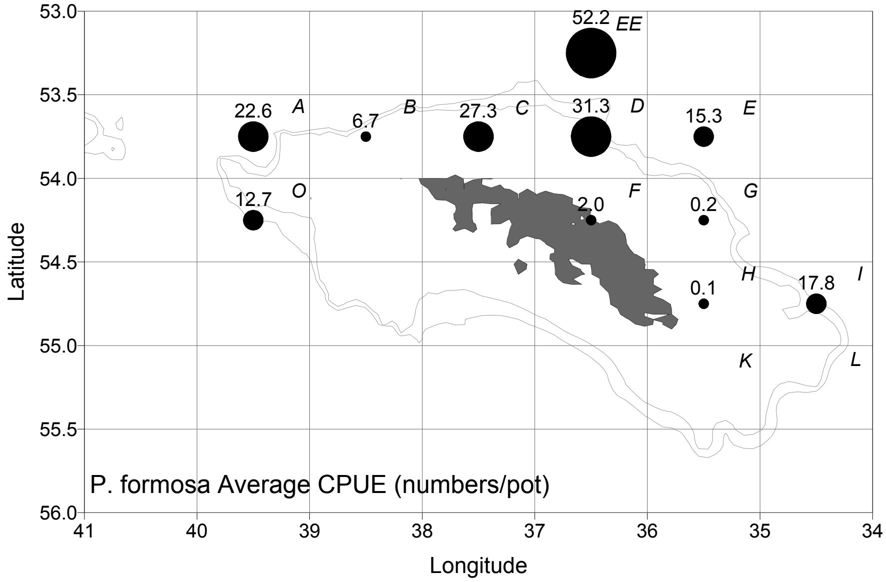


Figure 5.3.2: Retained catch (numbers) for: (a) *Paralomis formosa* and (b) *P. spinosissima* by experimental harvest regime block for the 2001/02 crab fishing season.

(a)



(b)

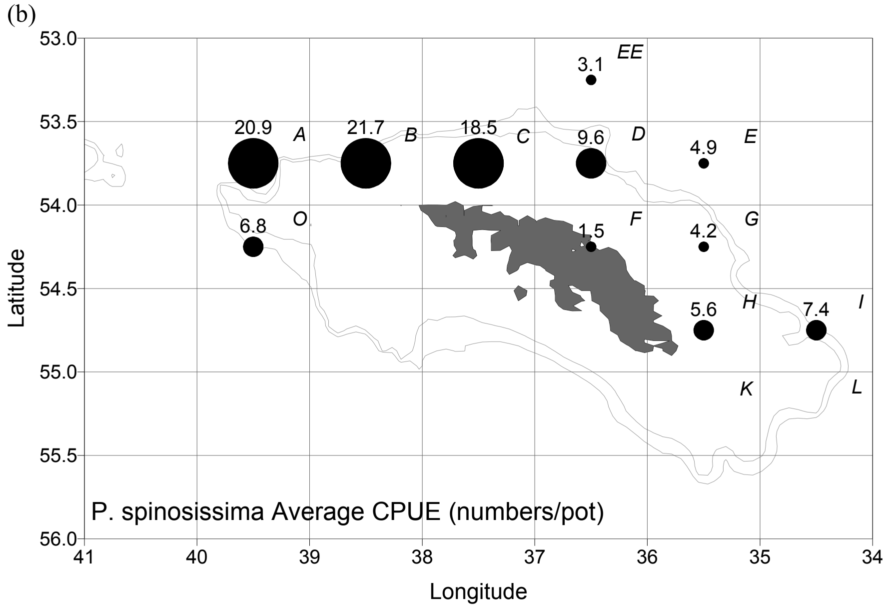
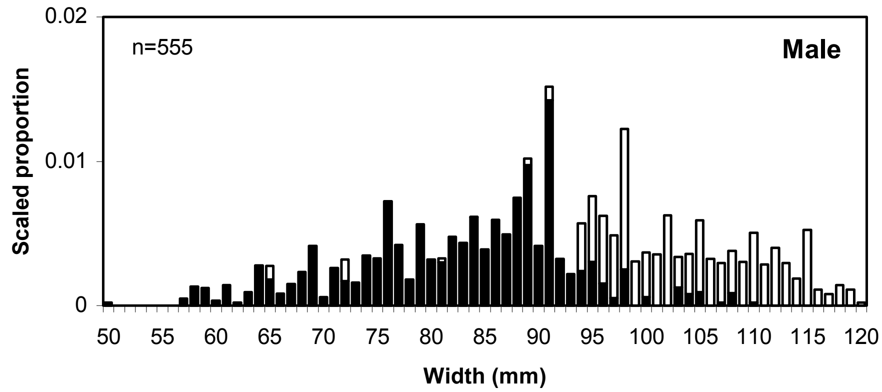
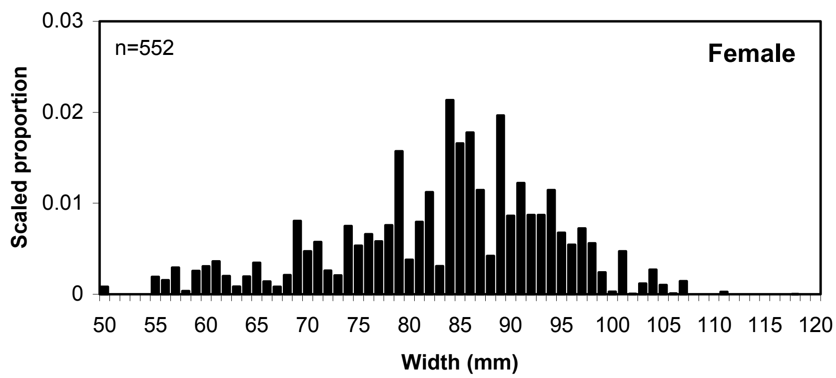


Figure 5.3.3: Nominal average catch rates (numbers/pot) for: (a) *Paralomis formosa* and (b) *P. spinosissima* by experimental harvest regime block for the 2001/02 crab fishing season.





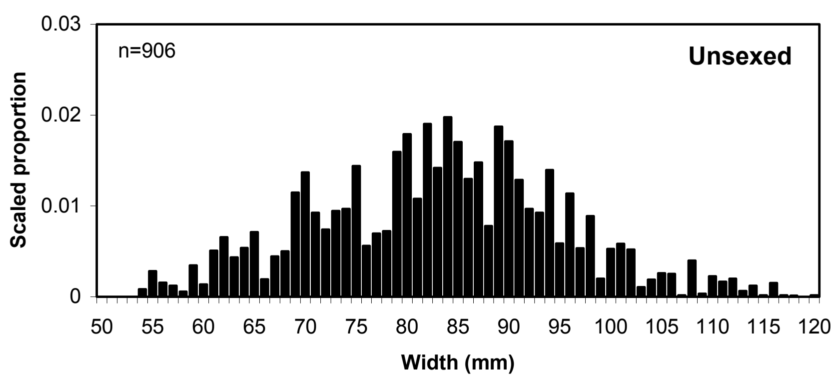


Figure 5.3.4.4: Scaled distribution of carapace width for *Paralomis spinosissima* caught in Subarea 48.3. Retained male crabs are shown as white bars.

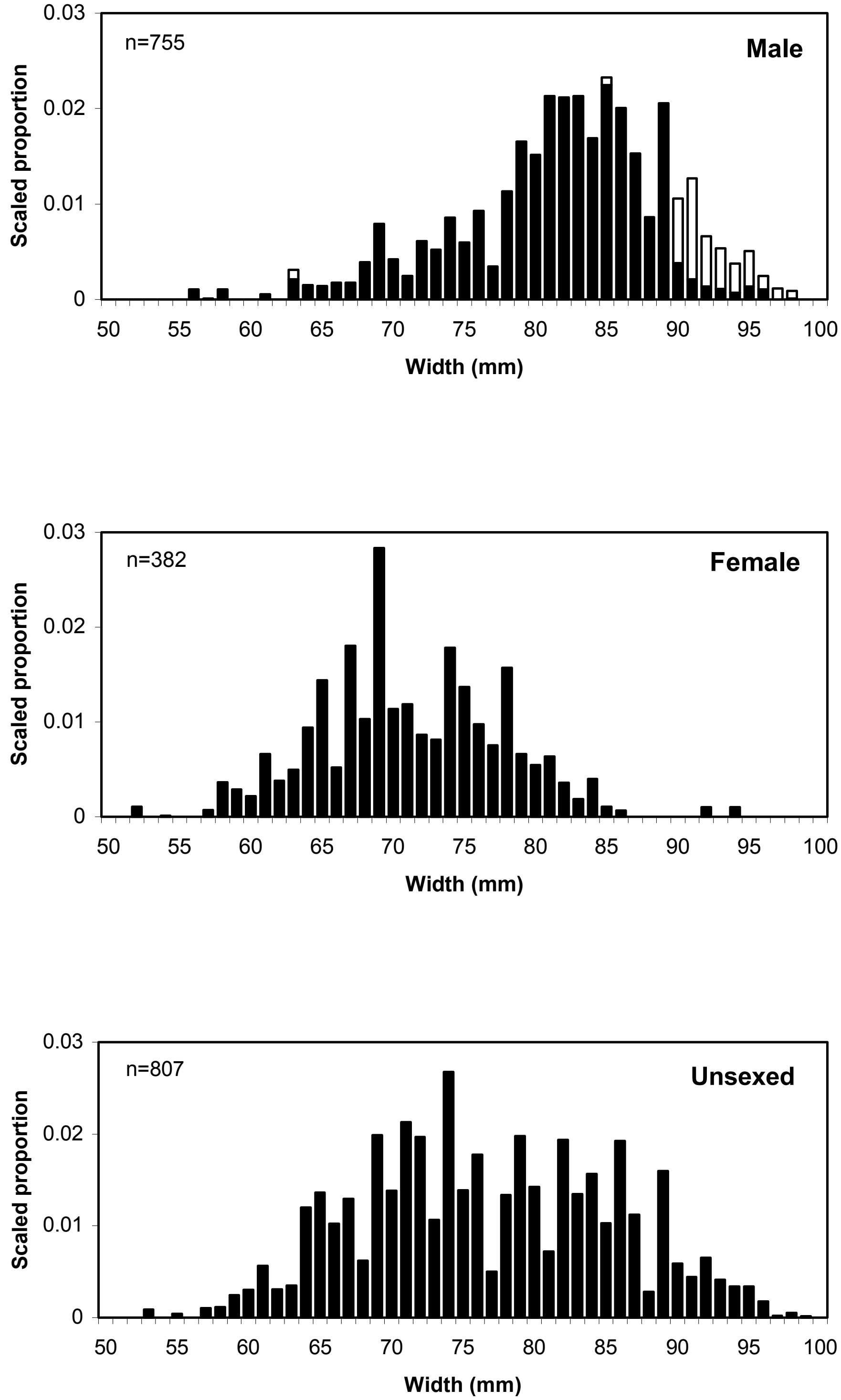


Figure 5.3.5: Scaled distribution of carapace width for *Paralomis formosa* caught in Subarea 48.3. Retained male crabs are shown as white bars.

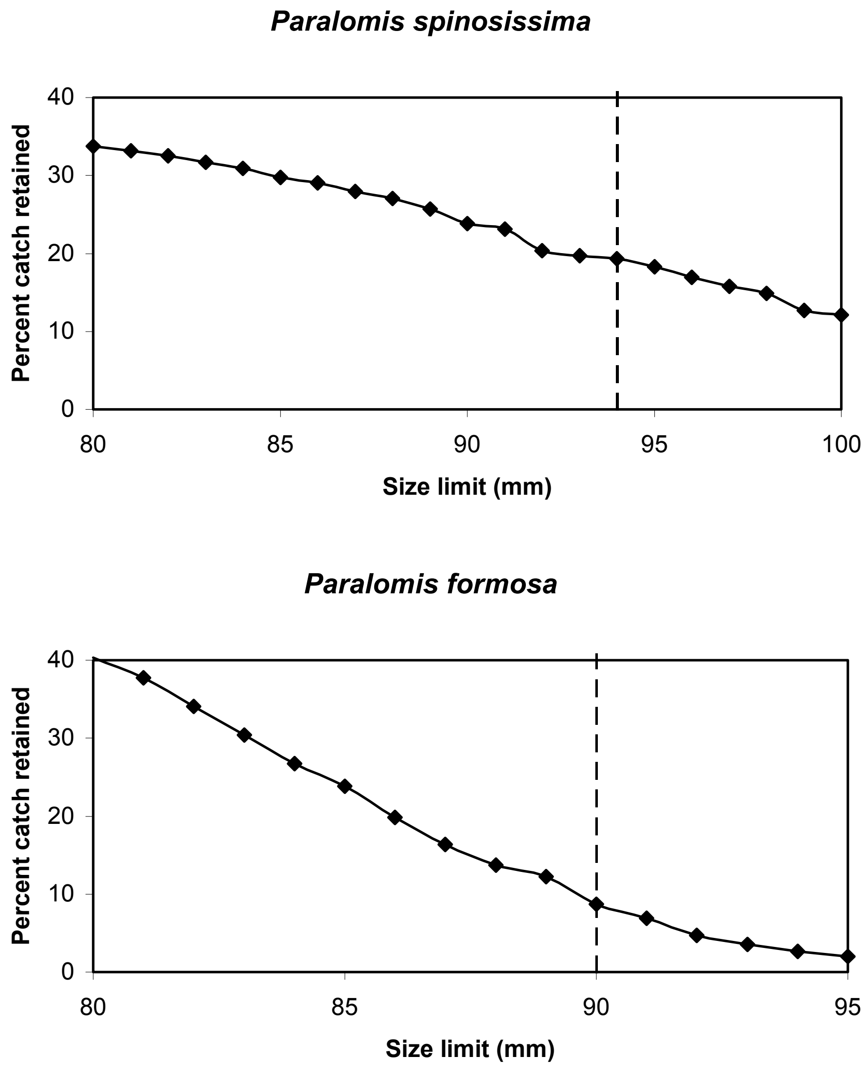


Figure 5.3.6: Simulation of the effect of different size limits on the percentage (by number) of the catch retained for in Subarea 48.3. Dashed lines indicate current legal minimum size of 94 mm carapace width for *Paralomis spinosissima* and 90 mm for *P. formosa*.

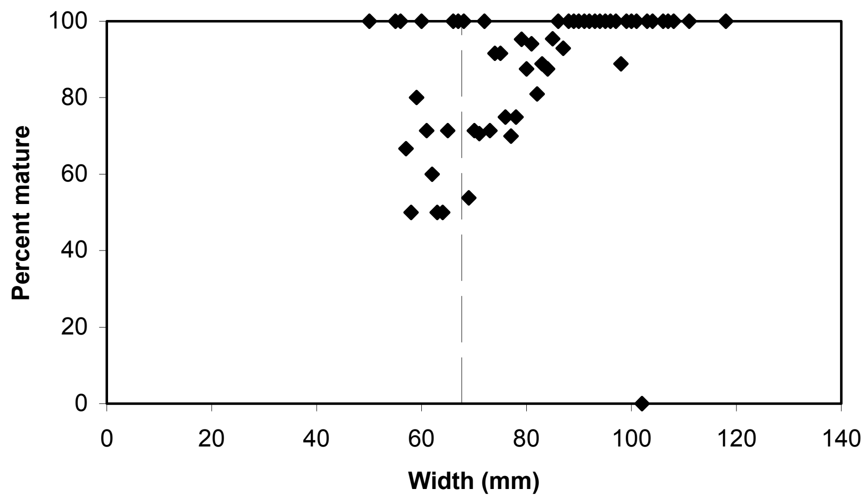
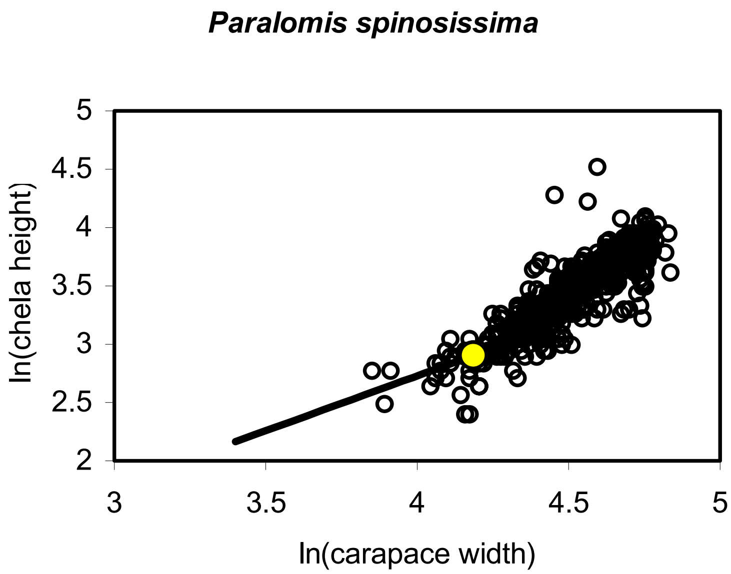


Figure 5.3.7: Female maturity as a function of carapace width for *Paralomis spinosissima*. Carapace width at 50% maturity of 67.7 mm reported in WG-FSA-01/32 for Shag Rocks is indicated by the dashed line.



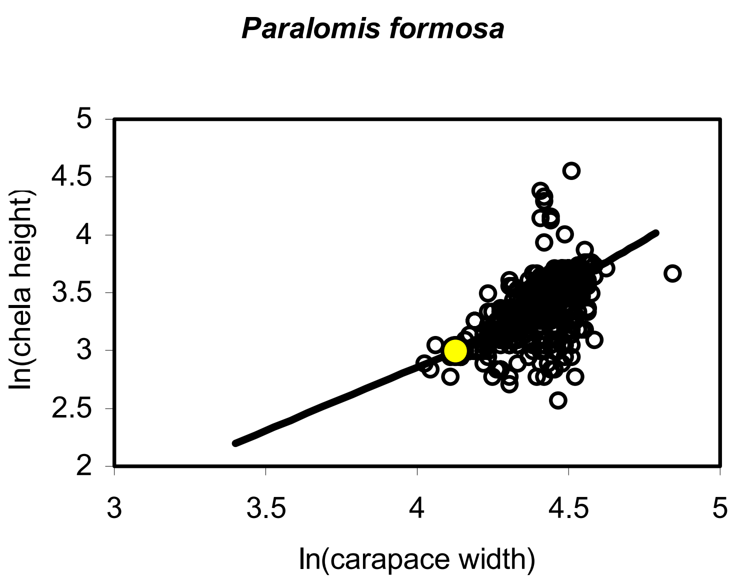


Figure 5.3.8: Ln(cheliped height) as a function of ln(carapace width) for male *Paralomis spinosissima* and *P. formosa.* The intersection of the fitted curves (grey dot) was used to estimate size at maturity.

AGENDA ITEM 5: ASSESSMENTS AND MANAGEMENT ADVICE

ASSESSMENT METHODS FOR MACROURIDS IN SUBAREA 88.1 AND DIVISION 58.5.2

Macrourus whitsoni in Subarea 88.1

Population Parameters

5.4.1 Population parameters for assessing the precautionary pre-exploitation harvest levels (γ) for *Macrourus whitsoni* in Subarea 88.1 were based on biological data collected by observers on New Zealand exploratory longline vessels in the Ross Sea (WG-FSA-02/32 and 01/43).

5.4.2 Preliminary growth parameters for *M. whitsoni* from Subarea 88.1 were presented in WG-FSA-01/43 and were reviewed and confirmed in WG-FSA-02/32. The von Bertalanffy growth parameters calculated for both sexes combined were: L_∞ = 857 mm, k = 0.048, t_0 = -3.89.

5.4.3 Otolith readings gave an unvalidated maximum age of 55 years. The best estimates of instantaneous M based on the minimum age of the oldest 1% of fish in the longline catch were 0.08 for males and 0.09 for females. Because of the uncertainty associated with these estimates, a range of 0.05 to 0.12 was used in this assessment.

5.4.4 Following the recommendation of SC-CAMLR-XX, paragraph 4.298, macrourids sampled by observers during the 2001/02 fishery in Subarea 88.1 were measured from the tip of the snout to the anus (AL). However, because von Bertalanffy growth parameters were only available relative to total length, all other biological parameters were converted to total length (TL) using sex-specific regression equations presented in WG-FSA-02/32. These were: males TL = 6.3052 + 2.6318 SL; females TL = 9.5933 + 2.3559 SL.

5.4.5 The Working Group recommended that future estimates of population parameters are expressed as snout–anal length.

5.4.6 The estimates of the total length at 50% recruitment were based on the length frequency of fish taken in the 2001/02 exploratory longline fishery in Division 88.1 (Figure 5.4.1). These were 440 mm for males and 470 mm for females.

5.4.7 Data on length at maturity were presented in WG-FSA-02/32. The total length at 50% maturity was estimated as 460 mm for males and 500 mm for females.

5.4.8 There are no estimates of standing stock for *M. whitsoni* in Subarea 88.1. The coefficient of variation (CV) for B_0 was calculated from the CV of nominal catch-per-unit effort (CPUE = kg/baited hook) for *M. whitsoni* reported from haul-by-haul longline data in Subarea 88.1 during the 2001/02 season. This is equivalent to the approach used for assessment of skates and rays in Subarea 48.3 (SC-CAMLR-XX, paragraph 4.307). The estimate of CV was 1.184.

Determination of γ

5.4.9 The decision rule used to assess the precautionary pre-exploitation harvest levels (γ) was that the median escapement of the spawning stock at the end of 20 years of exploitation is 50% of the pre-exploitation spawning stock biomass, and that the probability of depletion below 20% of the median pre-exploitation spawning biomass is no greater than 0.1 over a 20-year period. The parameter and simulation characteristics used to compute γ for *M. whitsoni* are presented in Table 5.4.1.

5.4.10 One of the model parameters with greatest uncertainty was the estimate of the standard deviation of the lognormal recruitment function. There were no estimates of recruitment for *M. whitsoni* in Subarea 88.1. Two alternative ranges for recruitment CV were used. A range of 0.1–0.32 was obtained from Myers et al. (1995) for two hake species (*Merluccius capensis* and *M. merluccius*). Members of the Working Group pointed out that the recruitment variability of many fish species is higher than 0.32, and a sensitivity analysis was carried out using an arbitrary range of 0.5–0.7 for the recruitment CV. It is recommended that a literature search be carried out intersessionally to obtain better estimates of recruitment variability in macrourids or related species.

Results

5.4.11 Estimates of γ were relatively insensitive to the range of recruitment CV. The estimate of γ using a recruitment CV of 0.1–0.32 was 0.02165. This resulted in a median escapement of 0.74 and probability of depletion of 0.10. The estimate of γ using a recruitment CV of 0.5–0.7 was 0.02044.

5.4.12 The estimate of γ suggests that *M. whitsoni* is a relatively low productivity species, and thus may be vulnerable to overexploitation.

5.4.13 Estimating a precautionary yield for *M. whitsoni* in Subarea 88.1 using γ requires an estimate of B_0 for the population. There are currently no estimates of B_0 in Subarea 88.1 or adjacent areas. Therefore the Working Group was not in a position to compute a precautionary yield with the available information.

5.4.14 The Working Group recommended that future work include research toward generating an estimate of B_0 for *M. whitsoni* in Subarea 88.1.

Macrourus carinatus in Division 58.5.2

Population Parameters

5.4.15 Population parameters for assessing the precautionary pre-exploitation harvest levels (γ) for *M. carinatus* in Division 58.5.2 were based on biological data collected from commercial and research fishing trips to Heard and McDonald Islands in Division 58.5.2 (WG-FSA-02/48).

5.4.16 All biological parameters were based on total length because measurements of snout–anal length were not available. It is recommended that future estimates of length are recorded as anal length.

5.4.17 Growth parameters were calculated from a sample of 156 otoliths collected from Division 58.5.2 (WG-FSA-02/48). The size range of sampled fish was 246–603 mm total length, with an estimated range of ages of 4–25 years. The calculated von Bertalanffy growth parameters for both sexes combined were: L_∞ = 635 mm, k = 0.0588, t_0 = -1.8. It was noted that the size range probably does not encompass the full range of ages in the population due to the depth of trawl fishing operations and the tendency of macrourids to increase in size with depth. The estimation of von Bertalanffy growth parameters would be improved with the inclusion of larger, older fish.

5.4.18 There are no estimates of M for *M. carinatus* in Division 58.5.2. Estimates of M for *M. whitsoni* in Subarea 88.1 were equal to about 1–2 times the von Bertalanffy growth parameter *k*. Applying this criteria to *k* estimated for *M. carinatus* gave a range of M from 0.09 to 0.17.

5.4.19 The total length at 50% recruitment was estimated as 320 mm based on the length frequency of fish taken in the commercial trawl fishery in Division 58.5.2 (Figure 5.4.1).

5.4.20 Data on length at maturity were presented in WG-FSA-02/48. The size at which 50% of the fish population was mature was 417 mm total length, and the size at which 50% of the population had spawned for the first time was 512 mm.

5.4.21 The CV of B_0 (0.5) for *M. carinatus* was calculated from data obtained from a research trawl survey carried out on BANZARE Bank, the southernmost part of the Kerguelen Plateau (Divisions 58.4.1 and 58.4.3) in 1999 (van Wijk et al., 2000).

Determination of γ

5.4.22 The decision rule used to assess the precautionary pre-exploitation harvest levels (γ) was that the median escapement of the spawning stock at the end of 20 years of exploitation is 50% of the pre-exploitation spawning stock biomass, and that the probability of depletion below 20% of the median pre-exploitation spawning biomass is no greater than 0.1 over a 20-year period. The parameter and simulation characteristics used to calculate γ for *Macrourus carinatus* are presented in Table 5.4.1.

5.4.23 One of the model parameters with greatest uncertainty was the estimate of the standard deviation of the lognormal recruitment function. There were no estimates of recruitment for *M. carinatus* in Division 58.5.2. Two alternative ranges for recruitment CV were used. A range of 0.1–0.32 was obtained from Myers et al. (1995) for two hake species (*M. capensis* and *M. merluccius*). Members of the Working Group pointed out that the recruitment variability of many fish species is higher than 0.32, and a sensitivity analysis was carried out using an arbitrary range of 0.5–0.7 for the recruitment CV. It is recommended that a literature search be carried out intersessionally to obtain better estimates of recruitment variability in macrourids or related species.

Results

5.4.24 Estimates of γ were 0.03226 using a recruitment CV of 0.1–0.32 and 0.03075 using a recruitment CV of 0.5–0.7. The estimate of γ using a recruitment CV of 0.1–0.32 resulted in a median escapement of 0.51 and probability of depletion of 0.10. This γ was very close to the γ of 0.033 estimated for *M. carinatus* in WG-FSA-99/69 using previous parameters.

Estimate of Precautionary Yield

5.4.25 An estimate of B_0 was derived using the mean density estimate (176 ± 14 kg km^{-2}) of *M. carinatus* obtained from a research trawl survey of BANZARE Bank, the southernmost part of the Kerguelen Plateau (van Wijk et al., 2000). This estimate was pro-rated by comparing the survey area between depths of 600–1 500 m to the area of the seabed in Division 58.5.2 between 600 and 1 500 m (81 827 km^2). This gave a mean biomass for Division 58.5.2 (applicable to depth range 600–1 500 m) of 14 402 tonnes, with a range of 13 256 to 15 547 tonnes.

5.4.26 The formula used for estimating the long-term precautionary yield was:

$$\text{Yield} = \gamma B_0$$

5.4.27 Applying γ = 0.03226 gives a mean estimate of yield for *M. carinatus* in Division 58.5.2 of 465 tonnes, with a range of 428 to 502 tonnes. For γ = 0.03075, the mean estimate of yield was 443 tonnes, with a range of 407 to 478 tonnes.

References

Alekseyeva, Ye.I., F.Ye. Alekseyeva, V.V. Konstantinov and V.A. Boronin. 1993. Reproductive biology of grenadiers, *Macrourus carinatus, M. whitsoni, Coelorinchus fasciatus* (Macrouridae), and *Patagonotothen guntheri shagensis* (Nototheniidae) and the distribution of *M. carinatus*. *J. Ichthyol.,* 33 (1): 71–84.

Myers, R.A., J. Bridson, and N.J. Barrowman. 1995. *Summary of Worldwide Spawner and Recruitment* Data. Department of Fisheries and Oceans, Northwest Atlantic Fisheries Centre, Canada.

van Wijk, E.M., A.J. Constable, R. Williams and T. Lamb. 2000. Distribution and abundance of *Macrourus carinatus* on BANZARE Bank in the southern Indian Ocean. *CCAMLR Science*, 7: 171–178.

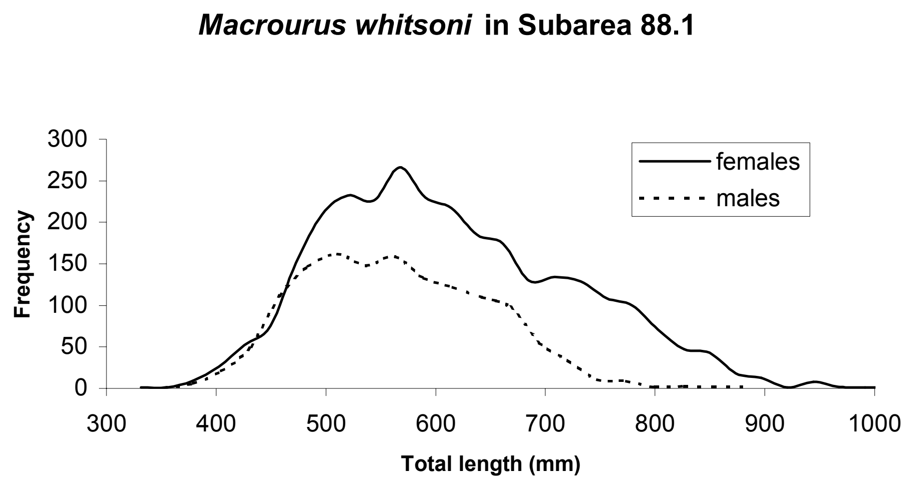
Table 5.4.1: Input parameters for generalised yield model (GYM) to assess γ of *Macrourus whitsoni* in Subarea 88.1 and *M. carinatus* in Division 58.5.2. All length parameters are given as total length in mm.

Input Parameters	*M. carinatus* 58.5.2	*M. whitsoni* 88.1		
		Both Sexes	Males	Females
L_∞	635	857	783	870
K	0.088	0.048	0.05	0.068
t_0	-1.8	-3.89	-5.3	1.34
Maximum length	670+			
Oldest age in stock	55	80		
Last age in stock	25+	55		
Minimum age in stock	1	1		
Natural mortality range	0.09–0.17	0.05–0.12		
Length–weight				
a	2×10^{-9}	1.609×10^{-8}		
b	3.1159	2.8603		
Birthday	July			
Spawning season	May–September	May–September		
Fishing selectivity				
Min length 50%	320	440		
Max length 50%	320	470		
Range	160	160		
Maturity				
Min length 50%	417 (age 10)	460 (12)		
Max length 50%	512 (age 17)	500 (14)		
Range	150	260		
Recruitment*				
Min SD	0.099751	0.099751		
Max SD	0.312233	0.312233		
CV of B_0	0.5	1.184		
Data sources	WG-FSA-02/48 van Wijk et al., 2000 Alekseyeva et al., 1993	WG-FSA-02/32 WG-FSA-01/43 Alekseyeva et al., 1993		

* Standard deviation of lognormal recruitment (SD) calculated from recruitment coefficient of variation (CV) using equation:

$$SD = \sqrt{(\log_e(1+CV^2))}$$

Range given corresponds to CV of 0.1–0.32 from Myers et al. (1995). A sensitivity trial was also done using CV = 0.5–0.7 (equivalent to min SD = 0.472, max SD = 0.631).



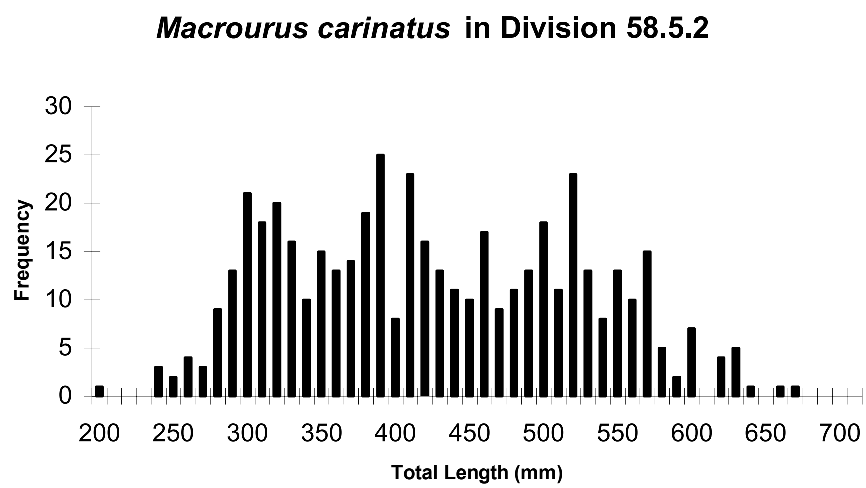


Figure 5.4.1: Unscaled length-frequency data used to estimate fishing selectivity for *Macrourus whitsoni* in Subarea 88.1 and *M. carinatus* in Division 58.5.2. Data for *M. whitsoni* are from the exploratory longline fishery in Subarea 88.1 in 2001/02. Data for *M. carinatus* are from the commercial trawl fishery in Division 58.5.2. *M. whitsoni* were measured by observers using anal lengths. These were converted to total length using the regression equations presented in WG-FSA-02/32.

AGENDA ITEM 7: SUMMARY OF PAPERS SUBMITTED TO WG-FSA ON BIOLOGY, DEMOGRAPHY AND ECOLOGY OF HARVESTED AND BY-CATCH SPECIES

Champsocephalus gunnari

Distribution and Demography

Subarea 48.3

7.1 WG-FSA-02/34, 02/44, 02/59 and 02/79 presented the results of surveys in Subarea 48.3. Strong cohorts with modal lengths of 23 cm and 34 cm were identified on the South Georgia shelf, and cohorts at 18 cm, 27 cm and 37 cm at Shag Rocks. As in previous years, the largest catches were taken north and northwest of the South Georgia shelf at 125–174 m depths. WG-FSA-02/44 further described the vertical zonation of icefish, with young fish (5–6 cm long) principally in the near-surface 50 m layer, a mixture of year classes of lengths between 15 and 30 cm long in the middle part of the water column and a single length mode of 25 cm in the zone within 58 m of the bottom. In the pelagic zone Myctophidae dominated in catches above the bottom depths greater than 200 m and icefish prevailed above the bottom depths less than 130 m. Icefish distribution in both pelagic and near-bottom zones correlated with distribution of krill. Up to 30% of the krill biomass was found in the near bottom zone. The observed krill distribution was probably responsible for keeping the fish near the bottom during the daytime. Given a different vertical krill distribution, a change in vertical distribution of the icefish biomass during the daytime can be expected.

Kerguelen Plateau (Divisions 58.5.1 and 58.5.2)

7.2 Since the last season in which commercial catches of *C. gunnari* were taken in Division 58.5.1 (1994/95) regular trawl surveys have demonstrated that the icefish population has remained low (WG-FSA-02/65). Although a progression of successive cohorts has been monitored through the years, as was seen during the earlier period of fishing, no clear recovery in the biomass of the northeastern Kerguelen shelf stock of icefish seems to have occurred. The maximum level of abundance was observed during the 1996/97 season and the data for the following years show levels five times lower. The causes for this decline could involve overfishing during the years before the surveys, when depletion of cohorts had been observed; increase of the local fur seal population and consequent higher predation; or an ENSO event in which the sea-surface temperature has been up to 2°C warmer than normal in the vicinity of the Kerguelen shelf area during 1998. The latter may have a direct effect on natural mortality or an indirect effect through lower abundance of pelagic prey or emigration southwards.

7.3 This is in contrast to the neighbouring Division 58.5.2 to the south, where there have been two periods in recent years when strong cohorts have been fished. WG-FSA-02/47 described the status of the current strong cohort at 4+ years old, which was found in very high densities on the usual fishing grounds. Growth rate from the previous year was not as high as expected in this cohort, and the modal length of the succeeding age 3+ cohort had merged with that of the age 4+ cohort. It is possible that some density-dependent factor, such as food availability, has limited the growth in this cohort.

Ageing

7.4 WG-FSA-02/57 reported on attempts to age icefish by reading otoliths. It was agreed that there were structures visible in the otoliths that might be used for age determination. Such a topic might be investigated through a practical workshop meeting.

Feeding

7.5 WG-FSA-02/79 established that during the 2002 surveys in Subarea 48.3, icefish feeding was moderate with average index of stomach fullness being 1.51; krill and copepods predominated in their diet. The highest feeding activity was observed in the evening and at night. Despite relatively high internal fatness, the fish continued feeding in the northwestern part of the shelf, probably due to the presence of large krill aggregations near the bottom in that area.

7.6 Results from surveys in the Elephant Island–South Shetland Islands (Subarea 48.1) in the 2001 and 2002 summers showed juvenile and adult *C. gunnari* primarily fed on krill (WG-FSA-02/73).

Dissostichus eleginoides

Tagging Experiments: Movement, Growth and Behaviour

7.7 Two papers presented further data on the movements and behaviour of fish provided by tagging experiments. In Subarea 48.3, results in WG-FSA-02/28 largely agree with those found previously in Division 58.5.2 that *D. eleginoides* generally do not move far from their point of release. Of 30 recaptures in the South Georgia area, 25 had moved up to 20 km from their release point, two had moved between 20 and 50 km and two had moved more than 100 km after periods at liberty of 1 to 2 years. Of 13 fish recaptured after release in an area near 42°S, north of Subarea 48.3, most had moved less than 20 km, but two had moved 46 km and 322 km respectively. Observed growth of tagged fish on recapture was in most cases less than that predicted by the von Bertalanffy growth curve used in current assessments.

7.8 WG-FSA-02/60 reported on behaviour and vertical movements of toothfish at Heard Island revealed by the use of archival tags. Most of the fish had periods of active vertical movement alternating with periods of relative inactivity, loosely correlated with moon phase. The direction of vertical movement was influenced by the bottom topography, with fish on the relatively shallow plateau or in the bottom of a valley only moving upwards from their resting depth, while those on the intervening escarpment moved both upwards and downwards. Major vertical movements took place between 0500 and 1100 local time. The frequency and scale of these movements suggest that *D. eleginoides* spends a considerable part of its time off the bottom.

Size and Sexual Maturity

7.9 WG-FSA-02/67 contained data on sexual maturity stages of *D. eleginoides* caught on William's Ridge, outside the CCAMLR boundary east of Division 58.5.2, by a Uruguayan vessel in April–June 2002. The mean depth of fishing was 900 m in all zones.

7.10 The mean length was 83.77 cm for males and 81.04 cm for females. In the three more southerly fishing zones the majority of both sexes were at stage 4 of gonad maturity and in the more northerly zones the majority were at stage 3. Remains of *Dissostichus* spp., *Muraenolepis* spp., *Macrourus* spp. and skates were identified in stomach contents.

Age and Growth

7.11 WG-FSA-02/51 reported on the progress made by the CCAMLR Otolith Network (CON) since the first meeting held in Norfolk, Virginia, USA, in July 2001. The otolith exchange program has become well established with the three laboratories that regularly age toothfish exchanging otolith preparations. Further progress was reported in assessing the precision of toothfish age estimates. The National Institute of Water and Atmospheric Research, Nelson, New Zealand; Central Ageing Facility, Victoria, Australia; and CQFE, Norfolk, Virginia, USA, each provided a sample of otoliths, processing and reading one randomly chosen otolith from each pair. Half of the remaining otoliths were sent to each of the other laboratories to process and read using their methodologies. Reasonable agreement between all three laboratories is reported with no biases >2 years between laboratories, that would indicate major differences in the criteria used by readers. There was little evidence that differences in otolith preparation method led to major biases in age estimates.

7.12 It was noted that differences between readers may be explained by apparent differences in the timing of formation of translucent zones between areas, and the interpretation of the age of the first year, particularly for South Georgia fish. Future CON exchanges should: (i) define better how these differences in interpretation may affect age estimates, and (ii) achieve consensus on further interpretation. Further work on toothfish age validation is recommended.

7.13 New age–length keys (ALKs) and von Bertalanffy growth parameters for toothfish were provided for the Falkland/Malvinas Islands and South Georgia in documents WG-FSA-02/74 and 02/75 respectively. Estimated growth parameters from these studies are shown below.

Area	Growth Parameters	Male	Female
Falkland/Malvinas Islands	L_∞ (cm)	110.9	129.3
	k	0.156	0.12
	t_0	-1.12	-1.55
South Georgia	L_∞ (cm)	123.8	144.9
	k	0.1	0.085
	t_0	-2.1	-2.0

7.14 The growth parameters for South Georgia were calculated with the inclusion of the age–length data obtained from juvenile toothfish presented in WG-FSA-01/16. Different growth parameters were calculated for males and females from both regions.

Dissostichus spp. in Subarea 88.1

Tagging Experiments: Movement, Growth and Behaviour

7.15 WG-FSA-02/38 provided an update on the tagging program for skates and toothfish in the 2002 fishery. Of a total of 793 *D. mawsoni* tagged, three (two originally tagged in 2002 and one in 2001), were recaptured during the 2002 fishery. The two within-season captures were to the south of their release site. The between-season recapture, a 101 cm, 10.2 kg fish recaptured on 26 February 2002 had grown 3 cm during its time at liberty of 359 days. No details are given of the distance these fish moved.

7.16 For *D. eleginoides*, a total of 278 fish have been tagged and two have been recaptured. Both recaptured fish were tagged in 2001 from a series of isolated features in SSRU 881A, with one fish captured on a different feature (~40 n miles away) to the one on which the fish had been originally tagged (76 cm, May 2001). The other was also recaptured in SSRU 881A (77 cm, January 2002) in a nearly identical location to its release (74 cm, April 2001). All the between-season recaptures show growth that is within the range previously described.

Diet

7.17 The diet of *D. mawsoni* in Subarea 88.1 during the 2001 and 2002 seasons is described in WG-FSA-02/15. A high proportion of stomachs were empty in both seasons (34% and 49% respectively), and of those containing food, only 13% and 8% in the respective years contained fresh remains. Fish was the most important component (frequency of occurrence 86% and 78%, mostly channichthyids and *Macrourus whitsoni*) with squid, bait and prawns being the other common components. The diet of *D. mawsoni* appears to vary geographically: under fast-ice and pack-ice the diet is principally *Pleuragramma antarcticum*, in deeper water away from ice the main diet component is benthic fish, as described in this paper, and in the open ocean the main food is squid. The authors conclude that the diet of *D. mawsoni* is dominated by locally abundant fish species and that they are piscivorous opportunists.

Reproduction

7.18 The fishery in Subarea 88.1 continued later in 2001/02 than in previous seasons, and allowed observations on the maturity cycle of *D. mawsoni* until May (WG-FSA-02/31). The onset of the spawning season was identified for the first time as being in May. There was a progression in the maturity state of fish from January to May; the gonadosomatic index (GSI) for both sexes increased from about 2% in January–March to 12% in May. Maximum GSI for a female was 26% with a 7.5 kg ovary and for a male was 43% with an 8.6 kg testis at stage 3. Fish less than 120 cm long had well developed ovaries, a 95 cm long female had a GSI of 7%. Maturing fish lose weight between summer and autumn, and this loss in weight is not accounted for by the increase in gonad weight. Overall it appears as though the Antarctic toothfish loses condition prior to spawning. This may be a result of extensive migration of maturing and spawning fish, and little feeding over this time.

Age and Growth

7.19 WG-FSA-02/33 reported on an otolith age validation study undertaken for *D. mawsoni*. Fish that had been tagged and injected with oxytetracycline in McMurdo Sound, and recaptured up to seven years later, had fluorescent zones in their otoliths indicating that post-mature fish laid down one zone annually. Otoliths from distinct length modes of juvenile *D. mawsoni* from the South Shetland Islands provided a good indication of the juvenile growth rate and indicated that one zone was also formed annually in the otoliths of these fish. Counting translucent zones in *D. mawsoni* otoliths is a valid method to age this species.

Skates and Rays

Species Identification

7.20 WG-FSA-02/54 described a previously unknown rajid species from South Georgia, *Amblyraja sp. anon,* and describes how it can be differentiated from *Amblyraja georgiana.* The two species differ in form, colour and patternation, maturity, male clasper length and distribution. The depth distribution of the two species is also significantly different. *A. georgiana* is caught at depths of less than 800 m in the longline fishery, with the highest capture rates between 300 and 500 m, whereas *A. sp. anon* is caught at depths greater than 1 000 m, and most frequently between depths of 1 200 and 1 600 m. Male skates of both species comprised the largest proportion of the total skate by-catch in the longline fishery and *A. sp. anon* contributed 84% of the total skate by-catch. The paper recommended that observers should discriminate between the two species, and that CCAMLR should adopt separate species codes for each.

Tagging Experiments: Movement, Growth and Behaviour

7.21 WG-FSA-02/42 summarised the results of tagging programs on the two common skate species in Subarea 88.1 (*A. georgiana* and *Bathyraja eatonii*). Tagging is providing initial information on survival following fishery interaction, within-season behaviour, and longer-term movements. To date, 5 468 *A. georgiana* and 546 *B. eatonii* have been tagged in Subarea 88.1 over the 1999/2000 through 2001/02 seasons. Fourteen returns, all of *A. georgiana*, suggest some long-term survival, small-scale migration within season, and limited movement between seasons. Results are considered preliminary, given the short time span of the program, and the confounding effect of spatial variation in fishing effort between seasons, resulting largely from changes in annual ice pattern. Of the between-season recaptures, one was at liberty for about one year and the other for 733 days; the former moved ~20 km and the latter moved ~7 km. For within-season recaptures, the period at liberty was 10–120 days within the 3–4 month season and the distance travelled was 9–74 km.

7.22 The mouth parts of the two between-season recaptures showed good healing around the original hook entry point, and the original hook was absent on recapture. The results to date are a positive indication that at least some skates, when handled appropriately, will survive release during exploratory fishing.

Survival Rate after Discard from the Fishery

7.23 Experiments reported in WG-FSA-02/55 suggest that the rate of survival of skates discarded from the longline fishery in Subarea 48.3 is likely to be very high if caught in depths of up to 1 000 m. Skates caught in depths of 1 200–1 500 m were likely to have 12–25% survivorship when discarded. These results must be treated with caution at this stage, however, because of the limited nature of the experiment and the different treatment of the skates used for the experiment compared with the way skates are treated in the fishery. These results should therefore be considered to be upper limits on what the effect of the fishery is likely to be on rays.

Other Biological Data

7.24 For skates in Subarea 88.1 (WG-FSA-02/42), regression equations relating total length (TL), pelvic length, disc width and weight are provided for *A. georgiana*. For all regressions, there were significant differences between the two sexes: females are broader and heavier than males at lengths greater than about 90 cm TL.

7.25 The length at 50% maturity for male *A. georgiana* is about 91 cm TL, and females appear to mature at a similar or slightly greater length. The length at 50% maturity of male and female *B. eatonii* could not be accurately determined, but may be around 90–100 cm, and greater than 100 cm respectively.

Macrourids

7.26 WG-FSA-02/29 gave a guide to the identification of three macrourid species; *Macrourus holotrachys, M. carinatus* and *M. whitsoni* from Subarea 48.3. Scaling under the snout, head ridges, the mean ratio of the distance between the pectoral and anal fins to the distance between the pectoral and second dorsal fins, and the number of scales between the dorsal end of the diagonal row and the second dorsal fin can be used to distinguish the three species. There is overlap between the three species in all of these measures but combinations of more than one measure should aid observers in identification.

7.27 In WG-FSA-02/32 two species of macrourids were identified from the Ross Sea, *M. whitsoni* and *M. holotrachys,* and characteristics similar to those used in WG-FSA-02/29 were used to discriminate between them. *M. whitsoni* dominated catches throughout Subarea 88.1 and *M. holotrachys* were only found north of 65°S (in SSRU A). Equations for relationships between snout–vent length, total length and weight are presented. These relationships were significantly different by sex, suggesting some degree of sexual dimorphism. There were also significant differences between regressions obtained from fresh and frozen specimens.

7.28 The mean length at maturity was 45 cm TL for males and 49 cm TL for females. The age of maturity was 12 years for males and 14 years for females. These results indicate that *M. whitsoni* is vulnerable to commercial longlining practices before becoming sexually mature. Approximately 3.3% of males and 7.5% of females were sexually immature. The high ages at maturity suggest that large biomass reductions would take a significant time to recover naturally.

7.29 WG-FSA-02/48 described the age, growth and size at sexual maturity of *M. carinatus* from the CCAMLR trawl fisheries in Division 58.5.2. The estimates of age in the sample ranged from 4 to 25 years. The von Bertalanffy growth parameters were estimated for both sexes combined. The size at which 50% of the population was sexually mature (stages 2–5) was 417 mm TL and the size at which 50% of the fish population has spawned for the first time (stages 3–5) was 512 mm TL. These values correspond to ages of 10 and 17 years respectively. An updated length–weight relationship is provided for Heard and McDonald Islands and Macquarie Island. Otolith and body size relationships were calculated for *M. carinatus* from Division 58.5.2.

7.30 WG-FSA-02/26 described the fecundity and size at sexual maturity of *M. holotrachys* in Subarea 48.3. The estimate of absolute fecundity ranged from 22 000 to 260 000 eggs. Mature ovaries contained eggs at different stages of development suggesting that *M. holotrachys* has an extended spawning season. The sizes at sexual maturity were defined as the lengths where 50% of the population were either maturity stages 2–5 or stages 3–5. These values were 20.6 and 29 cm pre-anal length, respectively. The large difference between these values suggests that yolk deposition and final ovarian development is a prolonged process, i.e. probably more than a year, in this species. Sex ratios of captured fish were also highly skewed towards females (32:1).

Ecology of Fish Communities in Subarea 48.1

7.31 Germany reported on biological information collected during a survey on Antarctic demersal fish species around Elephant Island and the lower South Shetland Islands (Subarea 48.1) in January–February 2002 in WG-FSA-02/20. Length–weight relationships were similar to the previous survey in March 2001 for those species for which an extended length range was covered (*Chaenocephalus aceratus, C. gunnari, Lepidonotothen larseni, L. squamifrons*) but were more variable in species where the length range caught was limited as in *Notothenia rossii* or *Chionodraco rastrospinosus*. As expected, gonado–somatic indices for *C. aceratus, C. gunnari, Chionodraco rastrospinosus, Cryodraco antarcticus, Notothenia coriiceps* and *Trematomus eulepidotus* were lower than those measured in March 2001. Dietary studies conducted on four channichthyids for the first time demonstrated that they primarily took krill and fish.

7.32 WG-FSA-02/73 provided a detailed account on the food of *C. aceratus* in the Elephant Island, South Shetland Islands, in March 2001 and January/February 2002. 595 and 597 stomachs of *C. aceratus* were investigated in 2001 and 2002 respectively. Juvenile *C. aceratus* smaller than 35 cm fed primarily on krill in both years. Mysids and *Themisto gaudichaudii* were taken in 2002 to a small extent. Fish formed the overwhelming part of the diet of fish larger than 30–35 cm in both years with a small proportion of krill being taken. Stomach content wet weight was closely related to fish length in both species and were described by the following equations:

C. gunnari: $8.7 \times 10^{-5} \times \text{total length}^{3.11}$; $r^2 = 0.97$
C. aceratus: $9.2 \times 10^{-5} \times \text{total length}^{3.36}$; $r^2 = 0.88$.

7.33 WG-FSA-02/77 reported on age determination of *Chaenocephalus aceratus* from the Elephant Island, South Shetland Islands, collected in January/February 2002. Otoliths were sectioned, ground and polished along their sagittal plane. Age was estimated to be 1–17 years for females and 1–15 years for males. Von Bertalanffy growth parameters were 79.8 cm and 60.0 cm for L_∞ and 0.07 and 0.09 for K in females and males respectively. Sexual maturity was attained at 10 years in females and 9 years in males.

7.34 WG-FSA-02/6 commented on the role of fish as prey in inshore and offshore zones, using the South Orkney Islands, South Shetland Islands and western Antarctic Peninsula as examples. Inshore, the ecological role of fish is more important than that of krill. Fish are major consumers of benthos and zooplankton, and are common prey of other fish, birds and seals. Offshore, demersal fish depend less on benthos and more on zooplankton (mainly krill) and are less accessible to birds and seals. Pelagic fish, especially myctophids, are more abundant and play an important role in energy flow from macrozooplankton to higher predators.

Crabs

7.35 Fecundity and egg size of lithodid crabs in Subarea 48.3 was found to vary with depth (WG-FSA-02/27). The highest fecundity and smallest egg size was found in *Paralomis spinosissima*, which had the shallowest depth distribution, while the lowest fecundity and largest egg size was found in *Neolithodes diomedeae*, which had the deepest distribution. In all species, fecundity increased with increasing body size. Different reproductive strategies may be a consequence of the preferred habitat. Limited food availability in deeper water is offset by larger eggs so that the larvae hatch larger and in a more advanced stage. Adult mortality decreases with depth and the longer life span would result in an overall increase in lifetime reproductive effort. The shallower water, more highly fecund species probably have a greater variation in recruitment. As these include one of the commercial species (*P. spinosissima*), this may have implications for management of the fishery.