APPENDIX E

FISHERY REPORT: *CHAMPSOCEPHALUS GUNNARI*
SOUTH GEORGIA (SUBAREA 48.3)

CONTENTS

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1. Details of the fishery

1.1 Reported catch

In Subarea 48.3, a pelagic or semi-pelagic trawl fishery targets *Champsocephalus gunnari* (Table 1). In 2010/11, the fishing season was from 1 December 2010 to 30 November 2011, with a catch limit for *C. gunnari* of 2 305 tonnes (CM 42-01). Limited commercial fishing was conducted by one vessel in February and one vessel in September/October 2011 but with zero catches. A total catch of 10 tonnes was reported from the research survey.

Table 1: Catch history for *Champsocephalus gunnari* in Subarea 48.3 (source: STATLANT data for past seasons, and catch and effort reports for current season).

Season	Reported effort (number of vessels)	Catch limit (tonnes)	Reported catch (tonnes)
1976/77	-	-	93 595
1977/78	-	-	7 472
1978/79	-	-	809
1979/80	-	-	8 795
1980/81	-	-	27 903
1981/82	-	-	54 040
1982/83	-	-	178 824
1983/84	-	-	35 743
1984/85	-	-	628
1985/86	-	-	21 008
1986/87	-	-	80 586
1987/88	1	35 000	36 054
1988/89	-	0	3
1989/90	-	8 000	8 135
1990/91	-	26 000	44
1991/92	-	0	5
1992/93	-	9 200	0
1993/94	-	9 200	13
1994/95	-	0	10
1995/96	-	1 000	0
1996/97	-	1 300	0
1997/98	1	4 520	6
1998/99	1	4 840	265
1999/00	2	4 036	4 114
2000/01	5	6 760	960
2001/02	5	5 557	2 667
2002/03	4	2 181	1 986
2003/04	7	2 887	2 683
2004/05	7	3 574	200
2005/06	5	2 244	2 169
2006/07	5	4 337	4 345
2007/08	5	2 462	2 491
2008/09	5	3 834	1 834
2009/10	2	1 548	12*
2010/11	1	2305	10*

* Catch in 2009/10 and 2010/11 was from the research surveys in those years.

1.2 IUU catch

2. There has been no evidence of IUU activity in this fishery.

1.3 Size distribution of the catches

3. Catch-weighted length frequencies for *C. gunnari* from 1986/87 to 2010/11 are presented in Figure 1. Data from 2009/10 and 2010/11 have not been included because total commercial catch in these seasons was 0 tonnes.

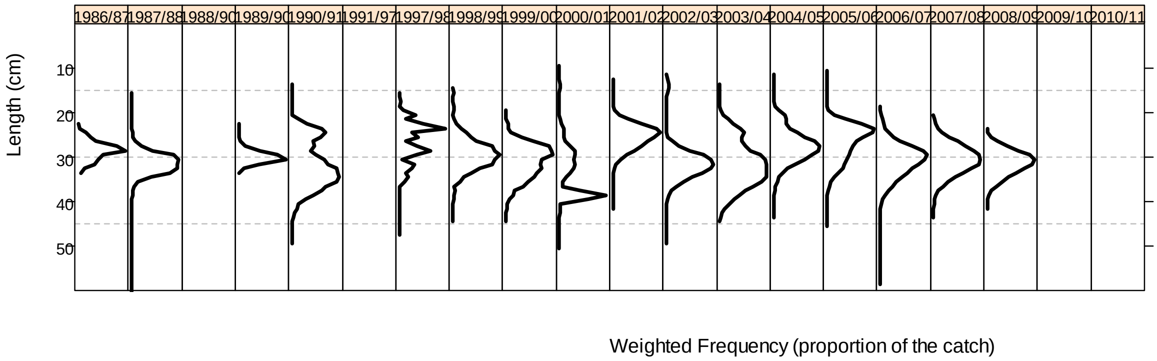

Figure 1: Catch-weighted length frequencies for *Champsocephalus gunnari* in Subarea 48.3 (source: observer, fine-scale and STATLANT data).

2. Stocks and areas

4. Within Subarea 48.3, *C. gunnari* is restricted to the shelf area generally shallower than 350 m. Differences in length distribution have been noted between Shag Rocks and South Georgia (WG-FSA-06/51). These differences are not thought to represent separate stocks and, for purposes of stock assessment, it is assumed that there is a single stock present. *Champsocephalus gunnari* is considered a semi-pelagic species, young (0+ and 1+) fish are found in the pelagic zone, but with increased age (size) fish become more demersal in habit (WG-FSA-02/7).

3. Parameter estimation

3.1 Estimation methods

<u>Acoustic surveys</u>

5. No new estimates of standing stock were available from acoustic surveys. Previous acoustic investigations have demonstrated that *C. gunnari* of all sizes/ages spend time in midwater and reinforced the belief that a bottom trawl survey significantly underestimates *C. gunnari* biomass (see WG-FSA-SAM-04/20).

Trawl surveys

6. In January/February 2011, the UK undertook a random stratified bottom trawl survey of the South Georgia and Shag Rocks shelves (WG-FSA-11/29). The survey employed the same trawl gear and survey design as previous UK surveys in Subarea 48.3.

Standing stock

7. Following the procedure agreed at WG-FSA-03, estimates of standing stock were obtained using a bootstrap on calculated icefish densities from the UK survey. Trawl densities were multiplied by the correction factor of 1.241, which takes account of the presence of a proportion of the icefish stock above the relatively low headline height of the UK trawl. Trawl densities were then weighted by the proportion of the total survey area in the stratum and inverse weighted by the proportion of the total hauls in the stratum:

$$D_C = D \times \frac{A_S}{A_T} \times \frac{H_T}{H_S}$$

where D_C = corrected density; D = trawls density; A_S = stratum area; A_T = total area; H_T = total number of hauls; and H_S = number of hauls in that stratum.

8. Seafloor areas derived from detailed bathymetric data (WG-SAM-08/10 Rev. 2) were used in the analysis. Ten strata were used (Figure 2; Table 2), with two depth strata (50–200 and 200–300 m, except in NW where 200–350 m were used) and five geographic strata (Shag Rock, plus NW, NE, SW and SE South Georgia). The 2011 survey (Figure 3) sampled 87 random and representative hauls, giving good geographic coverage. WG-FSA-11/29 detailed the sampling distribution among area and depth strata.

9. An estimate of the one-sided lower 95% CI of biomass was calculated for the assessment, using 10 separate estimates each using 500 000 bootstrap samples, and is tabled below. The estimated mean value of the standing stock was 49 353 tonnes in January 2011. The one-sided lower 95% CI was 31 373 tonnes.

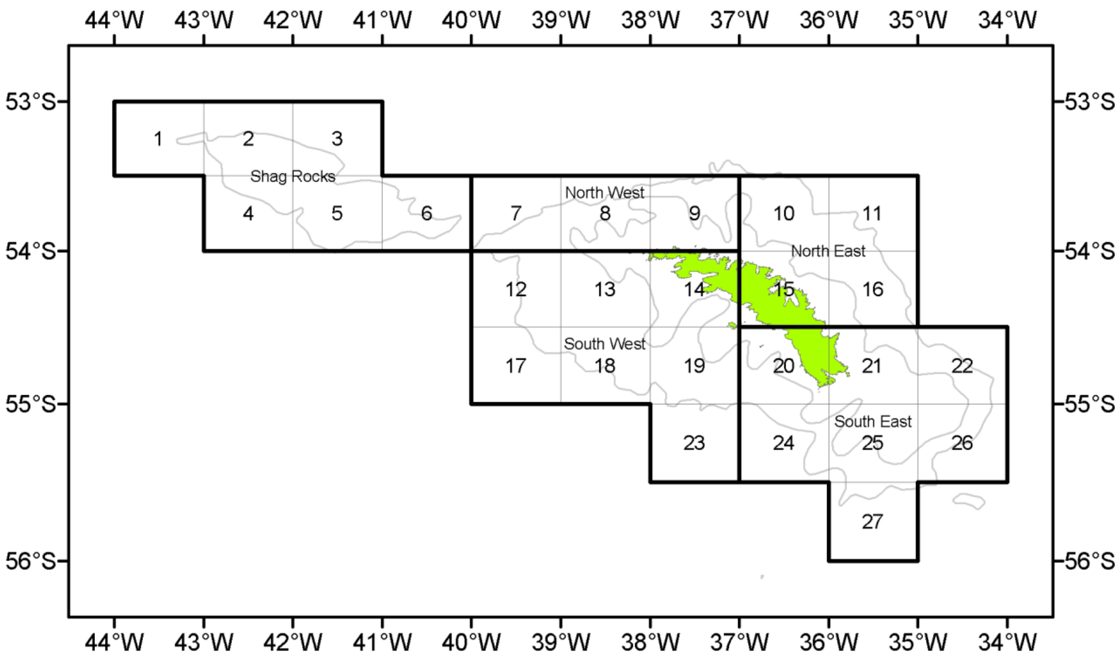

Figure 2: Strata and grid squares used in the 2011 UK survey of Subarea 48.3.

Table 2: Seabed areas of survey strata used to estimate biomass within the bootstrap procedure and results of bootstrap.

Component	Description	Value
Nominal date of survey	Mid-point	1 February 2011
Seabed area of survey strata	Strata (m)	km^2
	1. SR 50–200	2 553
	2. SR 200–300	1 438
	3. NW 50–200	3 371
	4. NW 200–350	2 059
	5. NE 50–200	2 766
	6. NE 200–300	3 576
	7. SW 50–200	4 276
	8. SW 200–300	6 637
	9. SE 50–200	6 617
	10. SE 200–300	3 828
Bottom trawl survey	Bottom to 6 m	tonnes
Biomass estimates from bootstrap procedure	Mean	49 353
	Lower CI	25 824
	Upper CI	75 715
	One-sided lower 95% CI	31 373

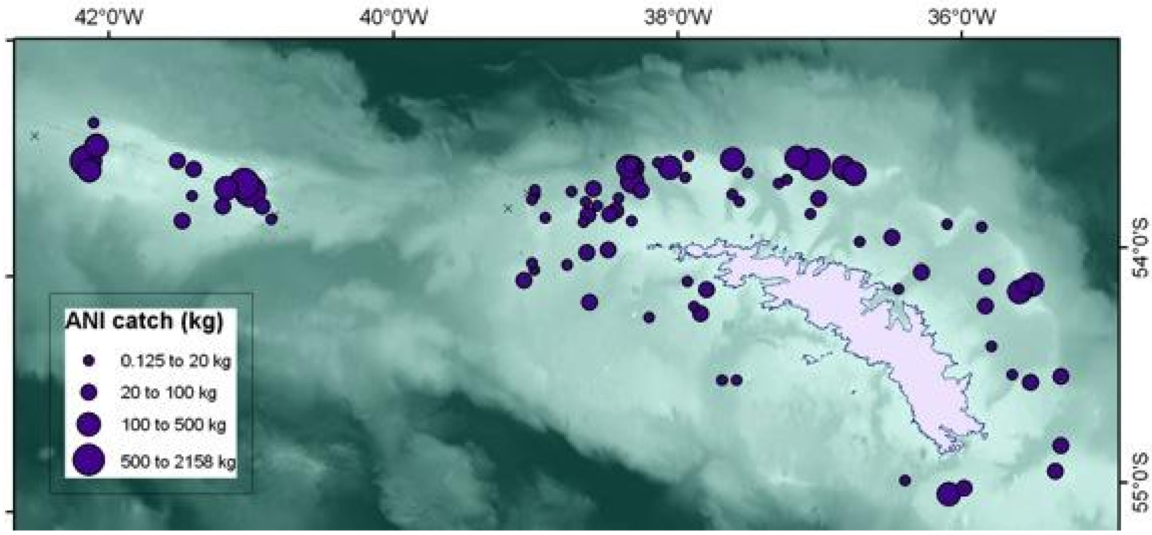

Figure 3: *Champsocephalus gunnari* catches from the survey in Subarea 48.3 in January/February 2011.

Population structure

10. Catches across South Georgia were dominated by two size classes, estimated to be at ages 1+ and 2+, with greater numbers of 1+ fish caught compared with catches in the 2010 survey (Figure 4). Catches of 3+ fish dominated at Shag Rocks.

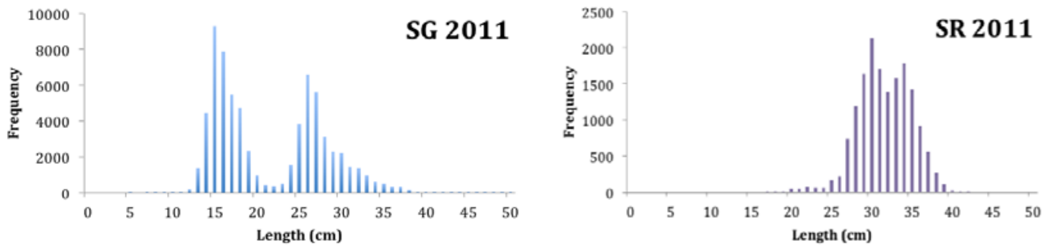

Figure 4: Catch-weighted length frequencies of *Champsocephalus gunnari* from the 2011 groundfish survey in Subarea 48.3.

3.2 Parameter values

Fixed parameters

11. The Working Group used a length-based assessment for icefish in Subarea 48.3, following the methodology presented in assessment paper WG-FSA-10/37. The growth parameters were those used by CCAMLR in previous years (SC-CAMLR-XXVI, Annex 5, Appendix O, Table 5). The length–weight parameters were, however, updated according to the 2011 survey results (WG-FSA-11/29). Table 3 presents the revised CCAMLR parameters which were used throughout the 2011 assessment.

Table 3: Life history parameters used for *Champsocephalus gunnari* in Subarea 48.3.

Component	Parameter	CCAMLR	North	Units
Natural mortality	M	0.71	0.71	y^{-1}
VBGF	K	0.17	0.27	y^{-1}
VBGF	T_0	-0.58	-0.26	y^{-1}
VBGF	L_∞	55.7	51.7	y^{-1}
Length-to-mass	a	5.47E-10	6E-10	kg.mm
Length-to-mass	b	3.42	3.4	

Removals

Fishing mortality (catches since survey)

12. Catches taken after the assessment of biomass from the bottom trawl survey (i.e. January/February 2011) must be included within the assessment. Following the survey, 2 295 tonnes of the catch limit remained to be taken in Subarea 48.3.

Initial size structure

13. Proportions-at-length were calculated according to the methodology outlined in WG-FSA-10/37 by weighting the raw data on length density per haul (in numbers/km^2 per length bin) by the same stratum weighting formula described in paragraph 7, to give weighted density-at-length:

$$\tilde{I}_p = \overline{I_{p,s,h}\omega_s}$$

where p is the length partition, h is haul and s is stratum and ω_s is the weighting factor described in paragraph 7:

$$\omega_s = \frac{\sum_{i=1}^{S} n_i}{n_s} \frac{A_s}{\sum_{i=1}^{S} A_i}$$

where n is the number of hauls and A is the area. Density-at-length was normalised to give the proportions-at-length (Figure 5), f_p:

$$f_p = \frac{\tilde{I}_p}{\sum_{i=1}^{12} \tilde{I}_i}$$

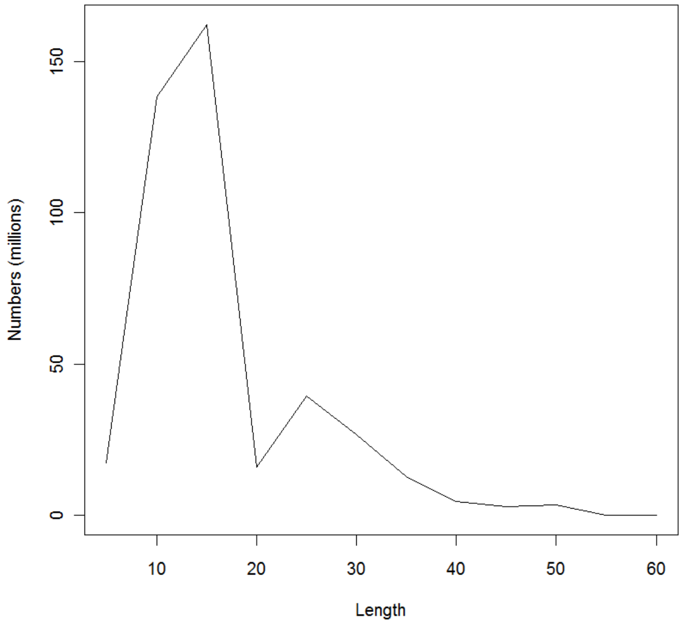

Figure 5: Numbers-at-length of *Champsocephalus gunnari* in Subarea 48.3 in the January/February 2011 survey.

14. Data were analysed in 5 cm length partitions; investigative analyses indicated that using smaller partition sizes resulted in sample sizes per partition that were too small, given the number of other partitions in the data (stratum and haul). Eleven length partitions were used, from 5–10 cm to 55–60 cm. Total numbers for each length partition were estimated using the bootstrap one-sided lower 95% confidence limit presented in Table 2 together with proportions-at-length and the allometric weight-at-length relationship $w_i = al^b$ updated using data from the 2011 survey (a = 0.002, b = 3.3506) applied for length at the mid-point of the partition. The total numbers of icefish in the population N, and in each partition, $N_p = Nf_p$ were calculated by:

$$N = \frac{B}{\sum_{i=1}^{12} f_i w_i \varphi_i}$$

$$N_p = Nf_p$$

where B is biomass from Table 2, f and w are previously described, and φ is the trawl selectivity, assumed to be equal to 1 for all length partitions.

Selectivity

15. A knife-edge selectivity vector was used for *C. gunnari*, starting at length 25 cm, which is approximately equal to the age 2.5 knife-edge selectivity used in the 2009 assessment.

4. Stock assessment

4.1 Model structure and assumptions

16. The performance of the length-based method was extensively tested against the age-based approach in WG-SAM-10/12. WG-SAM concluded that the length-based approach, with the method described in Hillary (2010) of generating the length-transition matrix, was suitable for determining catch limits (SC-CAMLR-XXIX, Annex 4, paragraph 3.36), but recommended that the code be validated by Dr S. Candy (Australia) prior to WG-FSA. The authors of WG-FSA-10/37, accordingly, provided full code both in the paper and in direct correspondence with the Secretariat prior to WG-FSA.

17. WG-SAM had commented that WG-SAM-10/12 showed that estimates of catch limits from the age- and length-based models were essentially the same in the first future year, with the length-based methods more conservative in the second future year. The reasons for this discrepancy were further investigated by UK scientists following the correspondence outlined above, and presented to the Working Group by Dr D. Agnew (UK). The results showed that the small discrepancy in the second year arose from minor differences between the definition of the age-based and length-based selectivities. The Working Group accepted the current length-based knife-edged selectivity (25 cm) for the purposes of calculating catch limits.

18. The Working Group used the length-based method described in WG-FSA-10/37 to calculate future catch limits in accordance with the CCAMLR decision rules for icefish. The method uses a transition matrix T_{ij} defined as the probability of an individual growing from length partition λ_i to λ_j in time τ. Population dynamics (N_{pt}: numbers in length partition p at time t) were represented by:

$$N_{pt} = \sum_{i=1}^{12} N_{i(t-\tau)} T_{ip} e^{-M\tau} (1 - H_{t-\tau} S_i)$$

where H is the harvest rate, M = 0.71 is the mortality rate and S_i the commercial selectivity (assumed to be knife edge, equal to one for lengths greater than or equal to 25 cm). Spawning stock biomass was estimated as:

$$B_t^{sp} = \sum_{i=1}^{12} N_{it} w_i m_i$$

where m_i is the maturity for length partition p (assumed to be one across all selected partitions). The harvest rate was estimated from the catch biomass removed from the population as follows:

$$H_t = \frac{C_t}{\sum_{i=1}^{12} N_{it} w_i S_i}.$$

19. The transition matrix was constructed using methods described in Hillary (2010), requiring an assumed growth increment function:

$$\Delta l = (l_\infty - l_t)(1 - e^{-\kappa\tau})$$

which describes the change in length between time t and $t + \tau$ (Hillary, 2010). The CCAMLR growth parameters were used in this equation (Table 2: $\kappa = 0.17y^{-1}$ and $l_\infty = 55.7$ cm).

20. The population was projected according to the length-based model accounting for growth and natural mortality and with no future recruitment or migration. The survey was assumed to take place at $t = 0$, with an immediate post-survey catch of the remaining catch limit of 2 295 tonnes. At the time of WG-FSA, this remaining catch limit had not been taken, but it was included because there remained the potential that it could be caught before the end of the fishing season (30 November).

21. The harvest rate H that will lead to 75% escapement of the spawning stock biomass at the end of the second annual time period (i.e. B^{sp} is equal to 75% of the spawning stock biomass assuming no fishing at time $t = 2$) was estimated using a numerical root finding algorithm (coded using the FLR framework; Kell et al., 2007). From this, the catch limit in the first and second years following the 2010/11 fishing season was calculated.

4.2 Model results

22. A single short-term projection of yield (tonnes) in 2011/12 (year 1) and 2012/13 (year 2) was computed:

	Catch limit (tonnes)
Year 1	3 072
Year 2	2 933

4.3 Discussion of model results

23. The catch limits have increased since the 2010/11 season, but remain slightly lower than the average catch limit over the last 10 years.

4.4 Future research requirements

24. One feature of the new length-based assessment is that small animals will grow fast, irrespective of whether they are from a young or an old cohort; likewise, large animals will grow slower, even if they are from a young cohort. The extent to which growth is likely to be dependent on age or size is currently unknown, but could affect the performance of the harvest control rule differently whether an age- or a length-based projection was undertaken. The impact of this uncertainty on the ability of the harvest control rule to constrain catches within acceptable limits, including its ability to allow stock recovery in the situation of increased recruitment and variable growth rates, should be investigated. The most appropriate framework for this would be a management strategy evaluation, which could look equally at age- and length-based approaches.

5. By-catch of fish and invertebrates

5.1 By-catch removals

25. Catches of by-catch species (*Gobionotothen gibberifrons*, *Notothenia rossii*, *Lepidonotothen squamifrons*, *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus*) reported in fine-scale data, and their respective catch limits, are summarised in Table 4.

26. None of these species have been caught as by-catch in the commercial fishery in the 2010/11 season to date. Note, however, that the UK survey made the following catches of these species in January/February: 2.3 tonnes, 3.5 tonnes, 4.9 tonnes, 0.7 tonnes and 0.9 tonnes respectively.

Table 4: Catch history for by-catch species (*Gobionotothen gibberifrons*, *Notothenia rossii*, *Lepidonotothen squamifrons*, *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus*) and catch limits in the fishery for *Champsocephalus gunnari* in Subarea 48.3 (see CM 33-01 for details). (Source: fine-scale data)

Season	*Gobionotothen gibberifrons* (tonnes)		*Notothenia rossii* (tonnes)		*Lepidonotothen squamifrons* (tonnes)		*Pseudochaenichthys georgianus* (tonnes)		*Chaenocephalus aceratus* (tonnes)	
	Limit	Reported	Limit	Reported	Limit	Reported	Limit	Reported	Limit	Reported
1998/99	1470	0	300	0	300	0	300	0	2200	0
1999/00	1470	0	300	0	300	0	300	0	2200	0
2000/01	1470	0	300	0	300	0	300	6	2200	0
2001/02	1470	0	300	0	300	0	300	5	2200	5
2002/03	1470	0	300	0	300	0	300	5	2200	1
2003/04	1470	0	300	0	300	0	300	3	2200	0
2004/05	1470	0	300	0	300	0	300	25	2200	1
2005/06	1470	0	300	1	300	0	300	6	2200	0
2006/07	1470	0	300	0	300	0	300	1	2200	0
2007/08	1470	0	300	0	300	0	300	1	2200	1
2008/09	1470	0	300	0	300	0	300	0	2200	0
2009/10	1470	0	300	0	300	0	300	0	2200	0
2010/11	1470	0	300	0	300	0	300	0	2200	0

5.2 Mitigation measures

27. The by-catch limits are set out in CM 33-01. Move-on rules are included in the annual conservation measure set for this fishery, e.g. CM 42-01.

6. By-catch of birds and mammals

28. Seabird mortality in this trawl fishery is summarised in Table 5. Only 5 trawls were undertaken, 100% of which were observed. There were no seabird or marine mammal mortalities observed in the 2010/11 season.

Table 5: Number of seabirds killed in the trawl fishery in Subarea 48.3. DIC – *Thalassarche chrysostoma*, DIM – *Thalassarche melanophrys*, PRO – *Procellaria aequinoctialis.*

Fishing season	Trawls observed	DIC	DIM	PRO	Other
2000/01	315	5	46	41	
2001/02	431		18	49	1
2002/03	182	1	7	28	
2003/04	221	1	26	59	1
2004/05	253		9	1	1
2005/06	457	1	11	20	1
2006/07	111	1	2	3	
2007/08	206			3	2
2008/09	154		6	5	
2009/10	14			1	1
2010/11	5				

29. No additional data was provided this year on distribution of seabirds, WG-IMAF therefore agreed the level of risk of incidental mortality of seabirds in Subarea 48.3 remains at category 5 (high) (SC-CAMLR-XXX, Annex 8, paragraph 8.1).

6.1 Mitigation measures

30. CM 25-03 applies to this fishery.

31. CM 42-01 has a further mitigation measure in that, should any vessel catch a total of 20 seabirds, it shall cease fishing and shall be excluded from further participation in the fishery in 2010/11.

7. Ecosystem implications/effects

32. The current pelagic trawl fishery for *C. gunnari* in Subarea 48.3 has minimal impact on the benthic ecosystem. There is a small by-catch of other icefish species, but this is typically much smaller than the catch limits for these species. *Champsocephalus gunnari* play an important role in the ecosystem of the South Georgia shelf as predators of krill, *Themisto* and other euphausiids, and as prey of fur seals and gentoo penguins (WG-FSA-08/30). Icefish may also be consumed by juvenile toothfish in years of high icefish abundance at Shag Rocks.

33. Estimates of icefish standing stock have been shown to vary with variability in krill abundance at South Georgia, and in years of poor krill availability, icefish condition is poorer and larger quantities are likely to be consumed by both fur seals and gentoo penguins, which are normally krill dependent.

34. In January 2009, South Georgia was subject to an ecosystem anomaly (WG-EMM-09/23) driven by increased sea-surface temperature which caused a rapid and marked decline

in krill abundance in the region. This in turn had an impact on predator performance, including significant changes to icefish diet which was dominated by amphipods rather than krill, and is likely in part to have resulted in the decrease in yield in 2008/09.

35. The krill anomaly did not last for the whole of 2009, and krill had returned by the end of the year. Samples taken on the 2010 survey indicated that adult icefish at Shag Rocks and the southeast of South Georgia were feeding primarily on krill. In 2011 the diets of icefish sampled were dominated by krill and other euphausids with the amphipod *Themisto gaudichaudii* of much less importance in the diet than in previous years.

8. Harvest controls and management advice

8.1 Conservation measures

36. The limits on the fishery for *C. gunnari* in Subarea 48.3 are defined in CM 42-01. The limits in force, and the Working Group's advice to the Scientific Committee for the forthcoming season, are summarised in Table 6.

Table 6: Limits on the fishery for *Champsocephalus gunnari* in Subarea 48.3 in force (CM 42-01) and advice to the Scientific Committee for 2011/12.

Element	Limits in force	Advice for 2011/12
Access (gear)	Trawling only Bottom trawl prohibited	Carry forward
Access (area)	Fishing prohibited within 12 n miles of South Georgia from 1 March to 31 May.	Carry forward
Catch limit	2 305 tonnes	Revise
Move-on rule	Move on if >100 kg caught of which >10% by number are <240 mm TL.	Carry forward
Season	1 December to 30 November	Carry forward
By-catch	By-catch rates as in CM 33-01 to apply, plus move-on rule.	Carry forward
Mitigation	In accordance with CM 25-03. Use of net binding and additional weights to codend. Limit of 20 seabirds per vessel.	Carry forward
Seabirds	Any vessel catching 20 seabirds to cease fishing.	Carry forward
Observers	Each vessel to carry at least one CCAMLR scientific observer and may include one additional scientific observer.	Carry forward
Data	Five-day catch and effort reporting Haul-by-haul catch and effort data Biological data reported by the CCAMLR scientific observer.	Carry forward Carry forward Carry forward
Target species	*Champsocephalus gunnari* By-catch is any species other than *C. gunnari*.	Carry forward
Research	No requirement.	Carry forward
Environmental protection	Regulated by CM 26-01. No offal discharge.	Carry forward

8.2 Management advice

37. The Working Group recommended that the catch limit for *C. gunnari* should be set at 3 072 tonnes in 2011/12 and 2 933 tonnes in 2012/13 based on the outcome of the short-term assessment.

References

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