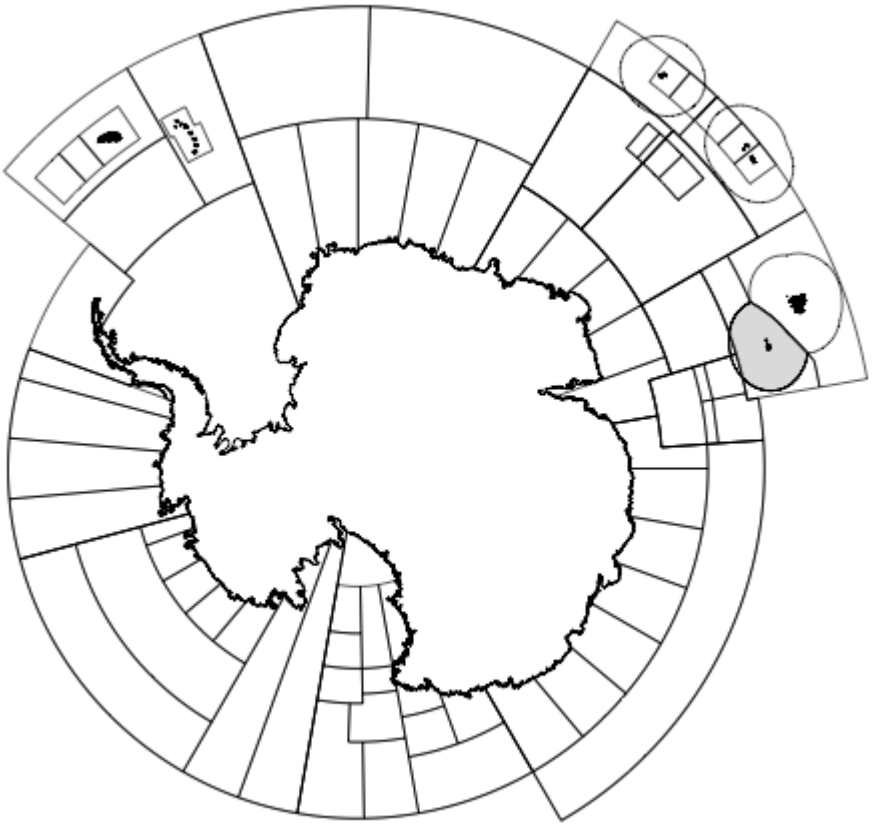
CCAMLR

Commission for the Conservation of Antarctic Marine Living Resources
Commission pour la conservation de la faune et la flore marines de l'Antarctique
Комиссия по сохранению морских живых ресурсов Антарктики
Comisión para la Conservación de los Recursos Vivos Marinos Antárticos

FISHERY REPORT

Fishery Report 2018: *Champsocephalus gunnari* Heard Island (Division 58.5.2)



The map above shows the management areas within the CAMLR Convention Area, the specific region related to this report is shaded.

Throughout this report the CCAMLR fishing season is represented by the year in which that season ended, e.g. 2015 represents the 2014/15 CCAMLR fishing season (from 1 December 2014 to 30 November 2015).

Fishery Report 2018: *Champsocephalus gunnari*
Heard Island (Division 58.5.2)

Introduction to the fishery

1. This fishery report describes the licensed fishery for mackerel icefish (*Champsocephalus gunnari*) in the area of the Australian Fishing Zone (AFZ) in Division 58.5.2. The area includes the AFZ surrounding Heard Island and McDonald Islands located on the Kerguelen Plateau between 50°–56°S and 67°–79°E. An Australian licensed trawl fishery for *C. gunnari* began in 1997, while other nations had fished in these waters during the 1970s prior to the declaration of the AFZ in 1979. The fishing methods used in this fishery are midwater and bottom trawl. The fishery is managed by the Australian Fisheries Management Authority (AFMA) in accordance with the conservation measures adopted by CCAMLR and Australian law. The annual catch limit is based on the management advice from CCAMLR.

2. *Champsocephalus gunnari* is a member of the family Channichthyidae. It is most abundant at depths of less than 350 m in the waters surrounding Heard Island. In this area they grow to a maximum length of around 45 cm and a maximum age of 6 years. Size at first maturity for females is 26.5 cm and for males is 28.5 cm total length.

Reported catches

3. The limits on the trawl fishery for *C. gunnari* in Division 58.5.2 are described in Conservation Measure (CM) 42-02. The catch limit of *C. gunnari* for 2018 was 526 tonnes.

4. In 2018, fishing was conducted by one vessel and the total reported catch was 520 tonnes. Historical reported catches of *C. gunnari*, along with catch limits and number of vessels active in the fishery, are shown in Table 1.

Illegal, unreported and unregulated (IUU) fishing activity

5. There has been no recorded evidence of illegal, unreported and unregulated (IUU) fishing activities in this fishery.

Length distribution of the catches

6. Length frequencies for *C. gunnari* from the last 10 years are presented in Figure 1. These length-frequency distributions of catches are unweighted and the interannual variability shown in the figure may reflect differences in the fished population, but is also likely to be affected by changes in factors such as the characteristics of the gear, the number of vessels in the fishery and the spatial and temporal distribution of fishing. In the case of Division 58.5.2, an additional factor to consider is whether commercial fishing or only research survey data predominated in any season. Nevertheless, the length frequencies for *C. gunnari* in Division 58.5.2 typically

show a single dominant age/size cohort progressing through the population over consecutive years.

Table 1: Catch history for *Champsocephalus gunnari* in Division 58.5.2. (Source: fine-scale data.)

Season	Vessels fishing	Catch limit (tonnes)	Reported catch (tonnes)
1995	-	311	0
1996	-	311	0
1997	1	311	87
1998	3	900	76
1999	1	1160	0
2000	2	916	87
2001	2	1150	971
2002	2	885	926
2003	2	2980	2293
2004	2	292	50
2005	2	1864	1791
2006	1	1210	660
2007	1	42	1
2008	1	220	199
2009	1	102	99
2010	1	1658	365
2011	1	78	1
2012	-	0*	0
2013	1	679	591
2014	1	1267	1123
2015	2	309	10
2016	1	482	463
2017	1	561	528
2018	1	526	514

* 30 tonne research and by-catch limit applied.

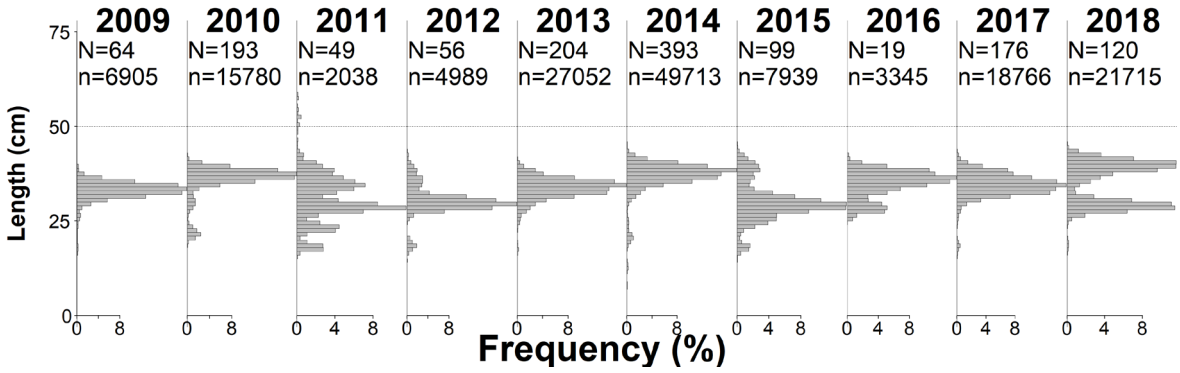


Figure 1: Length frequencies for *Champsocephalus gunnari* in Division 58.5.2 from 2009 to 2018, using observer data from both the commercial fishery and research trawl surveys with the number of hauls (N) and the number of fish measured (n) in each year at the top of each pane.

7. Only catch-weighted length-frequency data derived from a random stratified trawl survey are used in assessments in this fishery, as provided in the relevant section of this report.

Stock identification and stock hypothesis

8. Within Division 58.5.2, *C. gunnari* is restricted to the shelf area in the vicinity of Heard Island in water generally shallower than 500 m, and a non-contiguous area at Shell Bank to the northeast of the islands. The Heard Plateau and Shell Bank populations have different size structures and recruitment patterns. In 1997, the Working Group on Fish Stock Assessment (WG-FSA) agreed that in light of this, the two areas should be treated as separate stocks for assessment purposes (see SC-CAMLR-XVI, Annex 5, paragraph 4.277). Shell Bank has been closed to fishing since 1997 due to low population densities observed in annual surveys from 1997 to 2005.

Life-history parameters

Data collection

Survey results

9. The results of the bottom trawls undertaken during the annual random stratified trawl survey for the assessment of *C. gunnari* stocks in April 2018 were presented in WG-FSA-18/55. The survey sampled the stocks in the Gunnari Ridge, Plateau West and Plateau Southeast strata, areas known to have high *C. gunnari* abundance. The survey was undertaken to the same design as previous surveys for this region. The locations of sample stations in the three main icefish strata in relation to Heard Island and the McDonald Islands and catch-per-unit-effort are shown in Figure 2.

Parameter estimates

Fixed parameters

10. The length–weight parameters were re-estimated using the fish sampled during the 2018 survey (WG-FSA-18/56, Table 2).

11. Growth parameters were re-evaluated in 2017 using survey data between 2010 and2017 and used in the assessment (WG-FSA-18/56). Natural mortality was assumed to be 0.4 (de la Mare, 1998).

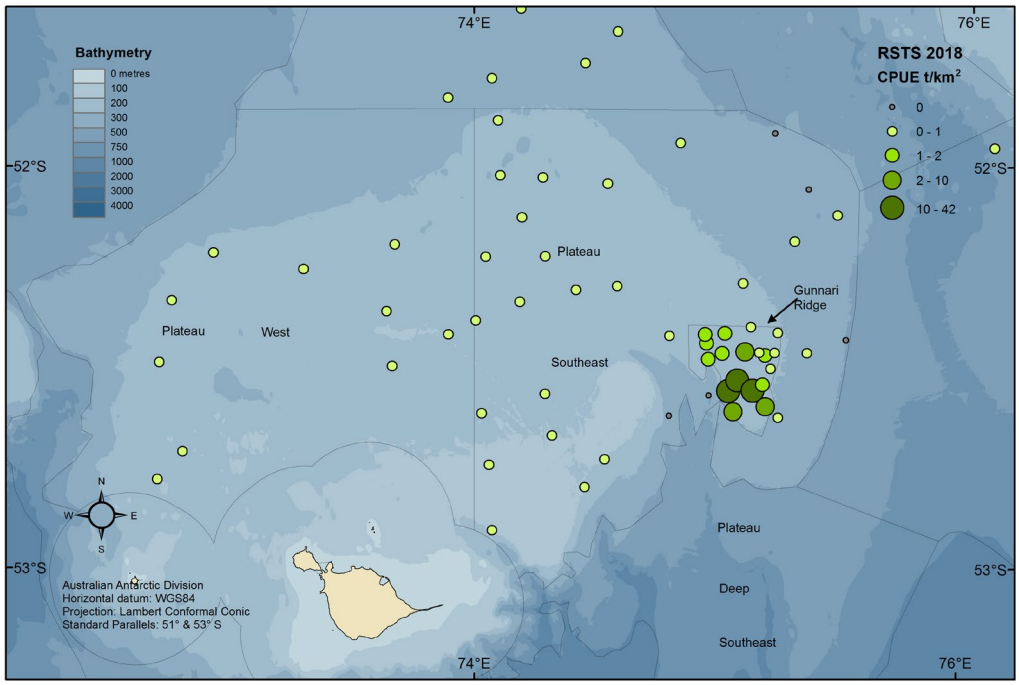


Figure 2: Strata and sampling hauls from the 2018 random stratified trawl survey in Division 58.5.2 used in the 2018 *Champsocephalus gunnari* assessment. Points are locations of hauls, with 10 stations in Plateau West, 18 stations in Gunnari Ridge and 30 stations in Plateau Southeast.

Table 2: Fixed parameters used in the 2018 assessment of *Champsocephalus gunnari* in Division 58.5.2.

Component	Parameter	Value	Units
Natural mortality	M	0.4	y^{-1}
VBGF	K	0.368	y^{-1}
VBGF	t_0	0.067	y
VBGF	L_∞	490	mm
Length-to-weight	'a'	1.259×10^{-9}	kg/mm
Length-to-weight	'b'	3.26	

Standing stock

12. Using the estimated weight-at-length relationship for 2017, the contribution by each age class to overall biomass present during the survey was estimated (WG-FSA-18/56). This indicated that up to 3+ fish constituted only around 50% of the biomass present across the three icefish strata (Table 3).

Table 3: Calculation of the proportion of biomass at age derived from the 2018 survey length density, using length–weight parameters re-estimated in 2018.

Age class	Mean length (mm)	Density ($n.km^{-2}$)	Mean weight (kg)	Proportion of biomass (%)
1+	180	18.5	0.03	0.13
2+	294	866.7	0.14	29.69
3+	354	309.7	0.26	19.44
4+	400	542.7	0.38	50.74

13. Estimates of standing stock biomass for the Heard Island Plateau were made using a bootstrap procedure to calculate the one-sided lower 95% confidence bound on the trawl survey estimate (method outlined in WG-FSA-10/12, Appendix 1), using data from the 2018 survey. The estimates of the mean and one-sided lower 95% confidence intervals (CI) of biomass are shown in Table 4.

Table 4: Abundance (tonnes) of *Champsocephalus gunnari* in the vicinity of Heard Island in Division 58.5.2 estimated by bootstrapping hauls from the trawl survey in 2017. SE = standard error; Lower CI, Upper CI = lower and upper confidence intervals respectively; LOS 95% CI = lower one-sided 95% confidence interval.

Stratum	Mean	SE	LowerCI	UpperCI	LOS 95% CI
Gunnari Ridge	4042	1656	1235	7509	1623
Plateau SE	1702	319	1140	2364	1219
Plateau W	3234	646	2126	4508	2278
Pooled	8978	1947	5556	13087	6018

Stock assessment

14. A full stock assessment has been carried out for *C. gunnari* at Heard Island and McDonald Islands (WG-FSA-18/56).

15. The generalised yield model is used routinely for the assessment of short-term yield of *C. gunnari* in the CAMLR Convention Area. The precautionary approach developed by CCAMLR requires the calculation of the level of mortality that would result in a probability not greater than 0.05 that the spawning stock would be less than 75% of the level it would have been if fishing had not occurred. This estimate is calculated using the bootstrap one-sided lower 95% confidence bound on the trawl survey biomass estimate, giving a two-year projection of the catch. In the assessment, a linear selectivity vector was used for *C. gunnari*, starting at 2.5 years and fully selected at age 3.

16. The short-term projection of *C. gunnari* does not include recruitment data.

17. The stock projection used the proportion of overall biomass made up by the 1+, 2+ and 3+ cohorts (49.26%, Table 3). This means that the overall lower 95% CI of 2 964 tonnes out of the overall 6 018 tonnes (Table 4) was used in the projection. An estimated 261 tonnes of icefish have been captured after the survey was conducted as part of the 2017/18 fishery, however, based on length data collected, 57% of the catch taken was assumed as 4+ fish and not included in the forward projections. Therefore, only 112 tonnes of the removals after the survey were considered to impact on the 2+ and 3+ in the catch.

18. Following the same approach as employed in previous years (see 'Decision rules' in Appendix 1), an initial biomass estimate of 2 964 tonnes and a target fishing mortality rate (0.14395 yr^{-1}) indicates that 443 tonnes of icefish could be taken in the 2019 and 320 tonnes in the 2020 season, allowing 75% escapement of biomass over two years.

By-catch of fish and invertebrates

Fish by-catch reported

19. The total reported by-catch (tonnes) of fish taken in the trawl fishery for *C. gunnari* in recent years is indicated in Table 5 from fine-scale C2 data. By-catch of unicorn icefish (*Channichthys rhinoceratus*) fluctuates strongly but reached a historical high in 2014.

Table 5: Total reported by-catch (tonnes) of four species in the *Champsocephalus gunnari* trawl fishery. Limits apply to all fisheries in Division 58.5.2. (Source: fine-scale data.)

Season	*Channichthys rhinoceratus* (tonnes)		*Lepidonotothen squamifrons* (tonnes)		*Macrourus* spp. (tonnes)		Rajids (tonnes)		Other catch (tonnes)	
	Limit	Reported	Limit	Reported	Limit	Reported	Limit	Reported	Limit	Reported
2004	150	6	80	<1	360	1	120	3	50	147
2005	150	34	80	<1	360	<1	120	5	50	125
2006	150	29	80	<1	360	<1	120	7	50	10
2007	150	3	80	<1	360	0	120	0	50	1
2008	150	8	80	<1	360	<1	120	2	50	9
2009	150	7	80	1	360	<1	120	7	50	3
2010	150	52	80	<1	360	1	120	12	50	25
2011	150	1	80	1	360	<1	120	<1	50	1
2012	150	0	80	0	360	0	120	0	50	67
2013	150	48	80	2	360	<1	120	16	50	18
2014	150	144	80	5	360	<1	120	9	50	38
2015	150	11	80	<1	360	<1	120	1	50	101
2016	1663	119	80	<1	769[1]	<1	120	28	50	17
2017	1663	109	80	<1	769[1]	<1	120	44	50	8
2018	1663	37	80	0	769[1]	0	120	26	50	10

[1] The catch limits for Macrourids are 409 tonnes for *M. caml* and *M. whitsoni* combined and 360 tonnes for *M. holotrachys* and *M. carinatus* combined. Since few macrourids are caught in this fishery, the catch limits have been added together in this table.

Assessments of impact on affected populations

20. Quantitative risk assessments of *C. rhinoceratus* and Caml grenadier (*Macrourus caml*) were undertaken in 2015 and presented in WG-FSA-15/50 and 15/63 respectively. WG-FSA recommended the catch limits be set to 1 663 tonnes for *C. rhinoceratus*. It also recommended that the limit derived from the risk assessment in WG-FSA-15/63 of 409 tonnes should apply for *M. caml* and Whitson's grenadier (*M. whitsoni*) combined, and the limit derived from the previous assessment of 360 tonnes should apply for bigeye grenadier (*M. holotrachys*) and ridge-scaled grenadier (*M. carinatus*) combined. The catch limits of grey rockcod (*Lepidonotothen squamifrons*) are based on assessments carried out in 1998 (SC-CAMLR-XVII, Annex 5, paragraphs 4.204 to 4.206). Catch limits for rajids (*Bathyraja* spp.) were set in 1997 (SC-CAMLR-XVI, paragraphs 5.119 to 5.122).

Mitigation measures

21. A number of conservation measures, which ensure that impacts on the target and other species are minimised, currently apply to this fishery. CM 42-02 defines the boundaries of the fishery area, the season, the catch limit and the move-on rules if large quantities of *C. gunnari* smaller than the specified minimum legal length of 240 mm are caught in a single haul. CM 33-02 specifies that there should be no directed fishing for species other than the target species, the by-catch limits for incidentally caught species and the move-on rules if the limits for any one haul are exceeded (Table 7).

Incidental mortality of seabirds and marine mammals

Incidental mortality reported

22. Bird by-catch in the fishery targeting *C. gunnari* in Division 58.5.2 remains low with three observed bird mortalities since 2006. The mortalities of black-browed albatross (*Thalassarche melanophrys*) and white-chinned petrel (*Procellaria aequinoctialis*) since 2002 are summarised in Table 6.

23. No incidents of mammal by-catch have been observed while fishing for *C. gunnari* in Division 58.5.2.

Table 6: Number of birds killed in the *Champsocephalus gunnari* trawl fishery in Division 58.5.2.

Fishing season	*T. melanophrys*	*Procellaria aequinoctialis*	Other
2002			
2003	1	1	
2004			
2005	7	4	
2006			
2007			
2008			
2009			
2010			1
2011			
2012			
2013	1		
2014			
2015		1	
2016			
2017			
2018			

Identification of levels of risk

24. The level of risk of incidental mortality of birds in Division 58.5.2 is category 4 (average-to-high) (SC-CAMLR-XXX, Annex 8, paragraph 8.1).

Mitigation measures

25. CM 25-03 is in force to minimise the incidental mortality of birds and mammals. Measures include the prohibition on the discharge of offal and discards during the shooting and hauling of trawl gear, and developing gear configurations which minimise the chance of birds encountering the net.

Ecosystem implications/effects

26. Bottom trawl and midwater trawl gear is used to target both *C. gunnari* and Patagonian toothfish (*Dissostichus eleginoides*) in Division 58.5.2. The potential impacts of fishing gear on benthic communities are limited by the small area of commercial trawl grounds, a strategy of fishing trawling gear lightly and the protection of large areas sensitive to the effects of bottom trawling within the Heard Island and McDonald Islands Marine Reserve, an IUCN Category 1a reserve, where fishing is prohibited. This marine reserve covers a total area of 71 200 km^2.

Current management advice and conservation measures

27. In 2011 it was agreed that, where the stock assessment of *C. gunnari* in Division 58.5.2 indicated a stock biomass of less than 1 000 tonnes, or where the decision rules indicated a catch limit of less than 100 tonnes, a commercial catch limit would not be set. Instead, a 30 tonne combined research and by-catch limit would apply, which would allow the annual trawl survey to continue to allow monitoring the stock, and accommodate the incidental catch of *C. gunnari* that may occur in the *D. eleginoides* trawl fishery in this division.

28. The limits on the fishery for *C. gunnari* in Division 58.5.2 are defined in CM 42-02 and are summarised in Table 7.

Table 7: Limits on the fishery for *Champsocephalus gunnari* in Division 58.5.2 in force (CM 42-02).

Element	Limits in force
Access (gear)	Trawling only
Access (area)	Definition of area open for fishing Chart illustrating area open (Annex 42-02/A)
Catch limit	2019 – 443 tonnes and 2020 – 320 tonnes
Move-on rule	Move on if >100 kg *Champsocephalus gunnari* caught of which >10% by number are less than minimum size (24 cm)
Season	1 December to 30 November
By-catch	Fishing shall cease if the by-catch limit of any species, as set out in CM 33-02, is reached: *Channichthys rhinoceratus* 1 663 tonnes *Lepidonotothen squamifrons* 80 tonnes *Macrourus carinatus* and *M. holotrachys* 360 tonnes *Macrourus caml* and *M. whitsoni* 409 tonnes Skates and rays 120 tonnes
Move-on-rule	If the catch limits for any one haul, as set out in CM 33-02, are reached, the vessel must not fish using that method within 5 n miles of the location for at least 5 days: *Channichthys rhinoceratus* 5 tonnes *Macrourus* spp. combined 3 tonnes *Lepidonotothen squamifrons* 2 tonnes *Somniosus* spp. 2 tonnes Skates and rays 2 tonnes Other by-catch species 1 tonne
Mitigation	In accordance with CM 25-03, minimisation of risk of the incidental mortality of birds and mammals
Observers	Each vessel to carry at least one CCAMLR scientific observer and may include one additional scientific observer
Data	Ten-day reporting system as in Annex 42-02/B Monthly fine-scale reporting system as in Annex 42-02/B on haul-by-haul basis Fine-scale reporting system as in Annex 42-02/B. Reported in accordance with the Scheme of International Scientific Observation
Target species	*C. gunnari* By-catch is any species other than *C. gunnari*
Environmental protection	Regulated by CM 26-01 Includes no offal discharge or dumping of discards

Reference

de la Mare, W.K., R. Williams and A.J. Constable. 1998. An assessment of the mackerel icefish (*Champsocephalus gunnari*) off Heard Island. *CCAMLR Science* 5: 79–101.

Appendix 1

Stock assessment

Population structure

A1. The distribution of densities at age was derived using the CMIX program (using input parameters in Table A1.1) consisting of four year classes from 1+ to 4+ (Figure A1.1). Details of the fit are presented in Table A1.2.

Table A1.1: Input parameters for the CMIX analysis of *Champsocephalus gunnari* length density in Division 58.5.2 for 2018.

Parameter	Value
Size range included	140–430 mm
Bounds	Age 1+: 140–200 mm Age 2+: 240–300 mm Age 3+: 310–400 mm
SDs related linearly to the mean	Yes
Bounds on intercept (start, step)	1, 10 (3, 1.0)
Bounds on slope (start, step)	0.0, 0.1 (0.01, 0.001)
No. of function calls	10 000
Stopping criteria	1E-10
Frequency for convergence testing	5
Simplex expansion coefficient	1

Table A1.2: Results generated from CMIX analyses for *Champsocephalus gunnari* from the 2018 random stratified trawl survey in Division 58.5.2.

	Mixture Components			
	1 (1+)	2 (2+)	3 (3+)	4 (4+)
Mean length (mm)	180	293	356	400
SD (mm)	14.0	16.7	18.1	19.1
Intercept of CV	9.93			
Slope of CV	0.02			
Total density (n.km^{-2})	18.6	866.7	309.7	542.7
SD (n.km^{-2})	10.0	143.2	115.8	151.5
Sum of observed densities	1755.4			
Sum of expected densities	1736.9			

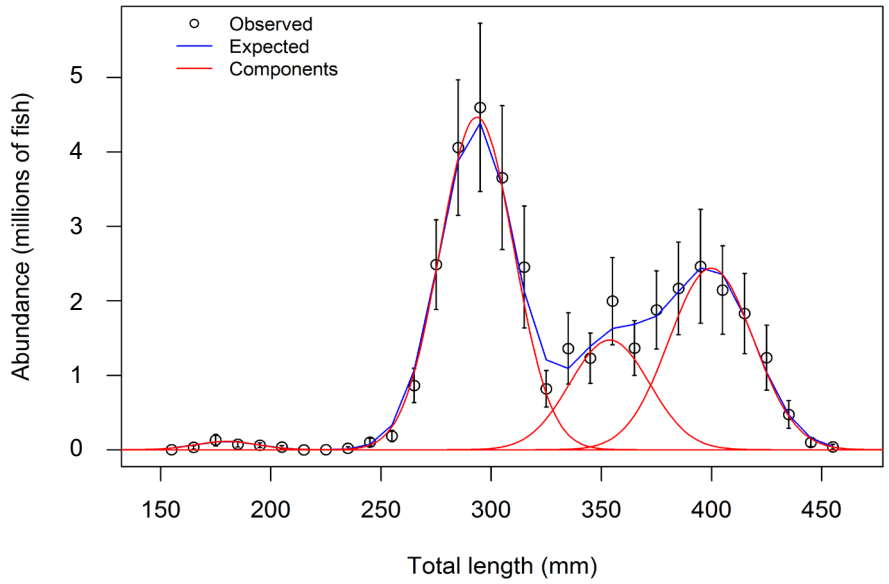


Figure A1.1: Size distribution of *Champsocephalus gunnari* from the 2018 random stratified trawl survey in Division 58.5.2 with standard errors. Cohorts were present in ages 1+ to 4+.

Stock assessment model

A2. The generalised yield model (GYM), used routinely for the assessment of long-term yield of this species in the CAMLR Convention Area, was configured to perform the short-term projection. The model configuration is provided in Table A1.3.

Table A1.3: GYM model configuration for the 2018 assessment of *Champsocephalus gunnari* in Division 58.5.2.

Category	Parameter	Values	Source
Age structure	Recruitment age	2 years	de la Mare et al., 1997
	Plus class accumulation	10 years	de la Mare et al., 1997
	Oldest age in initial structure	11 years	de la Mare et al., 1997
Initial population structure	Age-class density	See Table A1.2	WG-FSA-18/56
	Biomass	2964 tonnes	WG-FSA-18/56
Recruitment		0	
Growth (von Bertalanffy function)	L_∞	490 mm	WG-FSA-17/22
	K	0.368	WG-FSA-17/22
	t_0	0.067	WG-FSA-17/22
Weight-at-length	Weight–length parameter – A (kg)	1.259×10^{-09} kg	WG-FSA-18/56
	Weight–length parameter – B	3.26	WG-FSA-18/56
Maturity	L_{m50} (set so that the status of the whole stock is being monitored)	0 mm[1]	
	Range: 0 to full maturity	0 mm	
Natural mortality	M	0.4	de la Mare et al., 1997
Spawning season	Set so that status of the stock is determined at the end of each year	30 Nov–30 Nov	
Fishery information	Upper bound to annual F	5	

	Tolerance to finding *F*	1E-05	
Fishery projection	Age first selected	2.5	de la Mare et al., 1997
	Age fully selected	3.0	de la Mare et al., 1997
	Relative fishing effort	Date: 1 Dec, Effort: 1	CCAMLR season
Simulation specifications	Number of runs in simulation	1	
Individual trial specifications	Years to remove initial age structure	1[2]	
	Year prior to projection	2017[3]	
	Reference start date in year	1 Dec	
	Increments in year	365	
	Years to project stock in simulation	2	
	Reasonable upper bound for annual *F*	5.0	
	Tolerance for finding *F* in each year	0.000001	

[1] Maturity is not used in the short-term projection. It is set to 0 to allow the GYM to monitor the whole population.
[2] Set to 0 when no icefish were captured after the survey, else set to 1.
[3] GYM requires first year of the 2017/18 split-year.

Decision rules

A3. To assess a catch level such that fishing should not, without any substantial risk (specified in this instance as no more than 5% probability):

> reduce the stock biomass to below 75% of the level that would occur in the absence of fishing within the two years following an abundance biomass estimate provided by a survey.

A4. To achieve this, the lower one-sided 95% confidence bound of the biomass estimate was used as the estimate of the standing stock biomass at the start of the projection period. To allow the fishery to exploit abundant age classes prior to their disappearance from the population, past management advice has included provisions to take a higher catch in the first year of the two-year projection frame, while still satisfying the decision rule requiring 75% escapement over two years (e.g. SC-CAMLR-XXVIII, paragraph 4.132). In that case, two scenarios can be run:

(i) using the typical two-year projection of all cohorts less than 4+ in the population, and estimating the catch, spread across two years, that would ensure 75% escapement

(ii) estimating the catch from the current 3+ cohort that would ensure 75% escapement over one year, combined with that for the 1+ and 2+ cohorts with catch that would ensure 75% escapement over two years.

A5. In 2018 only scenario (i) was considered.

A6. Stock assessment projections used to determine catch limits were below subsequent estimated biomass levels in most years since 2005, indicating that the current harvest strategy is sufficiently conservative to avoid harvesting that would be inconsistent with CCAMLR's objective (Figure A1.2).

A7. Estimating biological parameters regularly for this assessment also ensures that long term environmental changes which may impact population characteristics are accounted for.

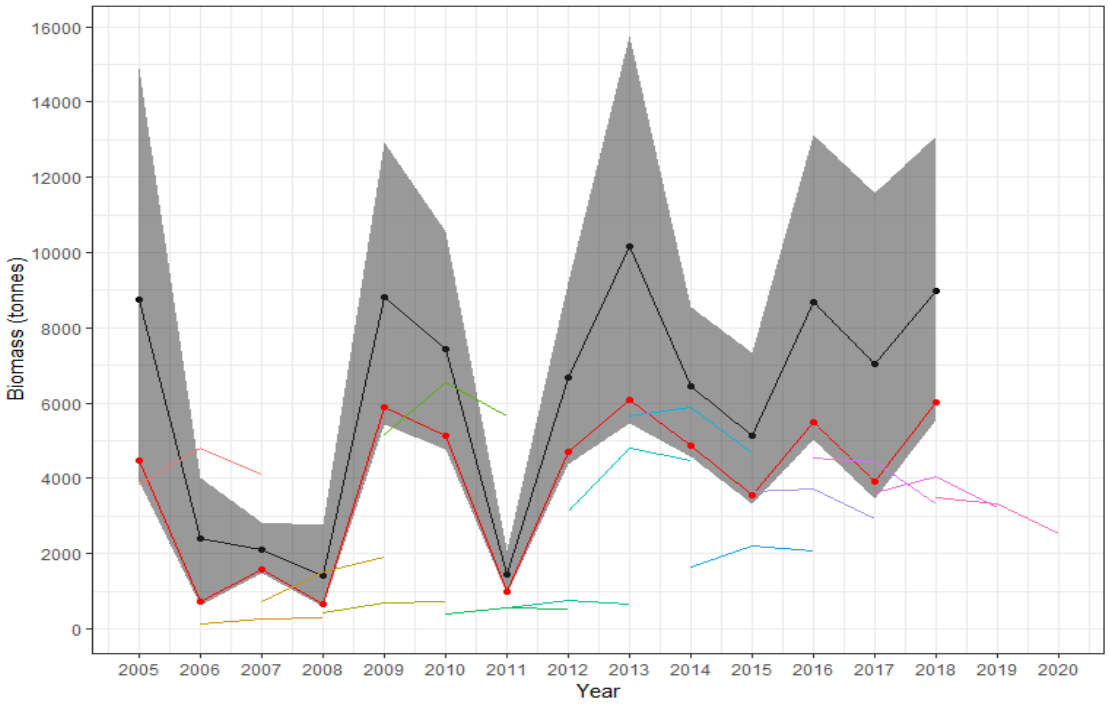


Figure A1.2: Mean time series of estimated biomass (including 4+ and 5+ cohorts; black) with confidence intervals (grey) and lower one-sided 95th confidence bound (red), and stock assessment projections (excluding 4+ and 5+ cohorts; colors) that were used to determine catch limits for mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2.

Sensitivity analyses

A8. Sensitivity tests indicated that the convention of using the lower one-sided 95th percentile of the survey biomass estimate is effective in accounting for uncertainty in mortality and growth rates.