Stock Annex 2022: *Champsocephalus gunnari* at Heard Island (Division 58.5.2)

CCAMLR Secretariat

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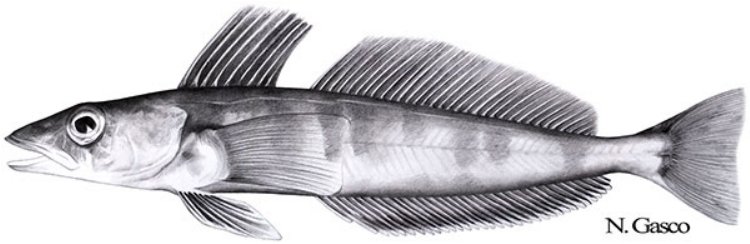
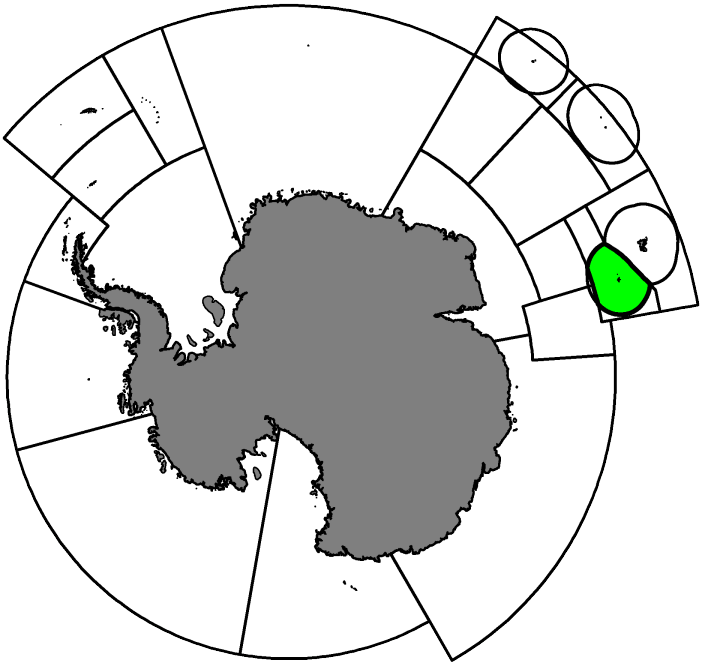


Mackerel icefish, *Champsocephalus gunnari* Lönnberg, 1905.



Map of the management areas within the CAMLR Convention Area. The region discussed in this report is shaded in green.

Stock Annex for the mackerel icefish (*Champsocephalus gunnari*) fishery in Division 58.5.2

1. General

The fishery for mackerel icefish (*Champsocephalus gunnari*) around Heard Island and McDonald Islands in Division 58.5.2 began in 1997 (CCAMLR 2017), although fishing had occurred in these waters during the 1970s prior to the declaration of the Australian Fishing Zone (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.

In 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 island. 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.

A random stratified trawl survey (RSTS) has been undertaken each year on the shallow plateau (<1000 m) in Division 58.5.2 to collect data on the distribution, abundance and population structure of Patagonian toothfish, mackerel icefish and other species.

Prior to 2011, the population of mackerel icefish in Division 58.5.2 generally exhibited one or two cohorts which dominated in abundance and biomass, and these were separated in age by one or two years (Welsford 2010, Welsford 2015, Williams et al. 2001). Since the maximum age of mackerel icefish in this region is thought to be around five years, strong cohorts have resulted in large variation of population abundance and the amount of production available to the fishery (SC-CAMLR 2010). However, between 2011 and 2016 at least four and often five cohorts were apparent in the population simultaneously, with no single cohort being overwhelmingly dominant (Maschette and Welsford 2019).

2. Catch data

The catch data are provided in the Fishery Report.

3. Biological parameters

The biological parameters used in the 2022 stock assessment are provided in Table 2.

3.1 Length-weight relationship

The parameters of the weight-at-length relationship, a and b were re-estimated by fitting the relationship:

$$W=aL^b$$

where W is the weight (kg), L is the length (mm) of individual icefish taken during the survey, and were fitted using the *nls*() function in R (R Development Core Team 2018).

3.2 Length-at-age

Growth parameters were re-evaluated in 2017 (WG-FSA-17/22) using survey data between 2010–2017 and used in the assessment.

3.4 Maturity

For the assessment, all fish were assumed to be mature so that the status of the whole stock was monitored.

3.5 Natural mortality

Natural mortality was assumed to be 0.4 (de la Mare 1998).

Table 1: Biological parameters used in the 2022 assessment of *Champsocephalus gunnari* in Division 58.5.2.

Component	Parameter	Value	Units	Source
Weight-at-length	a	8.219e 10^{-10}	kg/mm	WG-FSA-2022/08
	b	3.331		WG-FSA-2022/08
Length-at-age	L_∞	490	mm	WG-FSA-17/22
	K	0.368	y^{-1}	WG-FSA-17/22
	t_0	0.067	y	WG-FSA-17/22
Maturity	Lm50	0 mm		Set so that the status of the whole stock is being monitored
Natural mortality	M	0.4	y^{-1}	de la Mare et al. 1997

4. Abundance and other observations

4.1. Random stratified trawl survey

The design of the random stratified trawl survey (RSTS) conducted in 2022 used the same principles as previous surveys in Division 58.5.2 (WG-FSA-2022/07). The three strata where mackerel icefish are abundant (Gunnari Ridge, Plateau West and Plateau Southeast) were surveyed in daylight, when icefish are close to the seafloor and most effectively sampled by demersal trawls (van Wijk *et al.* 2001). Survey hauls were allocated at random within each stratum, however a minimum spacing of 5 nautical miles between survey stations was specified to ensure hauls would not overlap. Station locations and catches are detailed in WG-FSA-2022/07.

4.2 Population structure

A mixture analysis was undertaken using the CMIX procedure (de la Mare 1994, de la Mare *et al.* 2002) to estimate the density of fish in each age class and the contribution of each age class to the overall biomass estimated by scaling each age class by its mean weight at length. The survey data were pooled to a single survey data set. As in previous years the sampling effort across strata was un-equal, as such

the data is re-scaled so that the mean of the re-scaled data is the same as the stratified mean of the raw data. For each haul in *k* strata, the density data is re-scaled by the composite sampling fraction following de la Mare & Williams (1996):

$$D_{i,j} = d_{i,j} \frac{A_i}{\sum_k A_k} \times \frac{\sum_k n_k}{n_i}$$

where $D_{i,j}$ is the re-scaled density for haul i in stratum j, $d_{i,j}$ is the original density estimate for that haul, and A_i and n_i are the area and the number of hauls in stratum i respectively.

4.3 Survey biomass

Using the method described in Constable *et al.* (2005, Appendix 1), a bootstrap algorithm was implemented in R to estimate the uncertainty in the total biomass (tonnes) of mackerel icefish over the survey area. Prior to the bootstrap procedure, the observed densities from each haul were rescaled using the equation described above for cohort structure. The lower one-sided 95% confidence bound of the biomass estimate was then used as the estimate of the standing stock at the start of the projection period.

5. Assessment

The Generalised Yield Model (GYM) was fitted with the *Grym* package in R (Wotherspoon & Maschette 2020), with specifications for the icefish assessment model provided in Table 2.

5.1 Yield estimation

Fishing mortality and corresponding catch that meets the short-term decision rule, i.e. that will result in a 75% escapement relative to a two-year projection with zero fishing mortality (Figure 1) were calculated based on updated biological parameters and other input settings (Table 2).

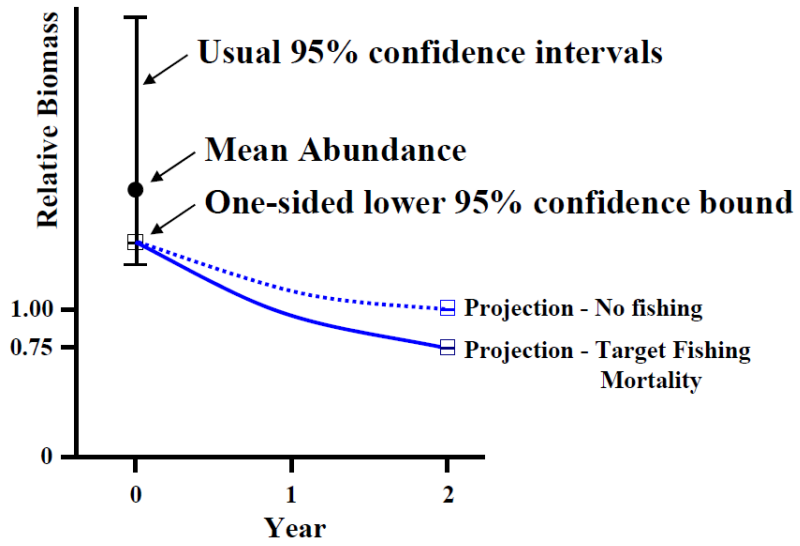


Figure 1. Decision rule for determining yield for mackerel icefish in year 1 and 2 after a survey (from Constable *et al.* 2005).

Few fish in the mackerel icefish population in Division 58.5.2 survive beyond age 4, with a drop in abundance between 3+ and 4+ cohorts observed in consecutive surveys (Welsford 2011, Welsford 2015). Consequently, the assessment scenarios only included the biomass estimated from the 0+ to 3+ cohorts.

Table 2: Model specifications for estimated parameters in the assessment for *Champsocephalus gunnari* in Division 58.5.2 in 2022.

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 Tables 2, 3 and 4	WG-FSA-2022/08
	Biomass	14879.59tonnes	WG-FSA-2022/08
	Date of estimate (RSTS)	22 April 2022	
Recruitment		0	
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[1]	
	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] Set to 0 when no icefish were captured after the survey, else set to 1.

6. References

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Welsford D.C. (2011) Data from recent trawl surveys in the vicinity of Heard Island and the McDonald Islands (Division 58.5.2), reveal an unusual cohort structure in the mackerel icefish (*Champsocephalus gunnari*) population. Document WG-FSA-11/22, CCAMLR, Hobart, Australia.

Welsford D.C. (2015) Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2015 random stratified trawl survey. Document WG-FSA-15/12, CCAMLR, Hobart, Australia.

Williams R., van Wijk E., Constable A. and Lamb T. (2001) The fishery for *Champsocephalus gunnari* and its biology at Heard Island (Division 58.5.2). Document WAMI-01/04, CCAMLR, Hobart, Australia.

Wotherspoon S. and Maschette D. (2020) Grym: R Implementation of the Generalized Yield Model. R package version 0.1.0.9000. github.com/AustralianAntarcticDivision/Grym

Additional Resources

- Fishery Summary: pdf, html
- Fishery Report: pdf, html
- Species Description: pdf, html
- Stock Assessment Report: pdf
- Fisheries Documents Browser