*CCAMLR Science*, Vol. 5 (1998): 79–101

# AN ASSESSMENT OF THE MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) OFF HEARD ISLAND

W.K. de la Mare, R. Williams and A.J. Constable*
Australian Antarctic Division
Channel Highway, Kingston
Tasmania 7050, Australia
*Correspondence should be addressed to A.J. Constable

Abstract

Assessments of the abundance and potential yield of the mackerel icefish (*Champsocephalus gunnari*) populations at Heard Island are developed from the results of four scientific surveys conducted in 1990, 1992, 1993 and 1997. The assessments include estimates of all the parameters required, based on the data collected during the surveys, including growth curves, natural mortality, ages and sizes of maturity and a weight–length relationship. The results show that characteristics of *C. gunnari* populations on the Heard Plateau are sufficiently different from those on Shell Bank for them to be managed separately. Precautionary catch limits calculated using the Generalised Yield Model (GYM) are found to be 180 tonnes for the Heard Plateau and 18 tonnes for Shell Bank. An assessment based on the results of a survey conducted at the end of the 1997 fishing season would allow for a catch limit on the Heard Plateau of 900 tonnes in the 1997/98 season and 600 tonnes in 1998/99.

Résumé

De quatre campagnes d'évaluation menées en 1990, 1992, 1993 et 1997, il a été possible de dériver des évaluations de l'abondance et du rendement potentiel des populations de poisson des glaces (*Champsocephalus gunnari*) de l'île Heard. Les données collectées au cours des campagnes d'évaluation ont permis d'estimer tous les paramètres requis, à savoir les courbes de croissance, la mortalité naturelle, les âge et taille à la maturité et un rapport poids-longueur. Il ressort que les caractéristiques des populations de *C. gunnari* du plateau de l'île Heard sont suffisamment différentes de celles du banc Shell pour justifier que ces populations soient gérées séparément. Par le modèle de rendement généralisé (GYM), il a été possible de calculer des limites préventives de capture de 180 tonnes pour le plateau de l'île Heard et de 18 tonnes pour le banc Shell. Selon les résultats d'une campagne d'évaluation menée vers la fin de la saison de pêche 1997, pour le plateau de l'île Heard, la limite de capture pourrait être estimée à 900 tonnes pour la saison 1997/98 et à 600 tonnes pour la saison 1998/99.

Резюме

На основе результатов четырех научно-исследовательских съемок, проведенных в 1990, 1992, 1993 и 1997 гг., были выполнены оценки численности и потенциального вылова популяций ледяной рыбы (*Champsocephalus gunnari*) в районе о-ва Херд. При этом были учтены рассчитанные с помощью съемочных данных величины всех соответствующих параметров, включая кривые роста, естественную смертность, возраст и длину по достижении половозрелости и размерно-возрастную связь. Согласно полученным результатам различия в особенностях популяций *C. gunnari* на плато о-ва Херд и банке Шелл требуют раздельного управления их промыслом. Предохранительные ограничения на вылов, рассчитанные с использованием обобщенной модели вылова (GY-модели), равняются 180 т для плато Херд и 18 т для банки Шелл. Результаты съемки, проведенной в конце промыслового сезона 1997 г., привели к оценке ограничения на вылов в районе плато Херд в 900 т на сезон 1997/98 г. и 600 т на сезон 1998/99 г.

Resumen

Los resultados de cuatro prospecciones científicas efectuadas en 1990, 1992, 1993 y 1997, fueron utilizados para evaluar la abundancia y rendimiento potencial de las poblaciones de draco rayado (*Champsocephalus gunnari*) en isla Heard. Las evaluaciones incluyen estimaciones de todos los parámetros necesarios, según los datos recopilados durante las prospecciones, incluyendo las curvas de crecimiento, la mortalidad natural, edad y talla de madurez y una relación peso-talla. Los resultados demuestran que las características de las poblaciones de *C. gunnari* en la plataforma de isla Heard y aquellas que habitan el banco Shell difieren lo suficiente como para requerir una ordenación por separado. Los límites de captura precautorios estimados mediante el modelo general de rendimiento (GYM) son: 180 toneladas para la plataforma de isla Heard y 18 toneladas para el banco Shell. Una evaluación basada en los resultados de una prospección efectuada al final de la temporada de pesca de 1997 ha estimado límites de captura de 900 toneladas en la plataforma Heard en la temporada 1997/98 y de 600 toneladas en 1998/99.

Keywords: mackerel icefish, *Champsocephalus gunnari*, abundance, potential yield, Heard Island, CCAMLR

## INTRODUCTION

In 1994 the Working Group on Fish Stock Assessment (WG-FSA) recommended a precautionary catch limit for mackerel icefish (*Champsocephalus gunnari*) in CCAMLR Division 58.5.2 based on the results of three Australian surveys (Williams and de la Mare, 1995). A modified form of the krill yield model (Butterworth et al., 1992) was used to calculate a rate of exploitation $\gamma$ which was applied to the lowest of the three biomass estimates to give a precautionary yield of 311 tonnes (SC-CAMLR, 1994b). This assessment relied on estimates of demographic parameters for *C. gunnari* obtained for other populations at South Georgia and Kerguelen.

In this paper, a new assessment is developed using results from the three previous surveys and results from a new survey carried out in August 1997. A precautionary catch limit is calculated by applying the generalised yield model (GYM) (Constable and de la Mare, 1996) to estimates of year-class strength from the trawl surveys, using the same methods as for recent assessments of Patagonian toothfish (*Dissostichus eleginoides*) by WG-FSA (SC-CAMLR, 1996). The estimates of year-class strength were obtained using maximum likelihood distribution mixture analysis (de la Mare, 1994a). The assessment uses growth curves, maturation ogives and weight-length relationships derived from the survey data collected at Heard Island. The assessment is carried out for the populations of *C. gunnari* in two regions:

(i) the plateau of Heard Island, including the locality known as Gunnari Ridge; and

(ii) Shell Bank, which is separated from the plateau by water of depths greater than 500 m.

The *C. gunnari* populations in these two regions have different spawning seasons and, as will be shown below, have different age structures in the same year and appear to have differences in their growth curves. For these reasons the two populations are treated separately in the assessments presented here.

An alternative catch limit is calculated using the results of the trawl survey carried out during August 1997. This allows for a higher catch limit due to the current high abundance of *C. gunnari* on the Heard Plateau.

## TRAWL SURVEY BIOMASS ESTIMATES

### Early Surveys

Three surveys were conducted around Heard Island in the years 1990, 1992 and 1993. The results of these surveys were reported in Williams and de la Mare (1995). A summary of the results is given in Table 1. The areas of the strata covered in all the surveys are given in Table 2.

### The 1997 Survey

A random stratified trawl survey was carried out on Shell Bank and on the Heard Plateau. In each location two strata were defined based on the results obtained in the earlier surveys. These strata and the trawl stations are shown in Figure 1. The areas of each stratum are given in Table 2. Ten hauls were made in each stratum. The details of the vessel and fishing gear used are given in the appendix. The 1997 survey did not cover as great an area of the plateau as the earlier surveys, and thus to some extent the abundance will be underestimated for this stratum. However, the 1997 plateau stratum has excluded the areas where C. *gunnari* were not abundant in the earlier surveys, and hence the degree of underestimation should not be substantial.

Biomass estimates and their confidence intervals were calculated using both the Delta-lognormal maximum likelihood estimator (Pennington, 1983; de la Mare, 1994b) and the sample means with bootstrap variance and confidence intervals (Efron and Tibshirani, 1993). The maximum likelihood and bootstrap estimates are shown in Table 3.

## LENGTH-DENSITY ANALYSES

For each stratum and survey the densities by length class for each haul were estimated from length samples and the swept area. A mixture of normal distributions was fitted to each stratum for all the surveys (see de la Mare, 1994a for details). The estimated density of a given year class in a stratum was taken to be the area under a designated component of the mixture distribution. The abundance of the year class was calculated as the product of the density and the stratum area. The estimates of the density of each age class by survey are given in Table 4. Estimates of total abundance for each age class are obtained by multiplying the estimates of density for each cohort by the stratum areas. Estimates of recruitment are obtained by adjusting the numbers in each age class observed for the cohort to the numbers at age 2, using a natural mortality coefficient (M) of 0.4 ($yr^{-1}$) (this is the mid-point of the range for M used in the 1994 WG-FSA assessment). The estimates are averaged in those cases where cohort abundance has been estimated from more than one survey.

The estimates of recruitment for the Heard Plateau and Shell Bank are given in Table 5. The estimates are highly variable, with a range of about two orders of magnitude. At South Georgia and Kerguelen it has been found that the abundance of *C. gunnari* can fluctuate markedly (Parkes, 1992; Duhamel, 1991). The survey results and recruitment estimates show that the same behaviour can be expected in the populations around Heard Island. Figure 2 shows no apparent relationship between the numbers of recruits on the plateau and on Shell Bank in the same years.

## GROWTH CURVES

The components of the mixture distribution from the length-density analyses also give estimates of the mean sizes at age. These data have been used to estimate growth curves by fitting a von Bertalanffy function, by nonlinear least squares regression, to the size data by assigning an age to each component, referred to a 'birthday' of July 1. The assigned ages take into account the median date at which each survey was conducted. The fitted growth curves for the two regions are shown in Figure 3. The fitted von Bertalanffy parameters are given in Table 6. Although the growth curves between the two locations are not significantly different statistically, the difference between the time intercept ($t_0$) for the two curves is 4.8 months. This is in good agreement with the observed five-month difference in spawning season between the two locations.

## NATURAL MORTALITY

The length-density analyses give estimates of density at age from the mixture distribution components. Because *C. gunnari* were not commercially fished at Heard Island prior to the 1997 season, the estimated year class densities can be used to estimate natural mortality. The estimator used is essentially the Heincke estimate (Heincke, 1913) for survivorship from age $a$ to all older ages, $S_a$, but it is based on densities rather than numbers sampled (see de la Mare, 1994c for the theoretical development of this method), that is:

$$S_a = 1 - \frac{d_a}{\sum_{i=a}^{\infty} d_i}$$

where $d_a$ is the density of age class $a$. Values of $S_a$ were calculated for each survey stratum and averaged for $a$ = 2 and $a$ = 3. The individual estimates are highly variable because of recruitment and sampling variability. The estimates are averaged over the strata and survey to give the following mean estimates of survivorship:

| Age | Mean $S_a$ | Std. Error |
|---|---|---|
| 2 | 0.731 | 0.108 |
| 3 | 0.513 | 0.102 |

An approximately unbiased estimator of M is given by de la Mare (1986) as:

$$M = -\ln\left(\hat{S}\right) - \frac{\hat{s}^2}{2\hat{S}^2}$$

where $\hat{s}$ is the standard error of the estimate $\hat{S}$. The resultant estimates of M are 0.30 ($yr^{-1}$) for age 2 and above and 0.64 ($yr^{-1}$) for age 3 and above. Neither of these estimates is very precise, and natural mortality in this species remains uncertain. However, these estimates provide a reasonable range for use in the further development of the assessment. The previous assessment for this species at Heard Island used a range for M of 0.3 to 0.5 (SC-CAMLR, 1994). The central value of this range (M = 0.4) has been used in calculations outside the GYM. The range of M for calculations using the GYM has been set at 0.3 to 0.64.

## AGE AND SIZE AT FIRST SPAWNING

*C. gunnari* on the Heard Plateau and Gunnari Ridge spawn in August/September, while those on Shell Bank spawn in April. Gonad maturity of females was scored according to the scale recommended in CCAMLR (1998) for fish during the spawning season in the respective localities. Data used were from commercial fishing on Shell Bank in April 1997, and from random stratified surveys in the Gunnari Ridge/Heard Plateau area in September 1993 and August 1997. Fish at stage 2 (developing) or later were considered to be mature. The percentage of mature fish was plotted against total length (Figure 4) and the size at first spawning was taken to be at the point where 50% of fish were mature. Results are in Table 7. Comparing these figures with the growth curve shows that the age at first spawning is three years.

## WEIGHT–LENGTH RELATIONSHIP

The weight–length relationship was determined from the research survey data (1990–92) according to the model:

$$W = aL^b$$

where $W$ is weight of fish (kg), $L$ is the total length (mm) and $a$ and $b$ are the parameters of the equation. The parameter estimates were obtained using the quasi-Newton nonlinear estimation method:

| Parameter | Estimate |
|---|---|
| $a$ | $2.629.10^{-10}$ |
| $b$ | 3.515 |
| $r^2$ | 0.975 |
| $n$ | 4 046 |

## AGE AND SIZE AT RECRUITMENT

Figures 5a and 5b show the cumulative length frequency of the catch at Heard Island for two different net types and for a range of codend mesh sizes from 60 to 129 mm. The median length in the catch for each gear type is given in Table 8. All of the meshes used for commercial fishing were larger than 90 mm, the minimum size allowed under the current mesh regulation for this species.

It is clear from these results that mesh size and gear type have had relatively little effect on the size structure of the catch. The size of fish taken seems to be predominantly affected by the length structure of the fish population. Mesh regulations do not appear to be an effective method for limiting the size and age of first capture for this species.

### Avoiding the Capture of Small Fish

A provision was included in CCAMLR Conservation Measure 110/XV (CCAMLR, 1997) which required that if more than 10% of *C. gunnari* in any haul were less than 280 mm in length then the fishing activities were to move away 5 n miles for at least five days. The intent of this measure was to maximise survival into the spawning stock by avoiding fishing juvenile fish. However, it was found to be difficult to avoid triggering this provision of the conservation measure. It was shown earlier that even a large mesh size of 129 mm led to a median length in the catch not greatly exceeding 280 mm. Figure 6 shows a comparison between the cumulative length distribution of the catch for the 'Gloria' net with a 110-mm mesh and the predicted cumulative length distribution of fish of age 3+. The predicted distribution uses a standard deviation of length at age of 13.25 mm, which is the average of the estimates of the standard deviations of the mixture distribution components fitted to fish of age 3 in the length-density analyses.

It can be seen that the two distributions are very similar, particularly in the lower tail. The difference in the upper end of the distribution arises because the catch consists of age classes other than 3. This shows that recruitment to the fishery was knife-edged at age 3 in the 1997 season. Even though virtually no pre-spawning 2-year-old fish were taken with this gear in 1997, the proportion of fish less than 280 mm is of the order of 10%, and it is therefore not surprising that avoiding 10% of 'small fish' was difficult.

The general yield assessments below show that there is no compelling reason to ensure that the age of recruitment to the fishery is strictly 3. However, it does seem reasonable to avoid the fishery targeting fish of age 2. The mean length at first spawning given above for the Heard Plateau is 275 mm. The growth curve gives a mean length for fish aged one year less than the age of first spawning of 206 mm. Figure 7 shows a plot of two cumulative normal distributions with $\mu = 206$, $\sigma = 11.23$ and $\mu = 275$, $\sigma = 13.25$, representing the distributions of the lengths of fishes of ages 2 and 3 respectively. The standard deviations of length at age were estimated as part of the length-density analyses. This plot shows that very few fish of age two have a length greater than 240 mm, and that very few fish of age 3 have a length below this point. Thus, if the intention is to avoid catching a proportion of fish of age 2 or less, the appropriate length to use in the criterion is 240 mm.

## ASSESSMENT BASED ON THE GENERALISED YIELD MODEL

Assessments of precautionary catch limits were developed using the GYM. Given the substantial variability in recruitment and indications that this was not modelled well by a lognormal distribution, some assessments were carried out using the option to model recruitment by bootstrapping from a table of recruitment estimates. However, these recruitment estimates themselves are uncertain. In order to take this into account, a parametric bootstrap procedure was added to the program so that the recruitment selected from the table was randomly modified according to a lognormal distribution with a coefficient of variation derived from the uncertainty in the recruitment estimate.

One of the consequences of the substantial levels of recruitment variability is that the probability of the population falling to below 20% of median spawning stock biomass is naturally high. In the case of *C. gunnari* on the Heard Plateau, the GYM predicts that, even in the absence of fishing, the probability of falling below 20% of the median unexploited spawning stock biomass is about 0.5. The current decision criterion used in formulating catch limits requires that this probability be held at 10%. Clearly this is not possible for this fish population, and application of this decision rule would prevent any fishing of it.

The current form of the decision rule was formulated to maintain a low risk of recruitment declining due to the effects of fishing. However, it appears that *C. gunnari* populations can naturally reach low spawning stock levels with high probability, and yet spawn strong cohorts. This suggests that the existing form of the rule is not appropriate for this particular population. An alternative form of the decision rule for such cases would be to ensure that the probability of falling below the 20% reference level is not substantially increased by the effects of fishing.

The input parameters used to assess long-term average yields of *C. gunnari* from the plateau and from Shell Bank at Heard Island are shown in Tables 9 and 10 respectively.

The effects of a constant catch level (in tonnes) over a 20-year period were evaluated. The criteria considered were the escapement of the spawning stock (median ratio of spawning biomass at the end of the run to median spawning biomass at time 0) and the probability of depletion to below 0.2 of the median spawning biomass at time 0. An assessment of the properties of the recruitment vectors showed substantial variation in mean recruitment between runs of only 1 001 replicates. Therefore, to increase precision in the estimate of escapement, 5 001 replicates were used.

Four trials were undertaken for each area to examine the sensitivity of the results to three models of recruitment and two minimum ages of fish selected by the fishery. The first trial used a bootstrap recruitment function based on the vector of recruitments for each area. The second trial incorporated uncertainty in each estimate of recruitment by modifying each recruitment chosen in the bootstrap by a random lognormal deviate based on the standard error of the recruitment. The third trial used the lognormal recruitment function derived from the vector of recruits. In these three trials, selection to the fishery was considered to be knife-edged at age 3. The fourth trial examined the consequences for the stock if selection was at age 2. This was examined only for the case of the full bootstrap model used in Trial 2.

Results are shown in Table 11. It can be seen that the results are not sensitive to whether or not fish of age 2 are taken by the fishery. Median escapement of the spawning stock is always well above 75% of median unexploited biomass, which is the decision criterion used in CCAMLR assessments to take into account the requirements for dependent predators (SC-CAMLR, 1994). Thus, the binding decision rule relates to the maintenance of stable recruitment.

The precautionary catch limits calculated here are based on a decision rule which requires that the probability of the spawning stock falling below 20% over the specified period (20 years is used here) should not be increased by more than 0.05. Combining this with the existing decision criterion leads to a composite form of decision rule where the decision probability level $p_{dec}$ is set according to the following formula:

$$p_{dec} = \begin{cases} 0.10 & ;\ p_{F=0} < 0.05 \\ p_{F=0} + 0.05 & ;\ otherwise \end{cases}$$

where $p_{F=0}$ is the probability of the population declining below the 20% level in the absence of fishing.

There was little difference in the results between the bootstrap and the parametric bootstrap recruitment methods, although the estimated yield is slightly greater for the parametric bootstrap method. The parametric bootstrap method takes into account the uncertainties associated with the estimates of recruits. The outcome is sensitive to the use of the lognormal function for recruitment. However, given that the recruitment distribution does not fit well with a lognormal distribution, and that these estimates of the parameters are very imprecise from the recruitment vector, the results of this trial are not recommended for use. The results were not sensitive to the age at which fish are recruited to the fishery. The precautionary yield for the Heard Island area arising from the models that take full account of the uncertainties gives a precautionary catch limit of 180 tonnes for the Heard Plateau and 18 tonnes for Shell Bank.

## AN ASSESSMENT BASED ON THE 1997 SURVEY

The catch limits calculated in the preceding section are precautionary, which means that they are based on a constant catch over a 20-year period, and as such they can be continued for some years without the need for annual reassessments. However, the precautionary catch limit is dominated by the periods in which the stock has naturally fallen to a low level. Consequently, the opportunity to increase catches is foregone when the stock is abundant due to the presence of one or more strong year classes. This is currently the case on the plateau at Heard Island where the recent trawl survey gives a biomass estimate of about 50 000 tonnes, with two strong year classes in the spawning stock. The current population level could support catches above the precautionary level for at least two years. This suggests that a form of management strategy based on recent abundance estimates would allow an increase in yield over the precautionary level. However, the development of such a strategy is a substantial task requiring further study and evaluation.

Nonetheless, as an interim step in this direction, catch limits are calculated here which allow for higher catches in the next two seasons without any substantial risk of depleting the spawning stock. The criterion applied is to calculate the fishing mortality which would result in a probability of no more than 0.05 that the spawning stock after fishing would be less than 75% of the level that would have occurred in the absence of any fishing. This is achieved by using the bootstrap one-sided lower 95% confidence bound on the trawl survey estimate as the current stock biomass. The numbers of fish in the cohorts are calculated using the following formula:

$$\tilde{N}_a = \frac{\hat{N}_a}{\sum_i \hat{N}_i} \cdot \frac{\tilde{B}}{\overline{w}} \tag{1}$$

where $\tilde{N}_a$ is the number of fish of age $a$, given the current age structure and a population biomass at the lower 95% confidence bound $\tilde{B}$, $\hat{N}_a$ is the estimated abundance of fish aged $a$ in the current population and $\overline{w}$ is the average weight of a fish in the current population. The average weight is given by:

$$\overline{w} = \frac{w_a \hat{N}_a}{\sum_i \hat{N}_i} \tag{2}$$

where $w_a$ is the average weight of fish of age $a$, calculated from the growth curve and weight–length relationship. Fishing mortality is found numerically by solving the following fisheries differential equations with an initial age structure derived from equation (1):

$$\frac{dN}{dt} = -zN$$

$$\frac{dB}{dt} = NaL_{\infty}\left( \begin{array}{l} bk\left(1-e^{-k(t-t_0)}\right)^{b-1} e^{-k(t-t_0)} \\ -z\left(1-e^{-k(t-t_0)}\right)^{b} \end{array} \right)$$

$$\frac{dC}{dt} = FB$$

where $N$ is the number of fish, $z$ = M+F where M and F are the natural and fishing mortality rates respectively, $B$ is the biomass of fish, $L$, $k$ and $t_0$ are the von Bertalanffy growth parameters, $a$ and $b$ are the weight–length parameters and $C$ is the catch.

The resulting fishing mortality is F = 0.095. This results in a combined catch over two years from the two abundant cohorts of 1 500 tonnes, comprising 900 tonnes in the first year and 600 tonnes in the second year.

## DISCUSSION

The assessments presented here are based on data collected from scientific surveys carried out on the populations of *C. gunnari* in the vicinity of Heard Island. The results of these assessments can be summarised as follows.

There are important differences in the populations of *C. gunnari* on the Heard Plateau and on Shell Bank. This indicates that the two areas should be managed separately.

For the precautionary catch limits from the GYM, median escapement of the spawning stock is always well above 75%. Fishing at the precautionary catch limit is unlikely to compromise predator requirements. Given that the abundance of the population is so variable, it is likely that predators of *C. gunnari* switch to other prey species when *C. gunnari* are scarce. It is also likely that the effects of predation on the *C. gunnari* populations would not be great when ice fish abundance is high.

The existing decision criterion for a precautionary catch limit, which limits the probability of the stock falling below 20% of the median spawning stock biomass to 0.1, is not applicable to these populations because this is exceeded naturally. An augmented decision criterion is used here which limits fishing so that the increase in the probability of the spawning stock biomass falling below the reference level is no greater than 0.05. This criterion gives precautionary catch limits of 180 tonnes for the Heard Island plateau and 18 tonnes for Shell Bank. This is lower than the previous precautionary catch limit of 311 tonnes. However, the parameters and decision criteria for the new calculations have little in common with the earlier calculations.

The precautionary catch limits are low because of the combination of highly variable recruitment with the short life-span of the fish. Consequently, the abundance of fish can fall to low levels. The precautionary catch limit is constrained by the periods of low abundance. This means that the precautionary catch limits fail to take advantage of periods when the populations are abundant due to sporadic strong year classes. Based on the results of a survey conducted at the end of the 1997 fishing season, some interim calculations were made using the criterion that fishing should not reduce the spawning stock biomass to below 75% of the level which would occur in the absence of fishing. These calculations give catch limits for the Heard Plateau of 900 tonnes in 1997/98 and 600 tonnes in 1998/99. The catch limit would need to revert to the precautionary level thereafter unless a further survey again showed that abundant cohorts had been recruited.

There appears to be no compelling requirement to protect juvenile fish from the effects of fishing up to the precautionary catch limit. However, this has not been established for the higher catch limits from the interim procedure for estimating catch limits for abundant cohorts. For this reason, it would be advisable to continue a procedure for limiting the proportion of small fish taken by the fishery. This could be achieved by requiring a fishing vessel to move to another location when the proportion of small fish exceeds 10% of the total (provided the haul is above a minimum threshold such as 100 kg). Small fish should be defined as those less than 240 mm total length.

A management system based on annual surveys may have substantial benefits for *C. gunnari* fisheries. This should be explored further as a component in the development of a management procedure for *C. gunnari* currently under way.

REFERENCES


Butterworth, D.S., A.E. Punt and M. Basson. 1991. A simple approach for calculating the potential yield from biomass survey results. In: *Selected Scientific Papers, 1991 (SC-CAMLR-SSP/8)*. CCAMLR, Hobart, Australia: 207–215.

Constable, A. J. and W.K. de la Mare. 1996. A generalised model for evaluating yield and the long-term status of fish stocks under conditions of uncertainty. *CCAMLR Science*, 3: 31–54.

CCAMLR. 1997. *Schedule of Conservation Measures in Force, 1997/98*. CCAMLR, Hobart, Australia: 97 pp.

CCAMLR. 1998. Maturity scales of Antarctic fish. In: *Scheme of International Scientific Observation: Scientific Observers Manual*, Part III, Section 5. CCAMLR, Hobart, Australia.

de la Mare, W. K. 1986. *On the Management of Exploited Whale Populations*. D. Phil thesis, University of York, York: 217 pp.

de la Mare, W.K. 1994a. Estimating krill recruitment and its variability. *CCAMLR Science*, 1: 55–70.

de la Mare, W.K. 1994b. Estimating confidence intervals for fish stock abundance estimates from trawl surveys. *CCAMLR Science*, 1: 203–207.

de la Mare, W.K. 1994c. Modelling krill recruitment. *CCAMLR Science*, 1: 49–54.

Duhamel, G. 1991. The biological and demographic peculiarities of the icefish *Champsocephalus gunnari* Lönnberg, 1905 from the Kerguelen shelf. In: di Prisca, G., B. Maresca and B. Tota (Eds). *Biology of Antarctic fish*. Springer-Verlag, Berlin: 40–53.

Efron, B. and R.J. Tibshirani. 1993. *An Introduction to the Bootstrap*. Chapman and Hall, New York.

Heincke, F. 1913. Investigations on the plaice. General Report 1. The plaice fishery and protective measures. Preliminary brief summary of the most important points of the report. *Cons. int. explor. Mer.*, 16: 1–67.

Parkes, G. 1992. Notes on the use of virtual population analysis for stock assessment of the mackerel icefish, *Champsocephalus gunnari* (Lönnberg, 1906) in Subarea 48.3 for the 1990/91 and 1991/92 seasons. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 49–79.

Pennington, M. 1983. Efficient estimators of abundance, for fish and plankton surveys. *Biometrics*, 39: 281–286.

SC-CAMLR. 1994a. *Report of the Thirteenth Meeting of the Scientific Committee (SC-CAMLR-XIII)*. CCAMLR, Hobart, Australia.

SC-CAMLR. 1994b. Report of the Working Group on Fish Stock Assessment. In: *Report of the Thirteenth Meeting of the Scientific Committee (SC-CAMLR-XIII)*, Annex 4. CCAMLR, Hobart Australia: 123–211.

SC-CAMLR. 1996. Report of the Working Group on Fish Stock Assessment. In: *Report of the Fifteenth Meeting of the Scientific Committee (SC-CAMLR-XV)*, Annex 5. CCAMLR, Hobart Australia: 301–447.

Williams, R. and W.K. de la Mare. 1995. Fish distribution and biomass in the Heard Island zone (Division 58.5.2). *CCAMLR Science*, 2: 1–20.

Table 1: Summary of the estimated abundance (in tonnes) of *Champsocephalus gunnari* from the three trawl surveys conducted off Heard Island from 1990 to 1993 (from Williams and de la Mare, 1995). Estimates and 95% confidence intervals are from the Delta-lognormal maximum likelihood estimator.

| Cruise | Lower 95% Confidence Interval | Estimate (tonnes) | Upper 95% Confidence Interval | CV |
|---|---|---|---|---|
| Autumn 1990 | 2 606 | 4 584 | 113 019 | 0.257 |
| Summer 1992 | 945 | 3 112 | 427 728 | 0.535 |
| Spring 1993 | 4 113 | 31 701 | 14 712 200 | 0.801 |

Table 2: Areas of seabed (in km$^2$) within each stratum for the various surveys.

| Stratum | Survey | | | |
|---|---|---|---|---|
| | Autumn 1990 | Summer 1992 | Spring 1993 | Winter 1997 |
| Plateau | 21 582 | 21 582 | 21 310 | 5 315 |
| Gunnari Ridge | 386 | 386 | 658 | 520 |
| Shell Bank | 2 085 | 2 085 | 2 085 | - |
| Shell inner | - | - | - | 561 |
| Shell outer | - | - | - | 1 088 |

Table 3: Abundance estimates and confidence intervals for *Champsocephalus gunnari* from the 1997 Heard Island survey.

| Stratum | Delta-lognormal Maximum Likelihood | | | | Sample Statistics with Bootstrap | | | |
|---|---|---|---|---|---|---|---|---|
| | Abundance (tonnes) | Std Error | 95% Confidence Interval | | Abundance (tonnes) | Std Error | 95% Confidence Interval | |
| | | | Lower | Upper | | | Lower | Upper |
| Shell 1 | 253.3 | 201.9 | 38.7 | 14 527.2 | 177.4 | 97.3 | 13.7 | 381.9 |
| Shell 2 | 4 190.0 | 2 822.8 | 1 000.3 | 77 998.0 | 4 354.3 | 2 893.2 | 407.8 | 10 365.5 |
| Plateau | 110 825.0 | 91 849.1 | 14 420.5 | $7.9*10^6$ | 49 050.0 | 30 426.7 | 7 194.3 | 112 745.5 |
| Gunnari R. | 840.0 | 598.9 | 182.0 | 19 344.8 | 611.7 | 324.7 | 124.2 | 1 278.9 |
| Shell 1 + 2 | | | | | 4 531.7 | 2 769.2 | 591.8 | 10 624.0 |
| Gunnari R. + Plateau | | | | | 49 661.7 | 28 946.1 | 7 810.9 | 113.2 |
| Total | 116 109.3 | 91 894.7 | 18 963.0 | $7.9*10^6$ | 54 193.4 | 29 071.7 | 11 765.6 | 118 235.2 |

Table 4: Estimates of *Champsocephalus gunnari* density (in numbers of fish per km$^2$) by age class and cohort from the four trawl surveys at Heard Island. Estimates of density for age classes 1 and 6 are treated as 'absent' (designated by - ) when none were detected. For the other age classes non-detection is taken to be an estimate of zero density.

| 1990 Survey | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | Age 1 1989 Cohort | | Age 2 1988 Cohort | | Age 3 1987 Cohort | | Age 4 1986 Cohort | | Age 5 1985 Cohort | | Age 6 1984 Cohort | |
| | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error |
| Gunnari R. | - | - | 0.0 | 0.0 | 158.0 | 396.0 | 4 779.0 | 12 039.0 | 4 173.0 | 12 516.0 | - | - |
| Plateau | 74.9 | 40.3 | 0.0 | 0.0 | 35.8 | 10.1 | 35.8 | 19.1 | 80.4 | 23.1 | - | - |
| Shell | - | - | 0.0 | 0.0 | 245.0 | 52 000.0 | 137.0 | 187.0 | 0.0 | 0.0 | - | - |

| 1992 Survey | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | Age 1 1990 Cohort | | Age 2 1989 Cohort | | Age 3 1988 Cohort | | Age 4 1987 Cohort | | Age 5 1986 Cohort | | Age 6 1985 Cohort | |
| | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error |
| Gunnari R. | - | - | 44 430.0 | 28 658.0 | 1 314.0 | 1 518.0 | 0.0 | 0.0 | 0.0 | 0.0 | 852.0 | 1 920.0 |
| Plateau | 1 976.0 | 1 828.0 | 167.0 | 60.0 | 24.9 | 13.4 | 21.6 | 13.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Shell | 17.6 | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 370.0 | 251.0 |

| 1993 Survey | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | Age 1 1991 Cohort | | Age 2 1990 Cohort | | Age 3 1989 Cohort | | Age 4 1988 Cohort | | Age 5 1987 Cohort | | Age 6 1986 Cohort | |
| | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error |
| Gunnari R. | 1 237.0 | 821.0 | 4 371.0 | 2 388.0 | 3 192.0 | 2 118.0 | 15.5 | 29.9 | 1 044.0 | 1 006.0 | - | - |
| Plateau | 20.5 | 175.0 | 0.0 | 0.0 | 9 238.0 | 11 198.0 | 0.0 | 0.0 | 682.0 | 3 585.0 | - | - |
| Shell | - | - | 10 231.0 | 15 147.0 | 10 126.0 | 23 551.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - |

| 1997 Survey | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | Age 1 1996 Cohort | | Age 2 1995 Cohort | | Age 3 1994 Cohort | | Age 4 1993 Cohort | | Age 5 1992 Cohort | | Age 6 1991 Cohort | |
| | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error | Density | Std Error |
| Gunnari R. | - | - | 10 650.0 | 8 538.0 | 3 517.0 | 2 982.0 | 62.2 | 43.3 | 0.0 | 0.0 | - | - |
| Plateau | 30.5 | 12.1 | 0.0 | 0.0 | 34 899.0 | 8 157.0 | 21 833.0 | 12 410.0 | 80.5 | 97.6 | - | - |
| Shell 1 | - | - | 0.0 | 0.0 | 29.7 | 44.3 | 2 332.0 | 1 682.0 | 0.0 | 0.0 | 37.8 | 21.8 |
| Shell 2 | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 27 254.0 | 21 316.0 | 0.0 | 0.0 | 615.0 | 523.0 |

Table 5: Estimates of cohort strength (recruits, in millions of fish) referred to age 2 for the Heard Island plateau and Shell Bank from 1985 to 1995.

| Cohort | Heard Plateau | | | Shell Bank | | |
|---|---|---|---|---|---|---|
| | Abundance (millions) | Std Error | CV | Abundance (millions) | Std Error | CV |
| 1985 | 11.11 | 16.13 | 1.452 | 1.91 | 1.30 | 0.678 |
| 1986 | 3.46 | 5.34 | 1.543 | 0.64 | 0.87 | 1.365 |
| 1987 | 17.60 | 84.60 | 4.803 | 0.25 | 53.9 | 212.2 |
| 1988 | 0.53 | 0.33 | 0.617 | 0.00 | 0.00 | - |
| 1989 | 161.0 | 178.1 | 1.106 | 15.80 | 36.60 | 2.333 |
| 1990 | 15.70 | 13.20 | 0.841 | 0.01 | - | - |
| 1991 | 0.84 | 2.56 | 3.037 | 8.86 | 10.68 | 1.205 |
| 1992 | 1.42 | 1.72 | 1.212 | 0.00 | 0.00 | - |
| 1993 | 258.3 | 146.8 | 0.568 | 68.9 | 51.70 | 0.750 |
| 1994 | 279.4 | 64.70 | 0.232 | 0.03 | 0.04 | 1.492 |
| 1995 | 5.54 | 4.44 | 0.802 | - | - | - |

Table 6: Parameters for the von Bertalanffy growth curves estimated for Heard Island plateau and Shell Bank.

| Parameter | Plateau | | Shell Bank | |
|---|---|---|---|---|
| | Value | Std Error | Value | Std Error |
| $t_0$ | 0.571 | 0.072 | 0.170 | 0.303 |
| $k$ | 0.410 | 0.036 | 0.445 | 0.097 |
| $L_\infty$ | 410.990 | 12.230 | 391.640 | 18.160 |

Table 7: Size at which >50% of *Champsocephalus gunnari* are mature.

| Location | Date | Size at First Spawning (mm TL) |
|---|---|---|
| Gunnari Ridge/Plateau | September 1993 | 258 |
| Gunnari Ridge/Plateau | August 1997 | 275 |
| Shell Bank | April 1997 | 258 |

Table 8: Lengths of first capture and median size of catch for two types of fishing gear and a range of codend mesh sizes.

| Net | Mesh Size (mm) | Location | Smallest Size Caught (mm TL) | Size at which 50% of Fish are Caught (mm TL) |
|---|---|---|---|---|
| Champion | 60 | Shell Bank | 250 | 307 |
| Champion | 60 | Plateau | 160 | 299 |
| Champion | 101 | Shell Bank | 260 | 289 |
| Champion | 101 | Plateau | 230 | 285 |
| Champion | 110 | Plateau | 220 | 285 |
| Gloria | 110 | Shell Bank | 240 | 288 |
| Gloria | 110 | Plateau | 230 | 291 |
| Gloria | 129 | Shell Bank | 240 | 287 |
| Gloria | 129 | Plateau | 220 | 282 |

Table 9: Input parameters for projections of the generalised yield model for *Champsocephalus gunnari* on the plateau at Heard Island.

| Category | Parameter | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| Age composition | Minimum age in stock<br>Maximum age (plus class)<br>Years in plus class | 2<br>6<br>5 | 2<br>6<br>5 | 2<br>6<br>5 | 2<br>6<br>5 |
| Times within year | Number of increments | 360 | 360 | 360 | 360 |
| Natural mortality | Mean annual M | 0.3–0.64 | 0.3–0.64 | 0.3–0.64 | 0.3–0.64 |
| Fishing mortality | Recruitment to fishery at age<br>Reasonable upper bound for annual fishing mortality<br>Tolerance (error) for determining fishing mortality in each year | 3<br>5.0<br>1E-05 | 3<br>5.0<br>1E-05 | 3<br>5.0<br>1E-05 | 2<br>5.0<br>1E-05 |
| Fishing season | | All year | All year | All year | All year |
| von Bertalanffy growth | Time 0<br>$L_\infty$<br>$K$ | 0.57<br>411 mm<br>0.410 | 0.57<br>411 mm<br>0.410 | 0.57<br>411 mm<br>0.410 | 0.57<br>411 mm<br>0.410 |
| Weight–length ($W = aL^b$) | $a$<br>$b$ | 2.629E-10<br>3.515 | 2.629E-10<br>3.515 | 2.629E-10<br>3.515 | 2.629E-10<br>3.515 |
| Spawning biomass | First age of maturity<br>Date when spawning occurs<br>Number of Increments in spawning season | 3.0 years<br>15 Sep<br>1 | 3.0 years<br>15 Sep<br>1 | 3.0 years<br>15 Sep<br>1 | 3.0 years<br>15 Sep<br>1 |
| Recruitment | Vector of recruitments (millions of fish) | 11.11, 3.46, 17.60, 0.527, 161.0, 15.7, 0.842, 1.42, 258.3, 279.4, 5.54 | 11.11, 3.46, 17.60, 0.527, 161.0, 15.7, 0.842, 1.42, 258.3, 279.4, 5.54 | | 11.11, 3.46, 17.60, 0.527, 161.0, 15.7, 0.842, 1.42, 258.3, 279.4, 5.54 |
| | Vector of standard errors associated with respective recruitments (millions of fish) | | 16.13, 5.34, 84.6, 0.325, 178.1, 13.2, 2.56, 1.72, 146.8, 64.7, 4.44 | | 16.13, 5.34, 84.6, 0.325, 178.1, 13.2, 2.56, 1.72, 146.8, 64.7, 4.44 |
| | $\text{Log}_e$-domain $\mu$<br>$\text{Log}_e$-domain standard error of $\mu$<br>$\text{Log}_e$-domain standard deviation<br>Proportion of median $SB_0$ when depletion begins to occur | | | 16.25117<br>0.641358<br>2.12714<br>0.0 | |
| Simulation characteristics | Number of runs to test each catch level<br>Replicates in formulating median $SB_0$ in each run<br>Years to project stock before start of projections<br>Vector of real catches for projecting over known catch period<br>Number of years to project stock following known catch period | 5001<br>5001<br>1<br>0<br>20 | 5001<br>5001<br>1<br>0<br>20 | 5001<br>5001<br>1<br>0<br>20 | 5001<br>5001<br>1<br>0<br>20 |
| Decision rules | Proportion of median $SB_0$ considered to be level of depletion | 0.2 | 0.2 | 0.2 | 0.2 |

Table 10: Input parameters for projections of the generalised yield model for *Champsocephalus gunnari* on Shell Bank at Heard Island.

| Category | Parameter | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| Age composition | Minimum age in stock<br>Maximum age (plus class)<br>Years in plus class | 2<br>6<br>5 | 2<br>6<br>5 | 2<br>6<br>5 | 2<br>6<br>5 |
| Times within year | Number of increments | 360 | 360 | 360 | 360 |
| Natural mortality | Mean annual M | 0.3–0.64 | 0.3–0.64 | 0.3–0.64 | 0.3–0.64 |
| Fishing mortality | Recruitment to fishery at age<br>Reasonable upper bound for annual fishing mortality<br>Tolerance (error) for determining fishing mortality in each year | 3<br>5.0<br>1E-05 | 3<br>5.0<br>1E-05 | 3<br>5.0<br>1E-05 | 2<br>5.0<br>1E-05 |
| Fishing season | | All year | All year | All year | All year |
| von Bertalanffy growth | Time 0<br>$L_\infty$<br>$K$ | 0.1698<br>391.64 mm<br>0.4474 | 0.1698<br>391.64 mm<br>0.4474 | 0.1698<br>391.64 mm<br>0.4474 | 0.1698<br>391.64 mm<br>0.4474 |
| Weight-length ($W = aL^b$) | $a$<br>$b$ | 2.629E-10<br>3.515 | 2.629E-10<br>3.515 | 2.629E-10<br>3.515 | 2.629E-10<br>3.515 |
| Spawning biomass | First age of maturity<br>Date when spawning occurs<br>Number of Increments in spawning season | 3.0 years<br>15 Apr<br>1 | 3.0 years<br>15 Apr<br>1 | 3.0 years<br>15 Apr<br>1 | 3.0 years<br>15 Apr<br>1 |
| Recruitment | Vector of recruitments (millions of fish) | 1.91, 0.64, 0.254, 0.0, 15.8, 0.012, 8.86, 0.0, 68.9, 0.025 | 1.91, 0.64, 0.254, 0.0, 15.8, 0.012, 8.86, 0.0, 68.9, 0.025 | | 1.91, 0.64, 0.254, 0.0, 15.8, 0.012, 8.86, 0.0, 68.9, 0.025 |
| | Vector of standard errors associated with respective recruitments (millions of fish) | | 1.30, 0.87, 53.9, 0.0, 36.6, 0.0, 10.68, 0.0, 51.7, 0.037 | | 1.30, 0.87, 53.9, 0.0, 36.6, 0.0, 10.68, 0.0, 51.7, 0.037 |
| | $\log_e$-domain $\mu$ | | | 15.23216 | |
| | $\log_e$-domain standard error of $\mu$ | | | 0.4121 | |
| | $\log_e$-domain standard deviation | | | 1.30328 | |
| | Proportion of median $SB_0$ when depletion begins to occur | 0.0 | 0.0 | 0.0 | |
| Simulation characteristics | Number of runs to test each catch level | 5 001 | 5 001 | 5 001 | 5 001 |
| | Replicates in formulating median $SB_0$ in each run | 5 001 | 5 001 | 5 001 | 5 001 |
| | Years to project stock before start of projections | 1 | 1 | 1 | 1 |
| | Vector of real catches for projecting over known catch period | 0 | 0 | 0 | 0 |
| | Number of years to project stock following known catch period | 20 | 20 | 20 | 20 |
| Decision rules | Proportion of median $SB_0$ considered to be level of depletion | 0.2 | 0.2 | 0.2 | 0.2 |

Table 11: The effects of different catch levels on escapement and probability of depletion of *Champsocephalus gunnari* at Heard Island.

| Area | Trial | | | Catch (tonnes) 0 | 100 | 150 | 175 | 200 | 225 | 250 | Yield (tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Plateau | 1 : | Recruitment – bootstrap; Age 3 selection | Escapement | 0.980 | | 0.957 | 0.954 | 0.950 | | | |
| | | | $p$(depletion) | 0.461 | | 0.502 | 0.510 | 0.519 | | | 178 |
| | 2 : | Recruitment – parametric bootstrap; Age 3 selection | Escapement | 0.981 | | 0.956 | 0.952 | 0.948 | | 0.940 | |
| | | | $p$(depletion) | 0.519 | | 0.560 | 0.568 | 0.573 | | 0.588 | 180 |
| | 3 : | Recruitment – lognormal; Age 3 selection | Escapement | 1.000 | 0.976 | | | | | | |
| | | | $p$(depletion) | 0.281 | 0.341 | | | | | | 83 |
| | 4 : | Recruitment – parametric bootstrap; Age 2 selection | Escapement | 0.981 | | | 0.944 | 0.941 | | 0.931 | |
| | | | $p$(depletion) | 0.519 | | | 0.568 | 0.574 | | 0.589 | 83 |
| | | | | 0 | 10 | 15 | 20 | 25 | | | Yield |
| Shell Bank | 1 : | Recruitment – bootstrap; Age 3 selection | Escapement | 1.000 | 0.984 | 0.978 | 0.969 | | | | |
| | | | $p$(depletion) | 0.543 | 0.574 | 0.587 | 0.601 | | | | 17 |
| | 2 : | Recruitment – parametric bootstrap; Age 3 selection | Escapement | 1.007 | | 0.979 | 0.969 | 0.956 | | | |
| | | | $p$(depletion) | 0.623 | | 0.664 | 0.679 | 0.691 | | | 18 |
| | 3 : | Recruitment – lognormal; Age 3 selection | Escapement | 1.007 | | 0.985 | 0.978 | 0.971 | | | |
| | | | $p$(depletion) | 0.020 | | 0.038 | 0.046 | 0.055 | | | >25 |
| | 4 : | Recruitment – parametric bootstrap; Age 2 selection | Escapement | 1.007 | | 0.978 | 0.965 | | | | |
| | | | $p$(depletion) | 0.623 | | 0.659 | 0.669 | | | | 22 |

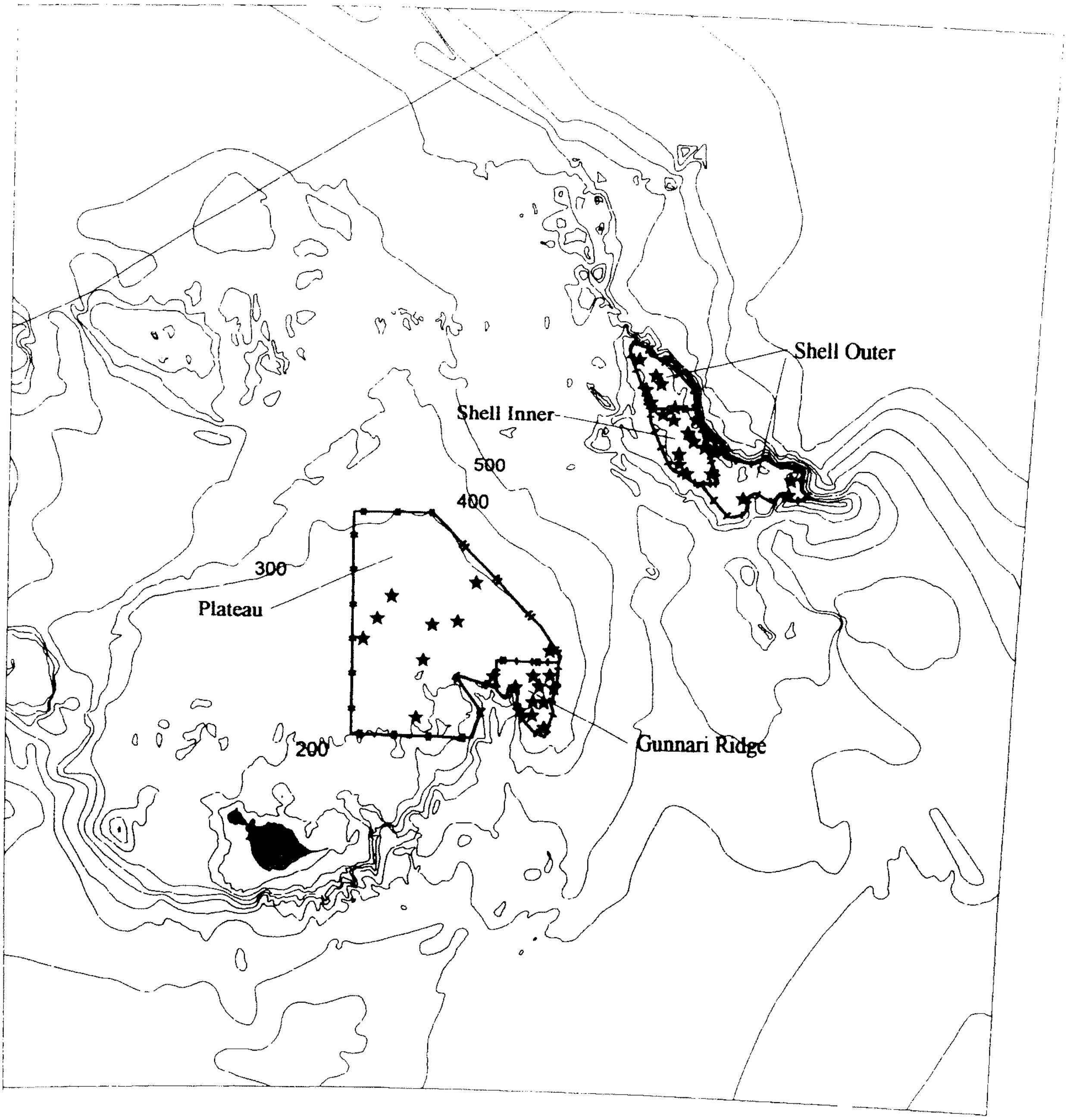


Figure 1: Chart showing the survey strata and station locations for the *Champsocephalus gunnari* survey conducted at Heard Island in August 1997.

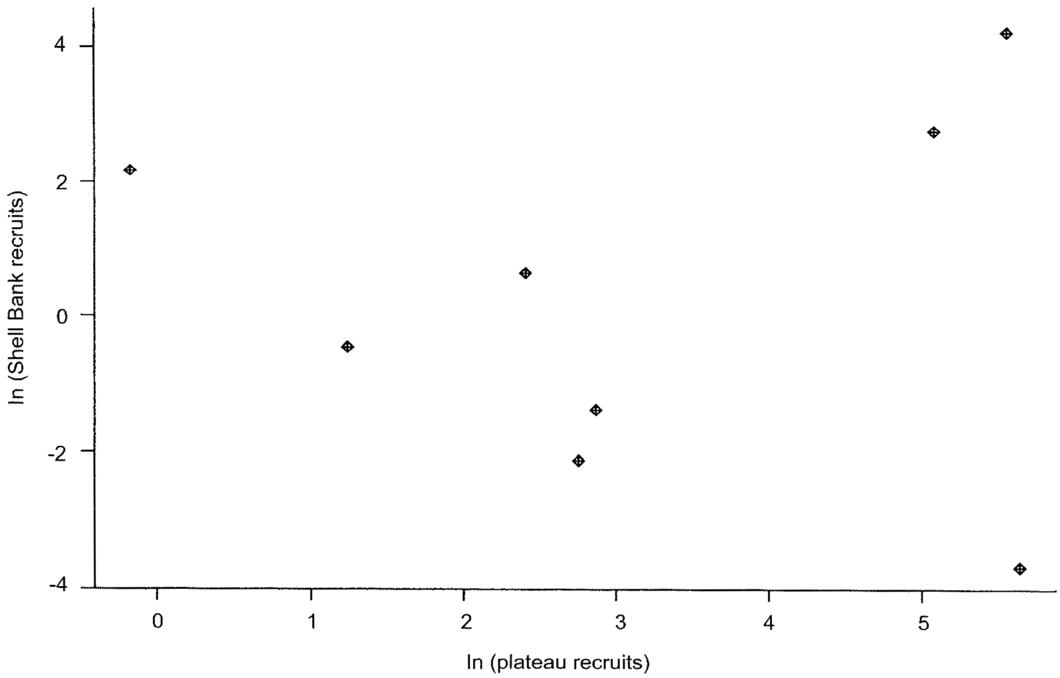


Figure 2: Scatterplot comparing the estimates of cohort abundance on the Heard Plateau and Shell Bank in the same years.

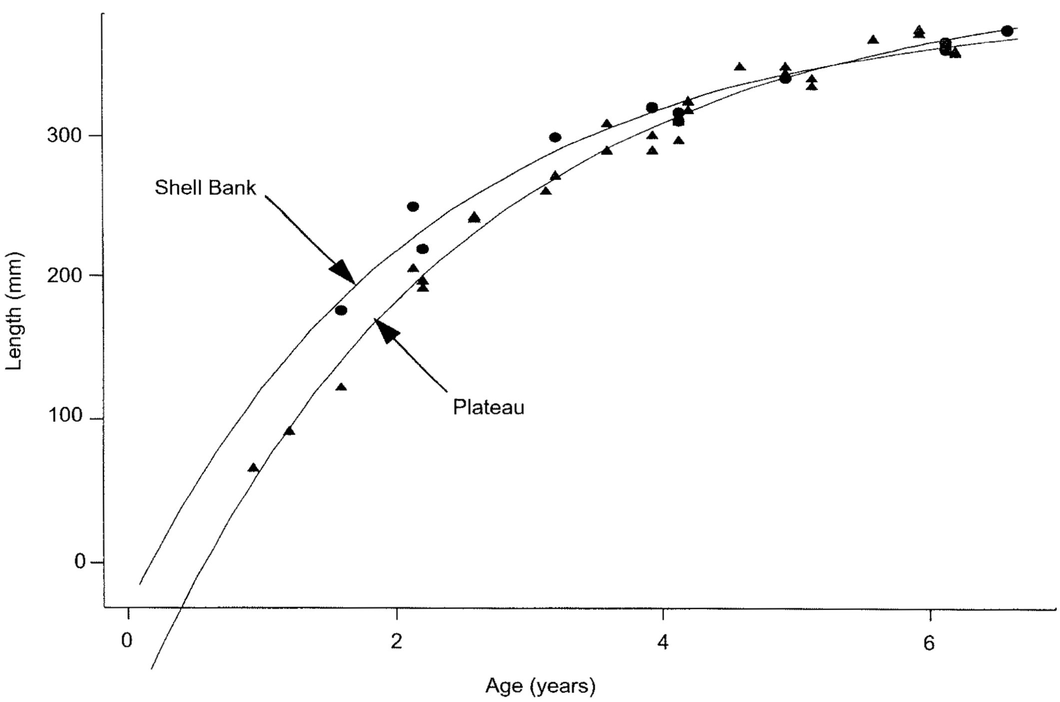


Figure 3: von Bertalanffy growth curves fitted to the length and age results derived from the length-density analyses for the Heard Plateau and for Shell Bank.

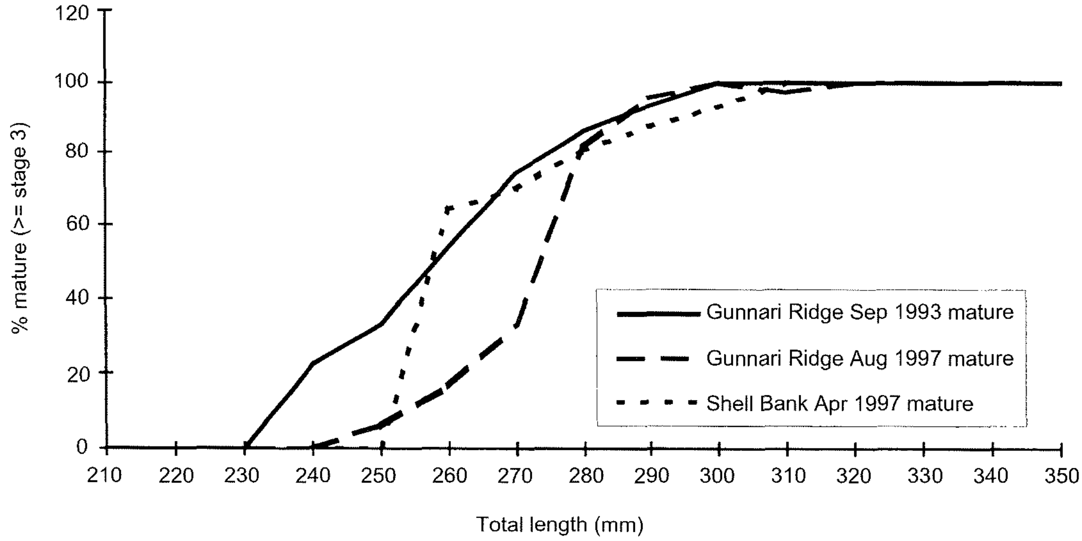


Figure 4: Proportions of fish mature at each length from several spawning seasons at Gunnari Ridge and Shell Bank.

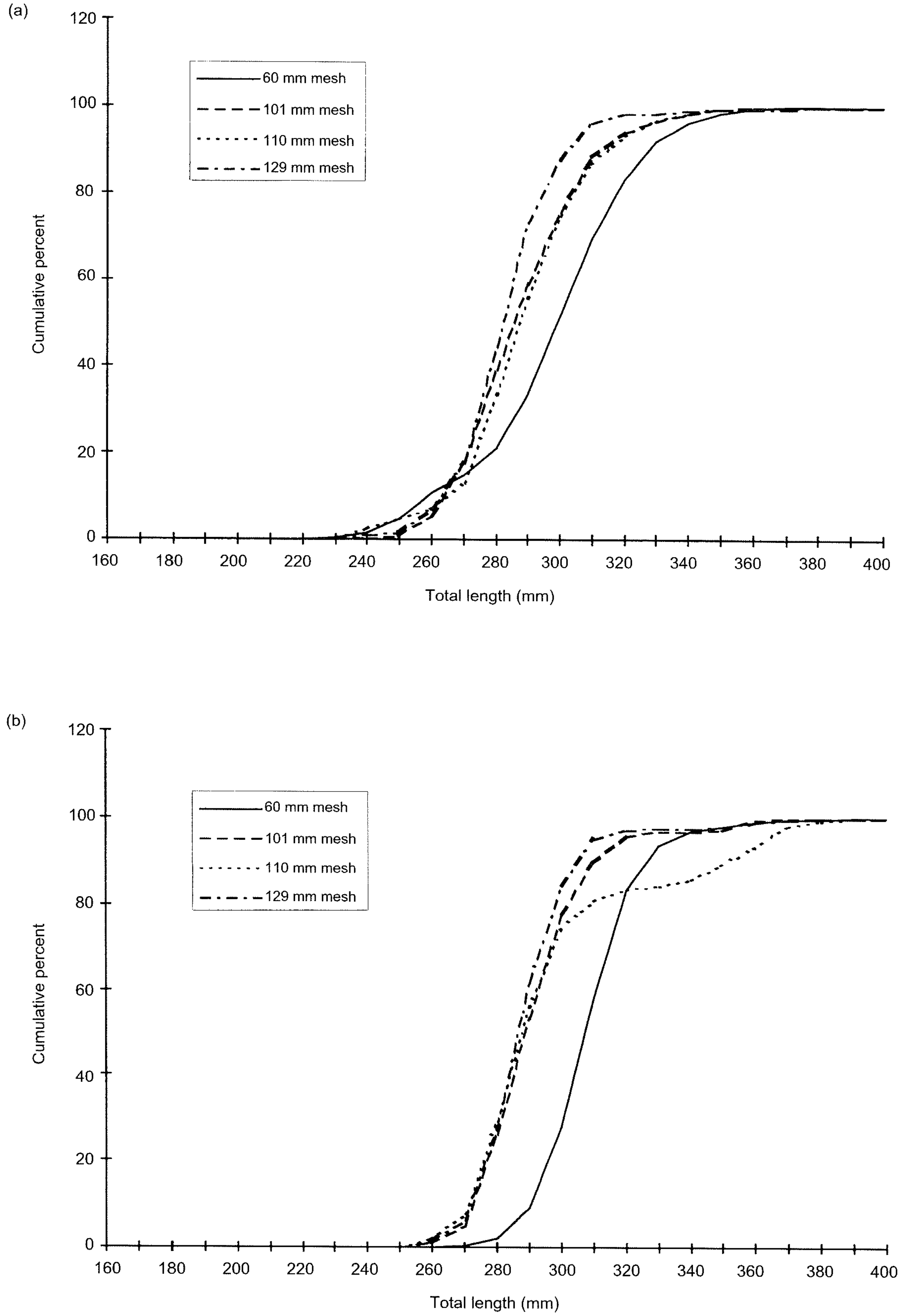


Figure 5: Cumulative length distribution of the catch for a range of codend mesh sizes on: (a) Gunnari Ridge; and (b) Shell Bank.

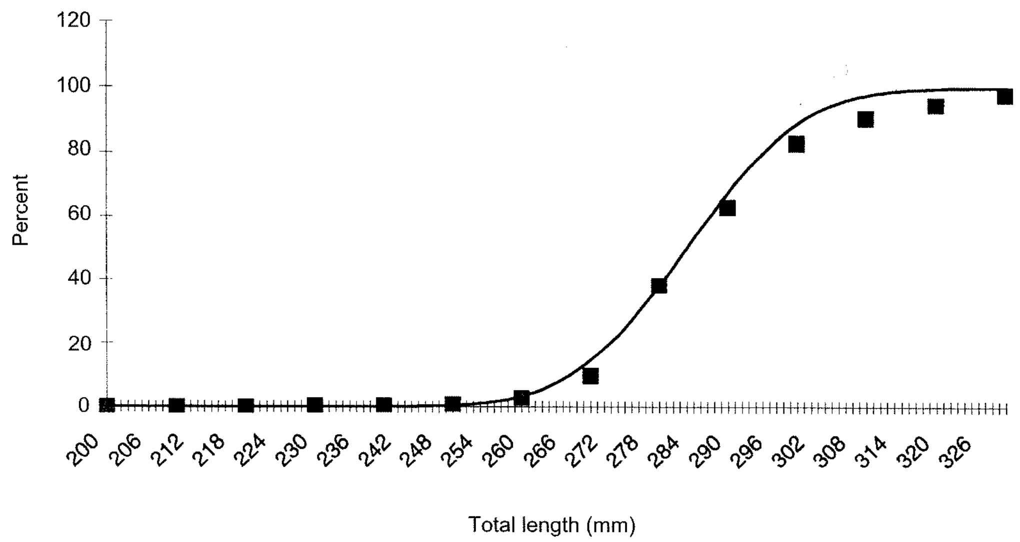


Figure 6: A comparison between the cumulative length distribution of the catch for the 'Gloria' net with a 110-mm mesh and the predicted cumulative length distribution of fish of age 3+.

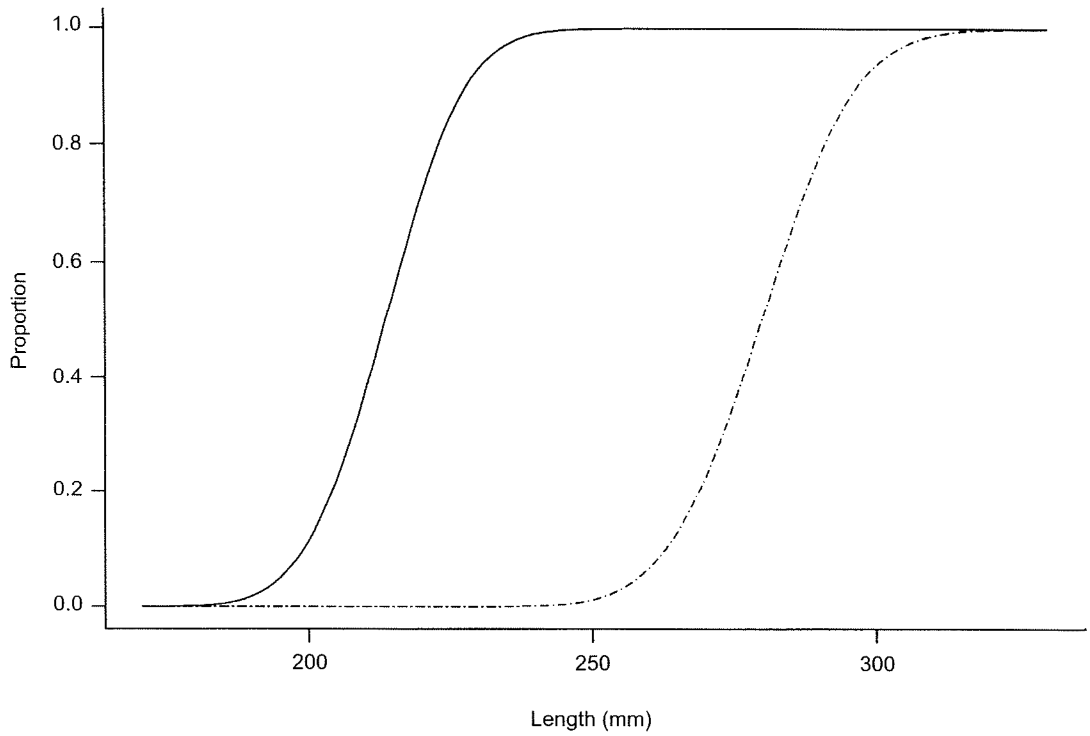


Figure 7: Cumulative length distributions of fish aged 2 (solid line) and 3 (dashed line) during the spawning season.

Liste des tableaux



Liste des figures

Список таблиц



Список рисунков

Lista de las tablas



Lista de las figuras

APPENDIX

## CHARACTERISTICS OF THE VESSEL AND GEAR USED IN THE HEARD ISLAND *CHAMPSOCEPHALUS GUNNARI* SURVEY

Description of vessel:

| | |
|---|---|
| Name | *Austral Leader* |
| Type | Factory stern trawler |
| Dimensions | 85.2 m LOA x 13.6 m breadth x 5.5 m draft |
| Tonnage | 2 154 gross, 646 net |
| Fishing winches | Electric/hydraulic self-tensioning with 2 x 3 000 m of 28 mm warp |
| Electronics | Marelec computer trawl winch control<br>Furuno CNIO net monitor<br>2 x netlinks – net position indicator<br>3 x Furuno colour sounders<br>2 x Furuno GPS and plotters |
| Fishing gear | 4 x 1 800 kg polyvalent trawl doors<br>4 x 'Champion' bottom trawl nets<br>37-m long headline<br>67-m ground line with 300-mm diameter bobbins<br>Sweep plus bridles, length 135 m<br>Horizontal opening ~ 22 m<br>Vertical opening ~7.5 m<br>Codend mesh size 60 mm, diamond meshes |