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ASPECTS OF THE BIOLOGY OF THE CAPE GURNARD, *CHELIDONICHTHYS CAPENSIS* (SCORPAENIFORMES: TRIGLIDAE) ON THE AGULHAS BANK, SOUTH AFRICA

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AGE AND GROWTH
REPRODUCTION
MATURITY
MORTALITY
CHELIDONICHTHYS CAPENSIS

ABSTRACT. – We present estimates of the population structure, reproduction, age, growth and mortality of the Cape gurnard, *Chelidonichthys capensis*, based on data from commercial and research trawls over the Agulhas Bank, South Africa. The mean total length for males (366 mm) was significantly smaller than that for females (411 mm). The sex ratio was close to parity with males being more dominant in commercial trawls, and less dominant in research trawls. Gonad maturation and gonadosomatic indices demonstrated that this species has an extended spawning period with peaks in reproductive activity during September, January and April. First approximations of size and age at 50% maturity revealed that the males matured at a younger age than the females, and at significantly smaller sizes (males: 299 mm TL/3.6 years; Females: 343 mm TL/4.6 years). Sagittal otolith growth marks were validated as annuli using marginal zone analysis. The maximum age estimated was 16 years for a female of 675 mm TL, and recruitment to the commercial fishery was estimated as taking place in the fifth year of growth for both males and females. First approximation of fishing mortality for the commercial trawl fishery (0.52 year^{-1}) was higher than that of the natural mortality (0.085 year^{-1}), and therefore indicates a degree of fishing pressure on this species on the Agulhas Bank.

AGE ET CROISSANCE
REPRODUCTION
MATURITÉ
MORTALITÉ
CHELIDONICHTHYS CAPENSIS

RÉSUMÉ. – La structure de la population, la reproduction, l'âge, la croissance et la mortalité de *Chelidonichthys capensis* à partir de données commerciales et d'échantillonnages scientifiques au chalut sur l'Agulhas Bank en Afrique du Sud sont présentées. La longueur totale moyenne des mâles (366 mm) est significativement inférieure à celle des femelles (411 mm). La sex-ratio est proche de la parité, avec les mâles plus nombreux dans les chalutages de pêche commerciale et moins dominants dans les chalutages scientifiques. La maturation des gonades et les indices gonadosomatiques montrent que cette espèce présente une période de ponte longue avec des maxima de l'activité reproductrice en septembre, janvier et avril. Les premières approximations de la taille et de l'âge à une maturité de 50 % révèlent que les mâles atteignent la maturité plus jeunes que les femelles, et à une taille significativement inférieure à celle des femelles (mâles : 299 mm TL/3,6 ans ; femelles : 343 mm TL/4,6 ans). La croissance en longueur de l'otolithe est étudiée en validant les stries de croissance observées dans la zone marginale. L'âge maximum estimé est de 16 ans pour les femelles à 675 mm TL, et le recrutement pour la pêche commerciale est estimé avoir lieu dans la 5^e année de croissance pour les deux sexes. La première approximation de la mortalité ($0,52 \text{ an}^{-1}$) due à la pêche commerciale au chalut est plus élevée que la mortalité naturelle ($0,085 \text{ an}^{-1}$), et indique ainsi une certaine pression de pêche de cette espèce sur l'Agulhas Bank.

INTRODUCTION

The Cape gurnard *Chelidonichthys capensis* is an endemic Southern African triglid species found on the continental shelf between the Orange and

Umfolozzi rivers (Van der Elst 1993). Gurnards represent a significant proportion of the by-catch reported from many of the offshore trawl and line fisheries in Southern Africa (Smale & Badenhorst 1991, Japp *et al.* 1994). Indeed, *C. capensis* is the largest and most frequently caught gurnard, and is

regarded by Van der Elst (1993) as one of the six most important fish trawled off the Eastern Cape coast. Nevertheless, to date the majority of the *C. capensis* caught is discarded with only the larger specimens retained and sold locally. While there may be the potential to establish a fishery based upon the Cape gurnard, credible management and marketing strategies need to be developed.

To date, the majority of the research undertaken on this species has focused on its distribution (MacPherson & Mas Riera 1987, Konchina 1989, Meyer & Smale 1991) and feeding biology (Hecht 1977, Konchina 1989); only Hecht (1977) has addressed age, growth and reproductive issues. While Hecht's (1977) study provides the basis for the development of a management strategy, the data sets are over twenty years old. Furthermore, the data originated from an area that has experienced a rapid increase in fishing effort over this period, thus comparisons between the parameter estimates from the two studies may provide useful indicators of the impacts that fishing has had on the resource. Thus, prior to the development of a management plan, there is clearly a necessity to investigate the current biological status of the species. With this in mind, this study was designed to investigate aspects of the life history of *C. capensis* such as the population structure, age, growth, mortality and reproductive biology.

MATERIALS AND METHODS

Sampling was undertaken between August 1995 and January 1997 on the Agulhas Bank between Port Alfred and Cape Agulhas (Fig. 1). Samples were obtained from either commercial inshore (75 mm stretched mesh) or research (25 mm stretched mesh) demersal otter trawls. Individual fish were weighed (1g), measured (total length to 1 mm) and sexed. The gonads were removed and weighed (0.01g). Gonadosomatic indices were calculated using the formula:

$$GSI = \frac{\text{gonad mass (g)} \times 100}{\text{whole body mass (g)}}$$

Each gonad was macroscopically examined, and a gonad maturation index (GMI) awarded according to the classification outlined in Table I. Gonads were used to determine the temporal variability in reproduction, and length and age at sexual maturity.

The GMI values were used to establish the size at sexual maturity by determining the proportion of reproductively active individuals (stages 2, 3 and 4) in each size class. In order to minimise bias, immature animals were excluded from the calculation. Thus, those animals displaying GMI values of 1 were excluded as they were classed as "virgin or resting". It should however be noted that the exclusion of GMI 1 animals from the calculation introduces a degree of bias as some of the animals will be mature, but in the "resting" reproductive stage. Furthermore, the exclusion of GMI 1 animals may also

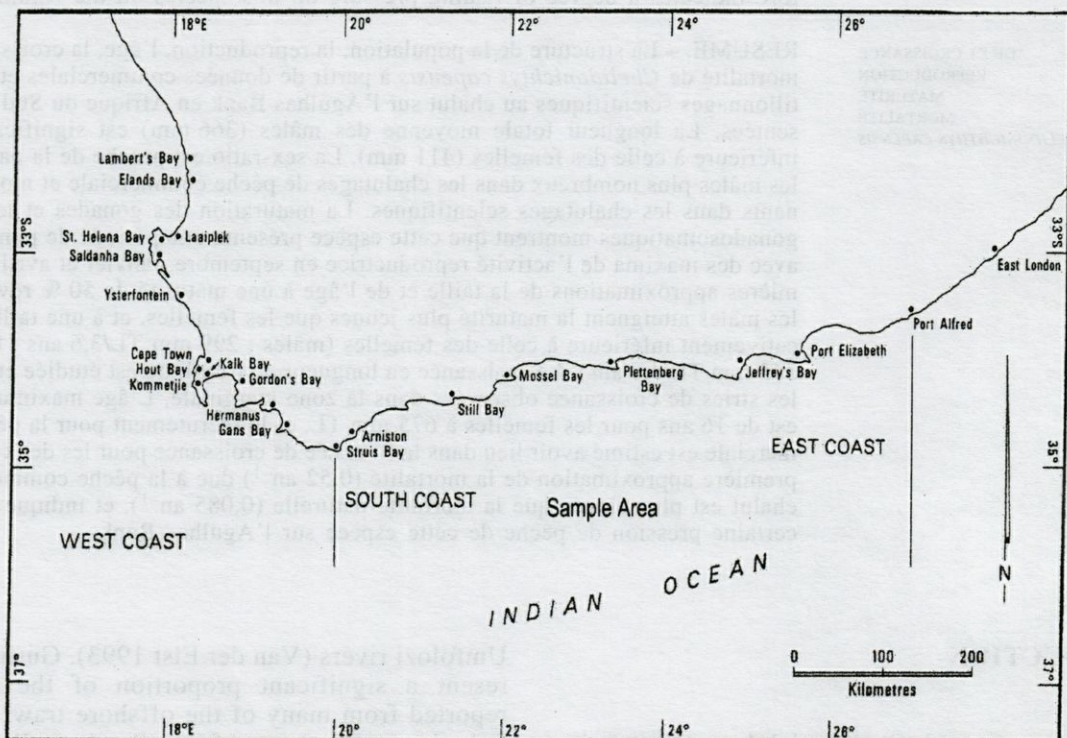


Fig. 1. – Map of the South African coast depicting the division area used for sampling by the Sea Fisheries Research Institute (Cape Town), and the position of the major commercial linefish landing ports.

Table I. – Classification of maturity stages for *Chelidonichthys capensis* (modified from Laevastu 1965, Nikolski 1978 and Buxton & Clarke 1986).

GMI	Stage	Description
1	Virgin and resting	Ovaries and testes small and lying close under the vertebral column. Testes thread-like, opaque and white. Ovaries pinkish and translucent. No eggs visible to the naked eye.
2	Developing	Gonads larger, especially on long axis, and blood vessels present. Testes pale opaque yellow-grey and thick. Ovaries red-orange with opaque eggs visible to the naked eye.
3	Ripe and running	Testes pinkish grey. Sperm runs freely out of sperm duct if pressure applied. Ovaries orange in colour, very large and swollen. Translucent eggs visible.
4	Spent	Testes hard with frilly appearance, pale pink in colour. Ovaries flaccid and much decreased in size, reddish orange and bloodshot.

cause bias as "slow developers" would be excluded from the analysis. Nevertheless, as the potential for bias from these sources may be considered minimal, they are unlikely to affect the L_{50} calculation. The GMI 1 animals were excluded from the sample by applying the following logistic ogive:

$$P_{(L)} = \frac{1}{1 + \exp^{-(L - L_{50})/\delta}}$$

where $P_{(L)}$ is the proportion of mature fish at size L , L_{50} is the length at which 50% of the sample was found to be mature, and δ is the width of the ogive. The data was fitted using Newton's non-linear minimisation procedure (Zar 1996). The average length at sexual maturity was taken as the size at which 50% of the population was mature (King 1995). A likelihood ratio test was used to test for differences in the ages of maturity between males and females when all the data were combined, and when research and commercial data were treated independently.

Sagittal otoliths were removed, cleaned and stored dry in paper envelopes. The left sagittae were lightly burnt over a methanol flame to enhance annuli checks. The otoliths were embedded in clear casting resin and sectioned through the nucleus to 0.2 – 0.5 mm using a double-bladed diamond edged saw. The sections were mounted on microscope slides using DPX mountant, and the annuli counted under transmitted light (Campana & Neilson 1985). Each otolith was read on three occasions at weekly intervals. If two out of the three values agreed, this estimate was taken as the age of the fish. If the values did not agree, but did not differ by more than two years, the mean was used, otherwise the otolith was rejected.

Length-weight relationships between male and female fish were compared using Analysis of Covariance (ANCOVA). Prior to analysis, the length-weight data was linearized using natural-log transformations. Tukeys' multiple range test was used to test for differences between slopes.

Growth curves were fitted (least squares) to the length-at-age data using the 3 parameter Von Bertalanffy growth model:

$$L_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

where L_t is the length at time t . L_{∞} is the predicted asymptotic length. K is a measure of the rate at which the length L approaches L_{∞} , t is the age, and t_0 is the age at zero length (Ricker 1975). Growth was modelled for males, females and pooled data. The best fit was obtained by minimising the squared differences between the observed and fitted data using the absolute-error model (Punt & Butterworth 1993). Von Bertalanffy parameter estimates were determined using Newton's non-linear minimisation procedure (Zar 1996). A likelihood ratio test was used to determine whether there was a difference between the growth models that had been fitted to male and female data sets (Draper & Smith 1966).

Length frequency data was transformed to age frequency distributions using an age-length key (Butterworth *et al.* 1989). Age at recruitment was estimated by fitting a logistic ogive – using non-linear minimisation of the residual sum of squares – to the percentage cumulative age frequency data. The logistic was described by the equation:

$$P_{(L)} = \frac{1}{1 + \exp^{-(L - L_{50})/\delta}}$$

where $P_{(L)}$ is the proportion of recruited fish at size L . L_{50} is the estimated length at 50% recruitment, and δ is the width of the ogive. Age at recruitment was taken as the age at which 50% of the population was recruited to the fishery (Punt & Japp 1995). A likelihood ratio test was used to establish differences in the ages of recruitment between the males and females.

First approximations of the total annual mortality (Z) were obtained from the generated catch curves (Butterworth *et al.* 1989). The negative of the slope of the linear regression line, fitted to points greater than the age at full recruitment, provided an estimation of Z (King 1995). Analysis of Covariance was used to test for differences between the regression slopes. Natural mortality

Table II. – Top, mean observed total lengths (mean \pm std.), maximal total lengths and weights of *Chelidonichthys capensis* on the Agulhas Bank. Bottom, growth parameters of the von Bertalanffy growth equation as determined by non-linear minimisation of the residual sum of squares for *C. capensis*, including the parameter ϕ' , sampled on the Agulhas Bank from August 1995 to January 1997.

Group	Total Length (mm)	Maximum Total Length (mm)	Maximum Wet Weight (g)	n
Females				
Total	396 \pm 103	676	3300	821
Research	391 \pm 134	676	3300	386
Commercial	417 \pm 77	625	2835	362
Males				
Total	360 \pm 78	582	1100	766
Research	367 \pm 79	581	1100	462
Commercial	361 \pm 86	582	1061	262

Group	L_{∞}	K	t_0	ϕ'	n	Age range
Males	754.94	0.084	-2.527	6.17	144	1-12
Females	803.38	0.104	-1.619	6.51	239	1-16
All	894.23	0.079	-2.043	6.45	383	1-16

(M) was estimated from Pauly's (1980) empirical model. For this calculation, the mean annual seawater temperature ($^{\circ}\text{C}$ at which the species lives), and the L and K parameters from the Von Bertalanffy equation were employed. The mean annual seawater temperature was taken as 12°C (Schumann & Beekman 1984). Fishing mortality (F) was obtained by substitution ($F = Z - M$). It was noted that Pauly's (1980) empirical formula for estimating natural mortality (M) falls into the realms of "qualified guesses". Inherent in the formula are the assumptions that the ambient water temperatures are high, and that small fish and those with fast growth rates experience high mortalities. In addition, processes influencing M such as reproductive physiology, predation and scho-

oling behaviour, are regarded as "random noise about the regression line". As such, these processes may lead to biased estimates for those species in which they play an important role. Thus, while Pauly's equation has been shown to provide realistic mortality estimates for long-lived species (Buxton 1987), a second method, that of Rikhter and Efanov (1977) was also used to estimate M:

$$M = \frac{1521}{tm^{0.72}} - 0.155 \text{ yr}^{-1}$$

where $tm^{0.72}$ is the age at which 50% of the population is mature.

RESULTS

Population structure

Size frequency distributions for males and females were found to be significantly different (student *t*-test, $P < 0.001$) (Fig. 2). Mean and maximum lengths are presented in Table II. Males were found to be smaller than females (student *t*-test, $P < 0.001$). The mean size of females in the commercial landings (417 mm) was higher (student *t*-test, $P < 0.05$) than that from the research catches (319 mm), but there was no difference in the sizes of males caught from the two sampling regimes (student *t*-test, $P > 0.05$). Male/female sex ratios of 1:0.9 and 1:1.43 were observed in the commercial and research trawls respectively.

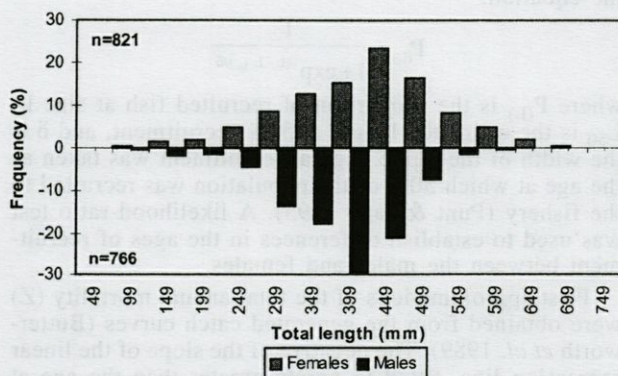


Fig. 2. – Size frequency histograms of male and female *C. capensis* sampled on the Agulhas Bank, South Africa.

Age and growth

The results of the length weight relationships are presented in Fig. 3. As a function of length, there was no difference between the slopes of the male and female weight regression models ($F = 2.892$, $d.f = 2, 1334$, $P > 0.05$). In both cases, the value of b was approximately 3.

Marginal zone analysis provided indirect evidence that hyaline and opaque zones are deposited annually. Hyaline zone formation occurred from September to March and opaque zone deposition from March to August. Of the 382 otoliths analysed, 31 (8%) were rejected as unreadable. The remaining otoliths were used to construct an age-length key. The data from the key were used to estimate growth parameters using the von Bertalanffy growth equation. The parameter values that were applied to the equation were calculated from combined, research and commercial data, and separately for males and females (Table II). In order to compare overall growth performance it was necessary to compare the parameters K and L_{∞} . However, as these parameters are statistically dependent, an additional index – phi prime (ϕ') (Pauly & Munro 1984) – was required. Phi prime (ϕ') was calculated using the formula:

$$\phi' = 2 \ln L_{\infty} + \ln K$$

The higher the ϕ' values, the larger the maximum size attained and the faster the growth rate.

Growth curves corresponding to the growth equations for each sex are shown in Figure 4. A likelihood ratio test established that there were differences between male and female growth models ($F = 38.58$, $d.f. = 3, 376$, $P < 0.05$). Mean observed and calculated length-at-age figures are presented in Table III.

Size at maturity

The observed and expected proportions of mature male and females plotted against length are presented in Fig. 4. Estimated total length and age at 50% maturity (L_{50} and t_m respectively) are presented in Table IV for males and females. A likelihood ratio test revealed that in comparison with the females, the males matured at significantly smaller lengths and at younger ages ($F = 5.32$, $d.f. = 2, 32$, $P < 0.05$; females: 343 mm TL/4.6 years; males: 299 mm TL/3.6 years). The rates of maturation (δ) for both males and females were similar (2.12 and 2.04 year⁻¹ respectively).

Age at recruitment and mortality estimations

Age frequency distributions derived from the normalised catch length frequency data, the esti-

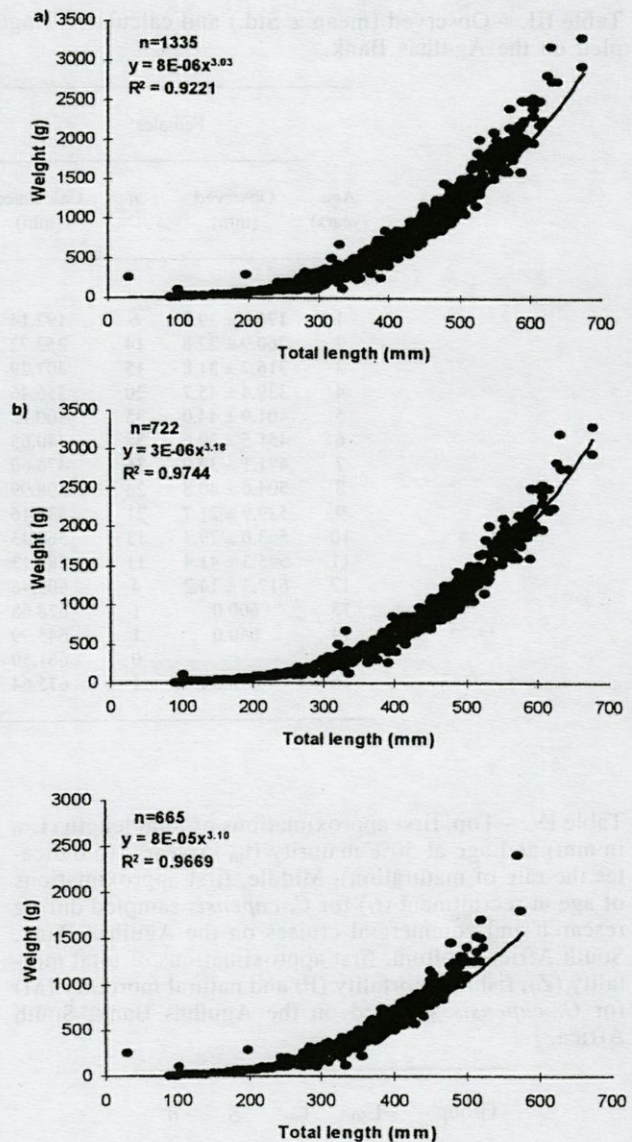


Fig. 3. – Length weight relationship for *C. capensis* sampled on the Agulhas Bank, South Africa. a, all samples; b, females; c, males.

mated age-at-recruitment and catch curves are presented in Fig. 5. The modal age for both males and females was 5 years. The estimated ages at recruitment to fishery for males and females were 4.9 and 5.2 years respectively (Table IV). The age at recruitment for females (5.2) was significantly higher than that observed in the males (4.9) ($F = 19.31$, $d.f. = 2, 52$, $P > 0.05$). First approximations of total mortality (Z), fishing mortality (F) and natural mortality (M) are presented in Table IV (bottom). While the estimates of Z and F are similar for both males and females, the estimates for M were higher for the females than for males.

Table III. – Observed (mean \pm Std.) and calculated length-at-age for female and male *Chelidonichthys capensis* sampled on the Agulhas Bank.

Age (years)	Females			Males		
	Observed (mm)	n	Calculated (mm)	Observed (mm)	n	Calculated (mm)
1	176.3 \pm 39.8	6	192.14	175.0 \pm 32.9	7	195.00
2	260.9 \pm 22.8	14	252.72	255.9 \pm 30.0	11	238.50
3	316.7 \pm 31.8	15	307.29	284.0 \pm 26.5	8	279.09
4	339.4 \pm 45.7	20	356.46	318.9 \pm 38.9	27	316.94
5	401.9 \pm 44.0	35	400.75	356.1 \pm 36.2	32	352.26
6	451.5 \pm 39.6	35	440.65	384.9 \pm 26.8	27	385.20
7	471.1 \pm 37.9	36	476.60	408.5 \pm 29.0	12	415.93
8	504.0 \pm 40.8	26	508.99	456.0 \pm 40.2	6	444.60
9	539.9 \pm 21.7	21	538.16	454.7 \pm 5.7	3	471.34
10	563.0 \pm 29.4	13	564.45	492.3 \pm 26.2	6	496.29
11	595.3 \pm 41.4	11	588.13	513.0 \pm 12.1	3	519.56
12	617.3 \pm 14.2	4	609.46	550.5 \pm 44.6	2	541.27
13	600.0	1	628.68			
14	640.0	1	645.99			
15	-	0	661.59			
16	675.0	1	675.64			

Table IV. – Top, first approximations of total length (L_{50} in mm) and age at 50% maturity (t_m in years) (δ indicates the rate of maturation). Middle, first approximations of age at recruitment (t_r) for *C. capensis* sampled during research and commercial cruises on the Agulhas Bank, South Africa. Bottom, first approximations of total mortality (Z), fishing mortality (F) and natural mortality (M) for *C. capensis* sampled on the Agulhas Bank, South Africa.

Group	L_{50}	t_m	δ	n
Males	299	3.6	2.12	632
Females	343	4.6	2.04	692

Group	t_r	δ	n
Males	4.9	1.076	683
Females	5.2	1.462	744

Group	Z	log M	M	F
Pooled	0.56	-1.07	0.085	0.52
Males	0.53	-1.01	0.097	0.44
Females	0.54	-0.96	0.110	0.43

Reproductive biology

Changes in gonad maturation indices and the seasonal variations in these indices are presented in Fig. 6-7 (Fig. 6 and 7 (top) for males; Fig. 6 and 7 (bottom) for females). Peaks in the numbers of spent females occurred in November 1995, March and May 1996, and from October 1996 to January 1997 (Fig. 6, bottom). Peaks in the GSI values occurred just before these periods (Fig. 7, bottom), and therefore indicate the periods during which the females were spawning. A similar picture emerges for the males (Fig. 6,7). Thus, peaks in the numbers of spent males are preceded by peaks in GSI values (Fig. 7, top). Male GSI values were considerably lower than those calculated for the females. A Multiple comparison of mean monthly gonadosomatic indices using Tukey's multiple range analysis (95% confidence), suggests an extended spawning period with peaks of reproductive activity in August, September and January.

DISCUSSION

The von Bertalanffy parameter estimates derived for *C. capensis* suggest that in common with other triglid species (McEachran & Davis 1970, Elder 1976, Hecht 1977, Papaconstantinou 1984, Booth 1997), *C. capensis* is relatively long-lived and fast growing. Indeed, the oldest fish recorded was a

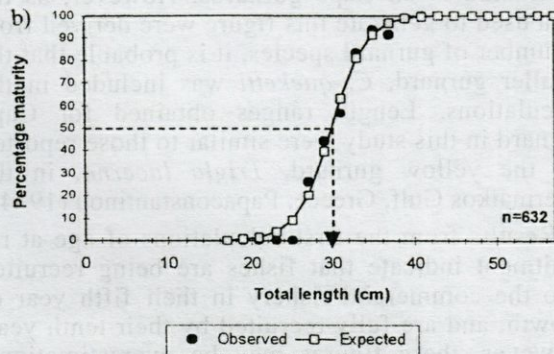
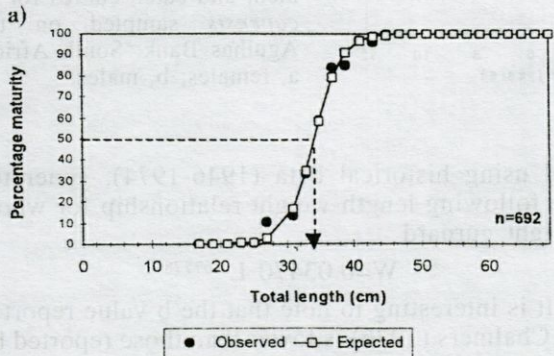
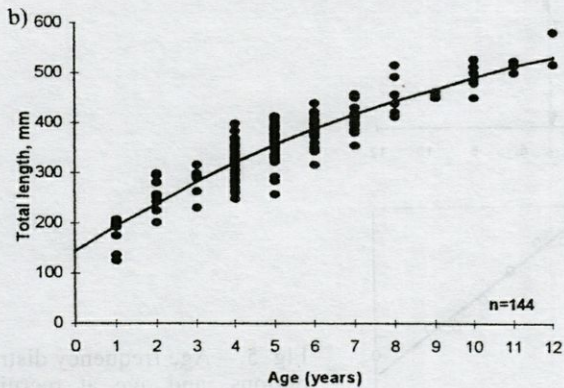
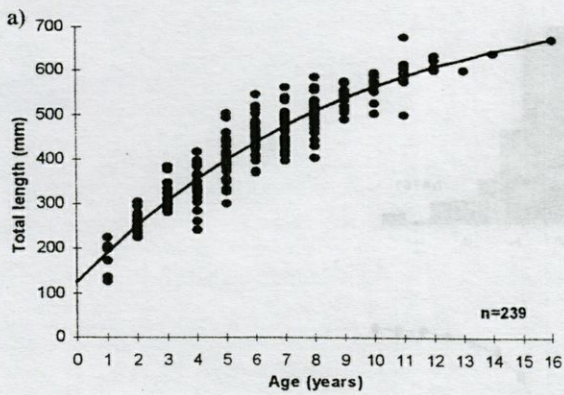


Fig. 4. – Top, growth curve fitted using the von Bertalanffy growth model for *C. capensis* sampled on the Agulhas Bank. a, females; b, males. Bottom, percentage frequency of mature *C. capensis* in different length classes sampled on the Agulhas Bank, South Africa. The curve was fitted using a 2-parameter logistic ogive. a, females; b, males.

16 years old female. As large Brody growth coefficients (K) generally indicate a fast growth rate, it was established that the females grew at a faster rate ($K = 0.104$) than the males ($K = 0.084$). A similar result was reported by Hecht (1976). Nevertheless, as K values are dependant upon the maximal asymptotic length, growth rate comparisons between populations, stocks or species cannot be interpreted independently (Pauly & Munro 1984). Thus, valid comparisons may only be undertaken once the growth performance index phi prime (ϕ') has been applied. A comparison of the phi prime values generated for both male and female fish confirmed the initial finding and established that, in contrast to *C. queketti* (Booth 1997), the females grew at a significantly faster rate than the males ($\phi' = 6.51$ and $\phi' = 6.17$ respectively).

The Cape gurnard is one of the larger gurnard species. The largest male and female recorded in this study were 582 and 676 mm TL respectively. These lengths are not inconsistent with either those previously recorded by Hecht (1976) (514 and 612 mm TL for males and females respectively), or those recorded by Bianchi *et al* (1993) and Smith & Heemstra (1986) (750 and 700 mm TL respectively). Sexual dimorphism is common amongst the larger triglids, and has previously been reported for *C. capensis* (Hecht 1976, Trunov & Maelvany 1974), *C. kumu* (Elder 1976), *Trigla lucerna*, *Eutrigla gurnardus* and *Aspitrigla cuculus* (Baron 1985). In all cases, females were larger than males.

Inclusion of all the available age data generated unrealistically large L_{∞} values (female – 803; male – 759), and illustrates one of the difficulties associated with fitting Von Bertalanffy growth models to data sets that are deficient in individuals at the extremes of their size range. Small fish are often under-sampled by the fishing gear, whereas samples from heavily exploited populations may underestimate the larger size classes of fish. As a result, the L_{∞} values that relate to the extreme upper limits of the growth curve represent extrapolations beyond the range of the sampled data. The same holds true for t_0 values. Commercial data obtained by Hecht (1977) generated more realistic values. Thus, it may be more appropriate to use L_{∞} values of 702 mm TL for all fishes combined, and 714 and 586 mm TL for females and males respectively. The values of t_0 in this study were closer to zero, ranging between -0.086 and -0.413 .

Analysis of Covariance revealed no significant difference in the length/weight relationship between males and females. Thus, as male and female growth (length and mass) was proportionally equivalent, the data can be pooled for use in stock assessment models. Hecht (1977) reported a value of 3.0151 for b in the length/weight equation, a value not dissimilar to that obtained in this study (3.0271). Chalmers (1976) studied weight conversion factors of several South African trawl species,

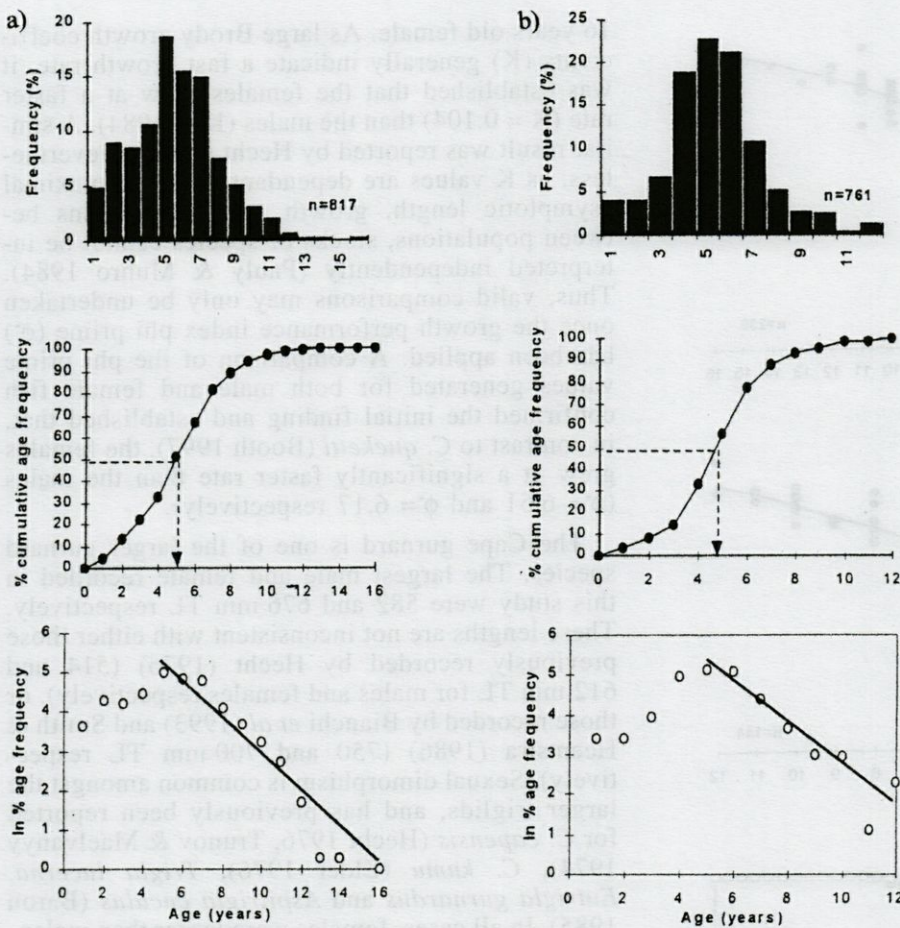
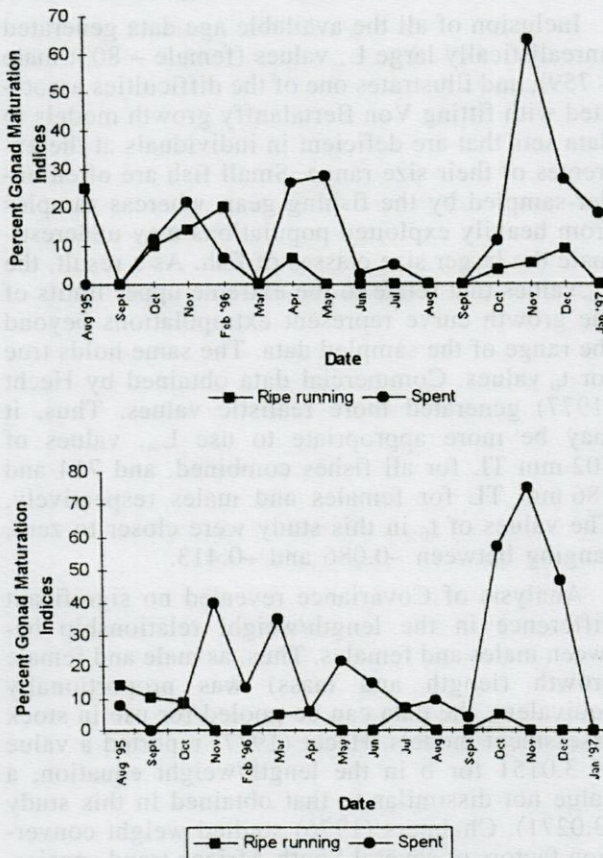


Fig. 5. – Age frequency distributions, and age at recruitment and catch curves for *C. capensis* sampled on the Agulhas Bank, South Africa. a, females; b, males.



and using historical data (1946-1974), generated the following length-weight relationship for whole weight gurnard

$$W=0.03470 L^{2.67778}$$

It is interesting to note that the b value reported by Chalmers (1976) is lower than those reported by other studies on Cape gurnards. However, as the data used to generate this figure were derived from a number of gurnard species, it is probable that the smaller gurnard, *C. queketti* was included in the calculations. Length ranges obtained for Cape gurnard in this study were similar to those reported for the yellow gurnard, *Trigla lucerna*, in the Thermaikos Gulf, Greece, Papaconstantinou (1984).

Results from the first calculations of age at recruitment indicate that fishes are being recruited into the commercial fishery in their fifth year of growth, and are fully recruited by their tenth year. However, these figures may be overestimations. The commercial data employed in this study refers

Fig. 6. – Monthly frequency distribution of the testes (top) and of the ovaries (bottom) of *C. capensis* in the ripe running and spent stages on the Agulhas Bank, South Africa.

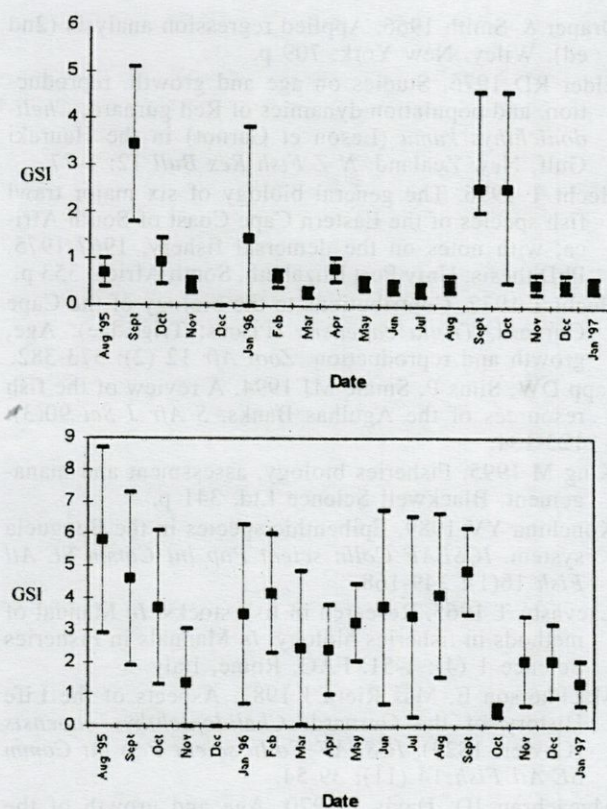


Fig. 7. – Mean monthly gonadosomatic indices (GSI) for male (top) and female (bottom) *C. capensis* sampled on the Agulhas Bank, South Africa. The error bars represent 1 standard error and deviation.

to landings and not catches. Fisheries observer data (Hart, unpubl data) has indicated that 29% of the gurnard catch is discarded at sea. Furthermore, as these fish do not command a high retail price, it is not unreasonable to assume that the smaller fish are selectively discarded. Thus, while further investigation is required, it is probable that the animals are being recruited to the fishery at an earlier age than this study would suggest.

The fishing mortality estimate (0.52 year^{-1}) for the pooled data was higher than the natural mortality estimate (0.085 year^{-1}), and therefore indicates that there is fishing pressure on *C. capensis* on the Agulhas bank. The total (0.56 year^{-1}) and natural mortality estimates (0.085 year^{-1}) for the pooled data recorded in this study were lower than those values obtained by Booth (1997) for *C. queketti* (0.73 and 0.38 year^{-1} respectively).

Male/female sex ratios of 1:0.9 and 1:1.4 were observed in the commercial and research data respectively. Similar sex ratios (approx. 1:1) are not uncommon in many fish species (Nikolsky 1978), and have been reported for other gurnard species (Elder 1976, Booth 1997). Hecht (1977) reported a

male/female sex ratio of 1:1.28 for Cape gurnard sampled from commercial trawlers on the east coast of South Africa, the results from the current study suggest that fewer females are now present in the population. The change in the observed sex ratio could be an indication of increased fishing pressure that has selectively targeted the larger females. Alternatively, it could be the result of discard practices in which the cut-off size of discarded fish creates a change in the sex ratios of the retained catches.

The gonad maturation indices suggest that the *C. capensis* has an extended reproductive season. Peaks of reproductive activity were observed during January/February and August/September. A result confirmed by egg and larval distribution studies undertaken at Tsitsikamma National Park, that have demonstrated that the number of *C. capensis* larvae are highest during February, August and October – months directly following those of peak reproductive activity observed in this study (Wood, Rhodes University, pers. comm.). An extended spawning period is common amongst gurnards, and has previously been reported in *C. capensis* (Hecht 1977). In common with many species (Baylis 1981), male gonadosomatic indices were considerably lower than those of the females, and thus indicate that with respect to energetic investment, the males reproductive effort is lower than the females. With respect to the males, the combination of faster growth and reproductive effort associated with the females is difficult to reconcile. It is probable that there are sex specific energetic costs that are associated with the males. For example, the males may have to expend considerable energy maintaining a territory. However, such issues were beyond the scope of this study, and therefore require further investigation.

Generally, Triglid males mature at a younger age and smaller size than their female counterparts (Baron 1985, Papaconstantinou 1984). *C. capensis* was no exception with males and females maturing at 299 mm (3.6 yrs) and 343 mm TL (4.6 yrs) respectively. Nevertheless, Hecht (1977) reported 50% maturity at 340 mm TL (4 yrs) and 305 mm TL (3yrs) for males and females respectively. Although the ages at maturity are similar, the female length at maturity reported in this study (343 mm) was considerably higher than that reported by Hecht (1977). In contrast, the male length at maturity reported in this study (299 mm) was considerably lower than that reported by Hecht (1977). Changes in the relative lengths at maturity may be attributed to a number of factors such as selective targeting, or alternatively, increases in fishing pressures precipitating a reduction in the biomass; and consequently promoting alterations in the density dependent pressures such as intraspecific competition for food. Increases in food availability may alter growth and maturation rates as more resources

become available for somatic and reproductive development. The maturation rates (δ) for the females (2.04 year^{-1}) and males (2.12 year^{-1}) indicated that there was little difference in the rates of maturation between the sexes.

In conclusion, the results of this study demonstrate that *Chelidonichthys capensis* is a long-lived, fast growing, r-selected generalist species with an extended reproductive season and correspondingly high reproductive rate. It is small at first breeding, and has a sex ratio of almost unity. The current levels of fishing do not appear to be negatively impacting the resource, and thus the potential to develop a fishery based on this species is promising. In particular, incorporation into the by-catch management plan that is currently being formulated for the South African fishing industry will promote the sustainable exploitation of this species.

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