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Growth and mortality parameters of *Pagellus bellottii* (sparidae) in the Cape Coast area of Ghana

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ABSTRACT

Estimates of the growth and mortality parameters of the red pandora, *Pagellus bellottii,* in the Cape Coast area were obtained from length-frequency data compiled over two years (November 1993 to October 1995) using the ELEFAN computer programmes. The asymptotic length (L_{∞}) was estimated at 34.2 cm total length, and the growth constant (K) as 0.53yr^{-1}; the total mortality (Z), natural mortality (M) and fishing mortality (F) were determined as 3.74yr^{-1}, 1.12yr^{-1} and 2.61yr^{-1}, respectively. Over exploitation of the stock is suggested by the calculated exploitation ratio (E) of 0.7.

1. Introduction

Fishes of the family sparidae, otherwise known as the red fish, are very important group of demersal fish, in terms of their commercial value, in Ghana. Sparids run second in value only to shrimps (Ofori-Adu, 1989).. *Pagellus bellottii* (Steindachner) ranks very high among the sparids in relative abundance (Ministry of Food and Agriculture, 1995). The species has wide distribution in the Eastern Atlantic (Peraltay and Martos, 1993; Santos, *et al.,* 1995), indicating its adaptability to wide environmental conditions.

P. bellottii is usually fished with bated hooks and, on the fishing grounds, the best yields are obtained between 15 and 100 m depth (Rijavec, 1973; Ofori-Adu, 1989; Schneider, 1990). The young usually inhabit shallow waters and are occasionally caught in beach seines along with juveniles of other sparids. This fish reportedly occurs on various substrata although it is more abundant on hard deposits up to a depth of about 250 m (Rijavec, 1973). *P. bellottii* attains a size up to 40 cm but common to 20 cm (Schneider, 1990). In Ghana the fish attains up to 34 cm total length (Williams, 1968). Total length estimate of the species by Koranteng and Pitcher (1987) however stood at 28.6 cm asymptotic fork length. Available information indicates that catches of the species have consistently declined over the years in Ghanaian waters. For example, in 1981 the total production of the species was 6.2% of the total marine fish catch (Mensah and Koranteng, 1988) but now it is barely 2% (Ministry of Food and Agriculture, 1995). Within the Cape Coast area *P. bellottii* is actively exploited and is a target species for both artisanal and semi-industrial fishers. The object of this study is to provide growth and mortality parameters of the species in the Cape Coast-Elmina and surrounding marine waters and assess the level of exploitation of the species. It is hoped that the estimates would provide a baseline for the optimum exploitation of the species in the area.

2. Materials and methods

2.1 Fish samples and data collection

Samples of the red pandora *P. bellottii* were taken from the landings of the commercial fishery at the Elmina Fishing Harbour from November 1992 to October 1995. The samples were sent to the laboratory, and for each specimen the total length (TL) to the nearest 0.1 cm and the body weight (BW) to the nearest 0.01g were determined. The sea surface temperature of the study area was obtained from the Fisheries

Department of the Ministry of Food and Agriculture and the mean determined.

2.2 Analysis of the length-frequency data

Estimates of the asymptotic length and growth constant of the von Bertlanffy growth function were obtained from the monthly lenth-frequency data using the Electronic Length-Frequency Analysis (ELEFAN) computer programmes (Gayanilo, *et al.*, 1989). The theoretical age at which the length of fish is zero (t_o) was derived from the formula:

$$\log_{10}(-t_o) = 0.39922 - 0.2752 \log 20\, L_{oo} - \log_{10} K$$

(Pauly, 1983b), where L_{oo} is the asymptotic length and K is the growth constant. The growth performance index ($\varnothing'$) was estimated from the relationship (Pauly and Munro, 1984):

$$\varnothing' = \log_{10}K + 2\log_{10}L_{oo}$$

The index is used to compare the overall growth activity of fish species exhibiting similar shapes, and is therefore species specific and gives a reliable evaluation of growth characteristics of fish (Moreau, *et al.*, 1986).

The total mortality coefficient (Z) was estimated from the catch curve (see Sparre, *et al.*, 1989; Sparre and Venema, 1992), and the coefficient of natural mortality (M) derived from the mean sea surface annual temperature in degree Celsius based on the relationship (Pauly, 1980):

$$\log_{10} M = 0.0066 - 0.279 \log_{10} L_{oo} + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$

The fishing mortality coefficient was based on the equation (Ricker, 1975):

$$F = Z - M$$

2.3 Yield-per-recruit analysis and seasonal recruitment pattern.

Estimates of the optimum level of exploitation was based on the relative yield-per recruitment model of Beverton and Holt (1966) as modified by Pauly and Soriiano (1986). The seasonal recruitment pattern obtained from ELEFAN using the estimated growth parameters (L_{oo} and K), and the occurrence of small-sized fish (fish of size 14.9 cm *TL* or less) in monthly samples (Gobert, 1992)

3. Results

3.1 Growth parameters

A total of 2,268 *P. Bellottii* specimen, measuring between 13.6 and 27.7 cm *TL* and weighing from 34.44 to 270.13 g, were sampled. The largest fish observed in the fishery L_{max}) measured 33.2 cm *TL* and weighed 621.35 g. The overal length frequency distribution of the species showed a modal length of 20.0 to 20.9 cm *TL* (Fig. 1). The length-weight relationship of *P. bellottii* in the study area was established as:

$$BW = 0.0099\, TL\, 3.15 \quad (r = 0.998),$$

Where BW is body weight in grammes and *TL* is total length in centimetres (Fig. 2).
Based on the equation asymptotic weight (W_{oo}) as estimated from L_{oo} was 611.54 g. The growth parameter estimates, based on the ELEFAN were L_{oo} = 34.2 cm *TL* and $K = 0.53 yr^{-1}$. The theoretical age at which the length of fish is zero (t_o) was estimated at $-0.31 yr^{-1}$. Growth of the species hence followed the von Bertalanffy pattern and can be described by the equation.

$$L_t = 34.2\ \{1 - \exp(-0.53(t + 0.30))\}\ \text{cm}.$$

The curve derived from this equation is shown in Fig. 3. Fig. 4 illustrates the resultant growth curves superimposed on the monthly-frequency distributions. Most of the monthly length distributions were unimodal and shifts in the modes were not apparent. The growth performance of the species was estimated as 2.78. The longevity (t_{max}) based on the equation (Pauly, 1983a)

$$t_{max} = 3/K$$

was approximately 6 years.

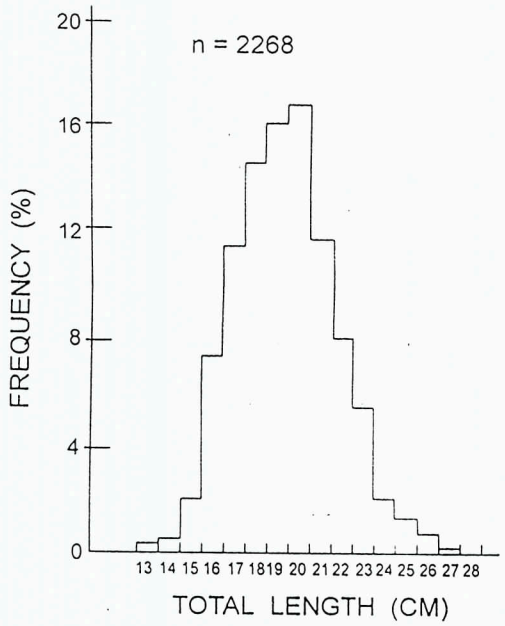

Fig. 1. Overall length-frequency distribution of Pagellus bellottii in landings at Elimina between Nov. 1993 to Oct. 1995 n = sample size.

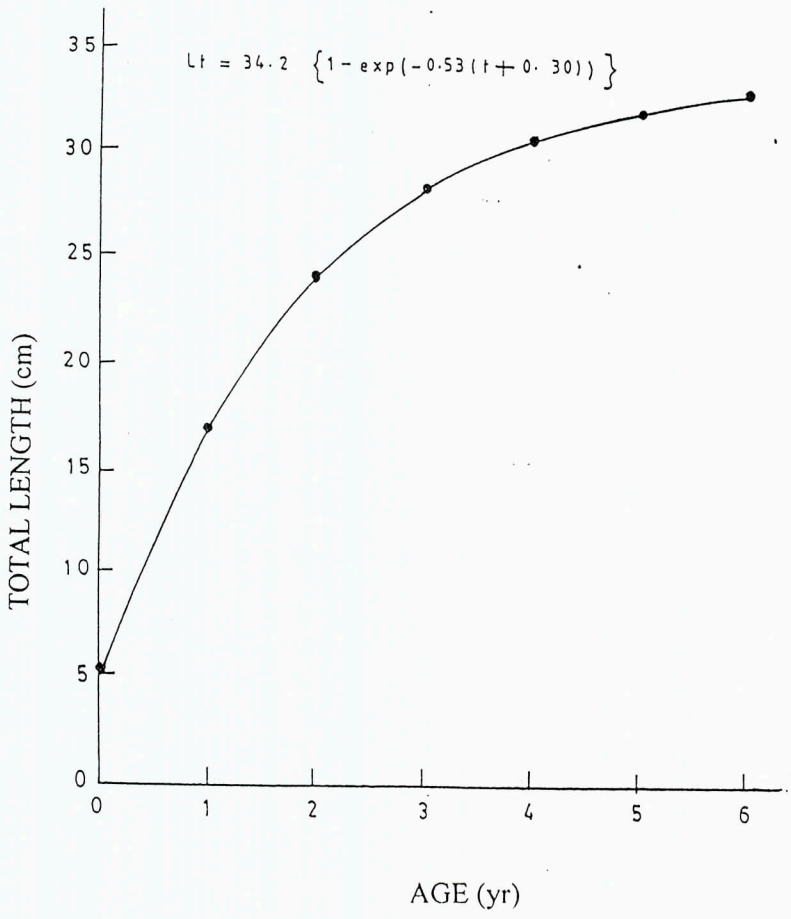

Fig. 2. Growth curve for Pagellus bellottii derived from the von bertalanffy growth equation.

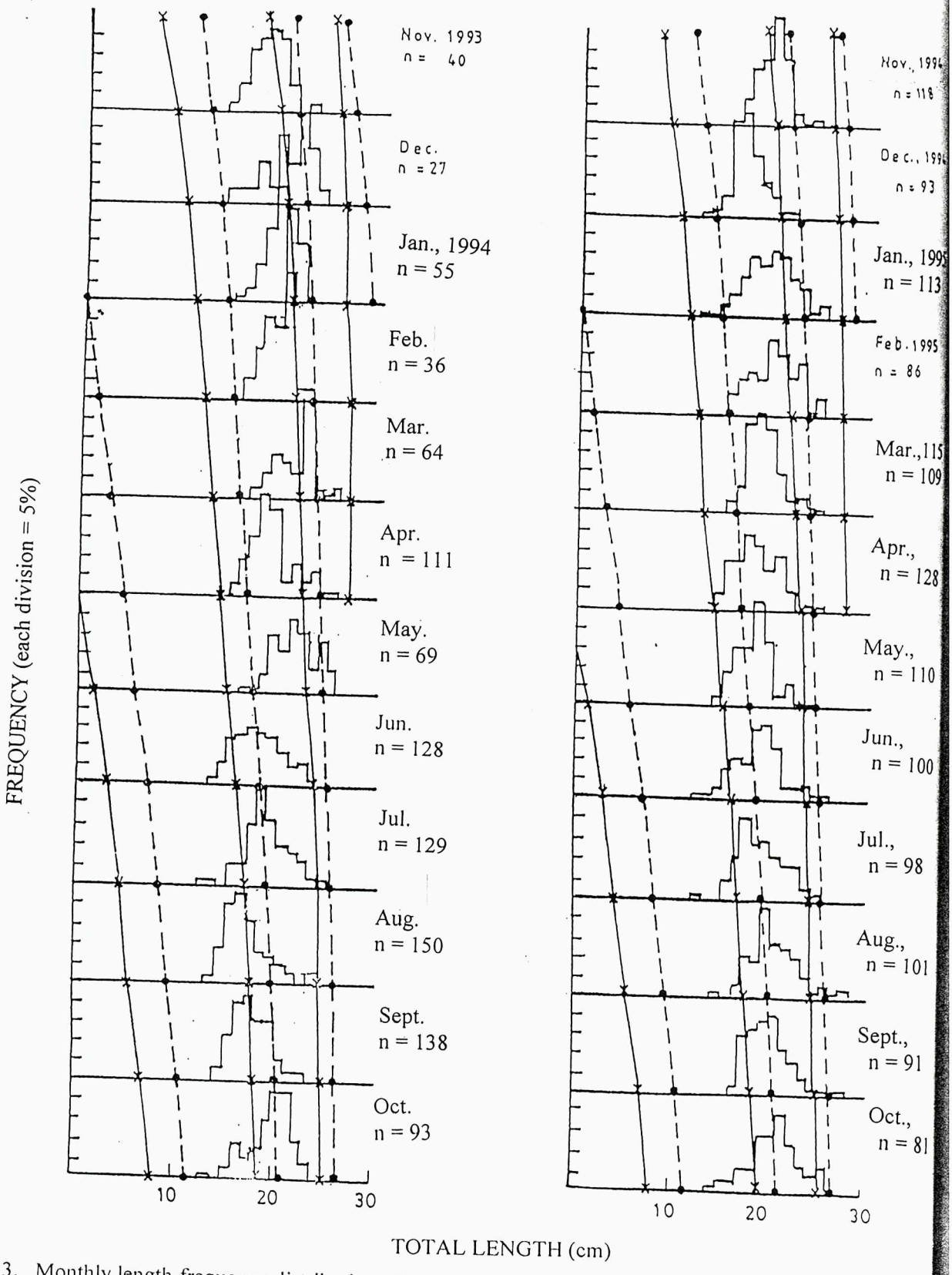

Fig. 3. Monthly length-frequency distribution of *Pagellus bellottii* fitted with growth curves obtained by ELEFAN I. n = sample size.

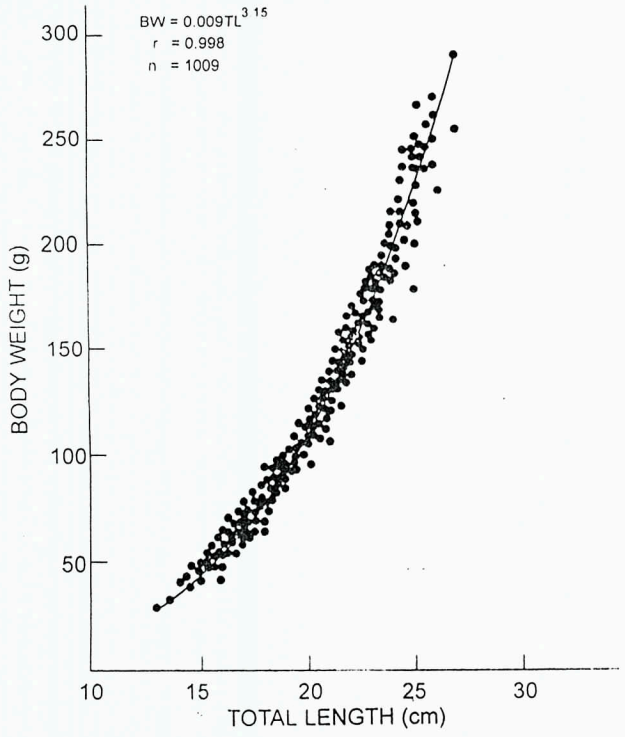

Fig. 4. Relationship between total length (*TL*) and body weight (BW) of *Pagellus bellottii*. n = sample size.

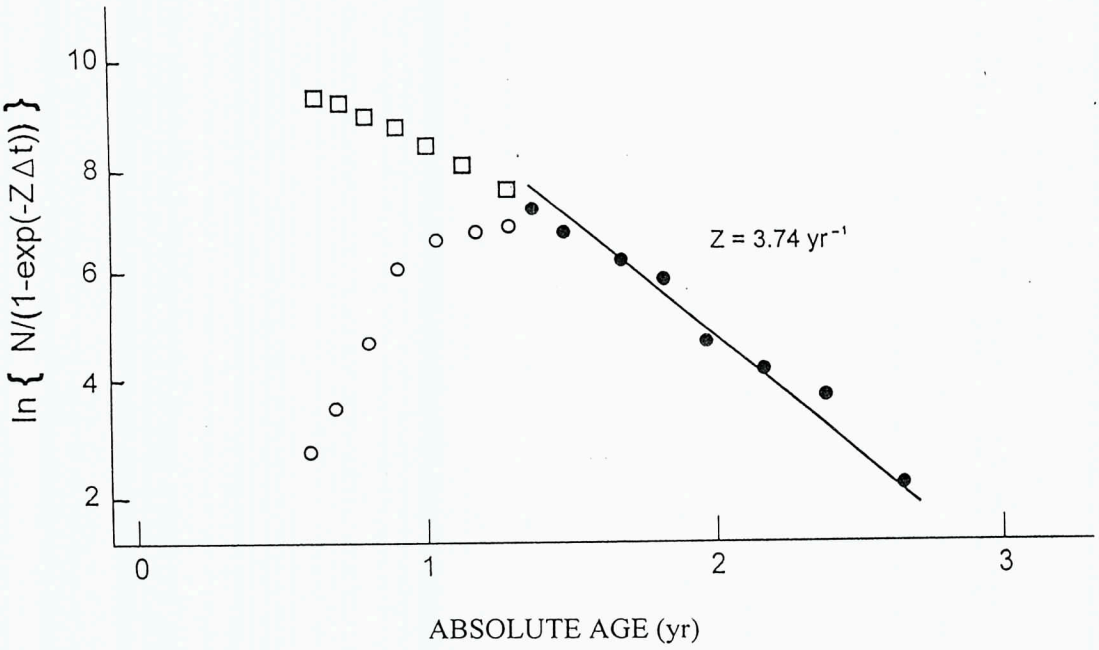

Fig. 5. Length – converted catch curve for *Pagellus bellottii* based on length-frequency data presented in figure 3; L_{oo} = 34.2 cm *TL* and K = 0.53 yr^{-1}. (•) points used for regression analysis to estimate the total mortality coefficient, Z; (o) points not used for analysis; (□) points projected backward to estimate probability of capture. Fig. 6 Selection curve for *Pagellus bellottii* landed at Elmina from November 1993 to October 1995. L_{c50} = mean length at first capture.

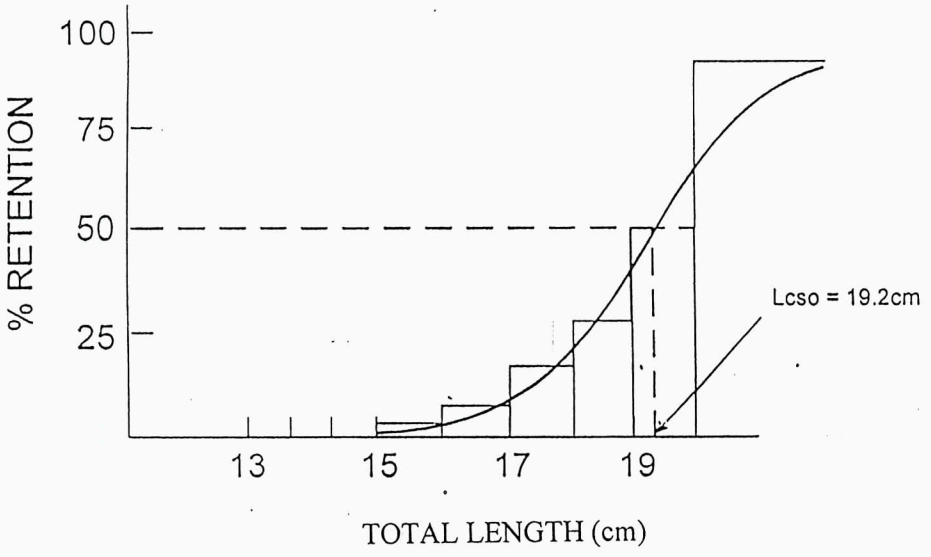

Fig. 6. Selection curve for *P. bellottii* obtained from the commercial catches at the Elmina Fishing Harbour (November 1992 – October 1995). *L*cso = mean length at first capture.

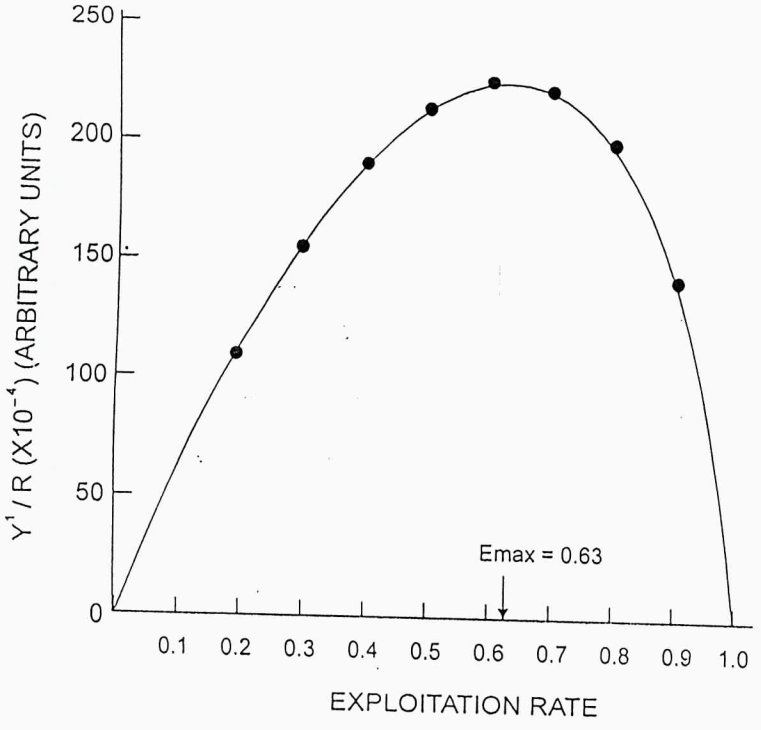

Fig. 7. Relative yield-per-recruit curve as a function of the exploitation rate of *Pagellus bellottii* from Elmina. E_{max} = optimum exploitation rate.

% RECRUITMENT

Fig.8

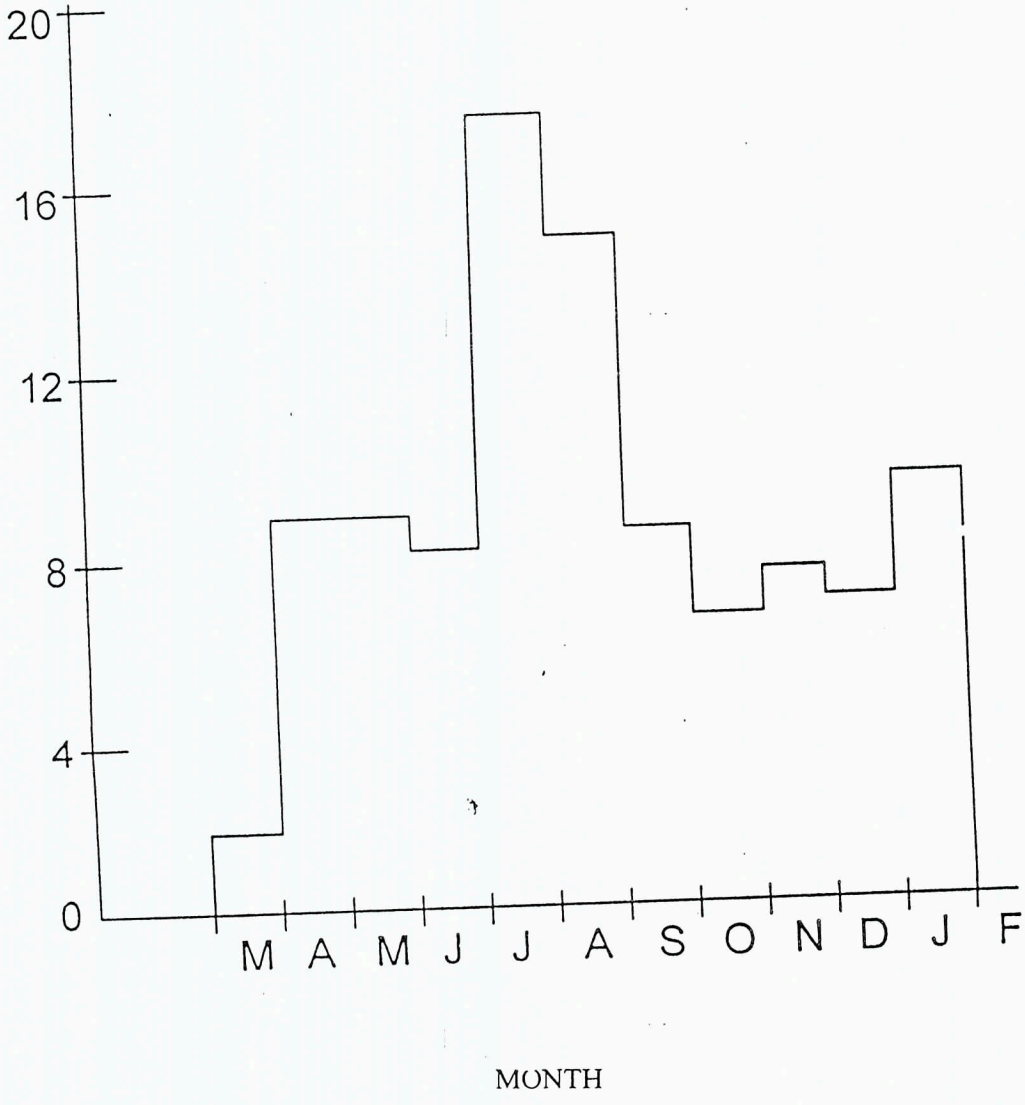

Fig.8. Recruitment pattern of the *Pagellus bellottii* population sampled at Elmina from November 1993 to October 1995.

3.2 Mortality parameters

The coefficient of total mortality (Z) was estimated at 3.74yr^{-1} from the descending right arm of the length-converted catch curve (Fig. 5). The points selected for estimating Z by linear regression were those corresponding to the relative ages at which *P. bellottii* is believed to be fully recruited to the fishery and vulnerable to the fishing gear used in the fishery. The mean annual sea surface temperature of the study area during the study period was 27.3°C and obtained from the Fisheries Department of the Ministry of Food and Agriculture sub-station at Elmina; this substitutedin Pauly's 1980 empirical equation provided an estimated natural mortality coefficient (M) of 1.12^{-1}yr. The coefficient of fishing mortality (F) was hence 2.61yr^{-1}.

3.3 Mean length at first capture

Fig. 6 presents the selection curve for *P. belottii* generated from the length converted catch curve. The mean length at first capture (L_{c50}) for the species was extrapolated as 19.2 cm *TL* which is very close to the modal size group (20.0-20.9 cm *TL*).

3.4 Exploitation rate

The exploitation rate (E), given as the ratio of fishing mortality to total mortality of the *P. bellottii* population in the Cape Coast-Elmina and surrounding fishery was estimated at 0.70. The estimate is higher than 0.5, the optimum rate, suggested for exploited fish stocks (Gulland, 1971).

3.5 Yield-per recruit analysis

Estimate of the optimum level of exploitation (E) of the species was based on the L_{oo} and K values together with the probabilities of capture from the selection curve. The relative yield-per-recruit attained a maximum (E_{max}) at 0.63. As the exploitation rate increased beyond this value the yield-per-recruit decreased (Fig. 7).

3.6 Recruitment pattern

Fig. 8 shows the annual recruitment pattern of *P.bellottii* in the Cape Coast and surrounding areas. Recruitment occurs throughout the year with a major peak between July and August and a minor peak in January. Based on the length frequency data fish of size 14.9 cm *TL* and less appeared in the fishery in June to August (Fig. 9) which may validate the peak recruitment established from the ELEFAN.

4. Discussion

The only estimates of growth parameters of *P.bellottii* in Ghanaian waters are those of Rijavec (1973) and Koranteng and Pitcher (1987). The exponent of the length-weight relationship (b = 3.15) of the red pandora, estimated in the Cape Coast - Elmina and surrounding waters shows isometric growth in the species. The value compares with that estimated by Rijavec (1973) for the species in Ghanaian waters. The estimates of the von Bertalanffy growth parameters of the species in this study (L_{oo} = 34.2 cm *TL*; K = 0.53yr^{-1}) differed from those of Rijavec and Koranteng and Pitcher which also differed between them. The L_{max} observed in the fishery (33.2 cm *TL*), however, compared well with our L_{oo} estimate which also agreed with Williams' (1968) observation. The estimate of t_{max} (longevity) of the species in this study was approximately 6 years, and agreed with those of Rijavec and Koranteng and Pitcher.

In Selar boops in the Davao Gulf (Philippines) a high Z estimate was attributed to migration of the adults from the fishing founds (Dy-Ali, 1988). The high Z value estimated for *P bellottii* in this study may have resulted from high exploitation of the species in the study area and probably migration of the adults into deeper waters. The latter proposition is without any firm foundation as the stock structure of the species in the area is unknown, and needs to be investigated in future studies. The former proposition seems more probable.

The present exploitation rate of *P.bellottii* in the study area is higher than the optimum level of yield-per-recruit which reached the rate of 0.63. This indicates high vulnerability of the species to the gear used. The high exploitation rate of *P.bellottii* may have contributed to the dwindling catches of the species in the area. The need for adoption of strategies which would ensure

sustainable yield of the species is recommended. *P. bellottii* in the area has been observed to spawn during the upwelling seasons (Asabere-Ameyaw, unpublished data). Interestingly, these are the periods for massive recruitment hence a temporary ban on the fishery during these periods will ensure the preservation of the spawning population. *P. bellottii*, reportedly, is a protogynous hermaphrodite (Ofori-Adu, 1989). Fish of size 19.0 cm *TL* and above are predominantly males (Personal observation). The use of fishing gears which would select fish of this size and above would probably select mostly males, thus preserving the females for a sustained reproduction to replenish the dwindling stock.

5. Conclusion

From the foregoing, we conclude that the *P. bellottii* stock in Ghana at present has a faster growth rate compared to the population ten years ago, although the maximum theoretical length has remained relatively stable. The stock, however, seems over-fished as a result of high fishing pressure. Some remedial measures along the lines suggested by Koranteng and Picther should therefore be considered to enhance recovery of the stock.

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