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Aspects of the dynamics of the inshore and offshore populations of *Brachydeuterus auritus* (Family: Haemulidae) in Ghana

A. Asabere-Ameyaw[1], J. Blay, Jr. and K. Yankson[2]

[1]*University College of Education of Winneba, Ghana.*
[2]*Department of Zoology, University of Cape Coast, Cape coast, Ghana.*

ABSTRACT

Growth and mortality parameters of the bigeye grunt populations in Ghana were estimated from length-frequency data collected between November 1993 and October 1995. The von Bertalanffy growth parameters, L_∞, K and t_o, were estimated as 23.0 cm TL, 1.20 yr^{-1} and - 0.14 yr, respectively, for the inshore population, and 22.7 cm TL, 1.16 yr^{-1} and -0.15 yr, respectively, for the offshore population. The growth performance index was calculated as 2.80 for the inshore population and 2.78 for the offshore population. Estimates of the mortality coefficients were: Z = 6.40 yr^{-1}, M = 2.14 yr^{-1} and F = 4.26 yr^{-1} for the inshore population, and Z = 6.40 yr^{-1}, M = 2.10 yr^{-1} and F = 4.30 yr^{-1} for the offshore population. Similar estimates of the exploitation rate (E = 0.67) were obtained for the two populations. This value exceeds the optimum (E_{opt}) of 0.46 and 0.57 derived by the yield-per-recruit analysis for the inshore and offshore populations, respectively. These observations suggest the over-exploitation of the *B. auritus* populations.

1. Introduction

The bigeye grunt, *Brachydeuterus auritus* (Valenciennes, 1831), is a semi-pelagic fish found in the Tropical Eastern Atlantic. Its distribution extends from Mauritania to Angola (Schneider, 1990) with the highest concentration occurring off La Côte d'Ivoire (FAO, 1991). It is the commonest haemulid in the Ghanaian marine fishery, forming a substantial portion of the beach seine catches as well as in the landings of the industrial and semi-industrial fishing activities. It is an important and cheap source of protein to many coastal dwellers in Ghana. It is marketed either fresh, smoked or salted and sun-dried. In Nigeria, it has been shown that it has high potential utility as a fish-meal and protein concentrate (Afolabi *et al.*, 1984).

Exploitation of the species in Ghana waters has been on the ascendancy with the composition of the catches increasing from about 3.0% in 1981 to 8.2% in 1986 (Mensah and Koranteng, 1988), and recently its contribution has increased to about 10.0% of marine fish landings (MOFA, 1995).

There is no known study on the dynamics of *B. auritus* populations in the Gulf of Guinea. However, some information is available on the growth of related species elsewhere, for example, *Pomadasys commersonni*, from southern Africa (Torres and Pauly, 1991), *P. kaakan* occurring off the coast of Pakistan (Majid and Imad, 1991) and *P. maculatus* from the Gulf of Aden (Edwards and Shaher, 1991). This work was undertaken to determine the population parameters of growth and mortality of *B. auritus* in the inshore and offshore waters off Cape Coast, Ghana, to provide the necessary baseline information, which could be used to formulate management strategies for the sustained exploitation of the species in this region.

2. Materials and methods

Monthly samples of the bigeye grunt were obtained from commercial catches at the fish landing quay at Elmina near Cape Coast, Ghana (5° 06' N; 1° 23' W), between November 1993 and October 1995. Samples were also obtained from beach seine operations at Elmina between January 1994 and October 1995. These were, however, treated separately from the commercial catches fished offshore. For each fish, the total length (TL) was measured to the nearest 0.1 cm, and the body weight (BW) determined to the nearest 0.01 g.

The von Bertalanffy growth function parameters L_∞ (asymptotic length) and K (curvature constant) were derived from the monthly length frequency data, using the ELEFAN computer programme (Gayanilo *et al.*, 1989). The third von Bertalanffy growth function parameter t_0 (i.e., the theoretical age at which the length of fish is zero) was derived from Pauly's (1983) formula:

$$\log_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K \quad (1)$$

The growth activity of the species in the inshore and offshore regions was evaluated, based on Pauly and Munro's (1984) equation:

$$\phi' = \log_{10} K + 2 \log_{10} L_\infty \quad (2)$$

where Φ' is the growth performance index.

The instantaneous coefficient of total mortality (Z) was derived from length-converted catch curve generated from the growth data, and the coefficient of natural mortality (M) calculated from Pauly's (1980) formula:

$$\log_{10} M = -0.0066 - 0.2790 \log_{10} L_\infty + 0.6453 \log_{10} K + 0.4634 \log_{10} T \quad (3)$$

where T is the mean annual sea surface temperature (27.3°C), and obtained from the Fishery Department of the Ministry of Food and Agriculture, Ghana. Estimates of the fishing mortality coefficient (F) were therefore based on the relationship (Ricker, 1975),

$$F = Z - M \quad (4)$$

and the estimates of the optimum level of exploitation based on the relative yield-per-recruit (Y'/R) model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986).

3. Results

3.1 Growth parameters

A total of 612 specimens of *B. auritus* were sampled from the beach seine catches at Elmina. These measured between 2.5 and 17.9 cm TL, and weighed 0.33-69.43 g body weight, and showed a bimodal length distribution. The modes were at 3.0-3.9 and 10.0-10.9 cm TL. Samples from the offshore commercial catches numbered 2,055 and ranged from 5.8 to 20.5 cm TL. These weighed between 2.22 and 116.73 g. The overall length-frequency distribution of the samples showed a modal group of 10.0-10.9cm TL (Fig.1).

Length-weight regressions were computed for the samples. In both the inshore and offshore samples, an exponential relationship existed between the length and weight of the fish. The equations describing the relationships are:

$$BW = 0.031TL^{2.59 \pm 0.01} (r = 0.894; p < 0.001) \quad (5)$$

and

$$BW = 0.13TL^{3.01 + 0.8} (r = 0.986; p < 0.001) \quad (6)$$

for the inshore and offshore populations, respectively. Curves for these relationships are presented in Fig. 2.

Monthly length frequency distributions of *B. auritus* from which the von Bertalanffy growth parameters L_∞ and K were derived and the resultant growth curves derived from the growth parameters are presented in Fig. 3. From January to July 1994, *B. auritus* in the inshore region grew by 8 cm and by July fish of size 15.0 cm TL and above were absent from the fishery. Specimens of the fish were

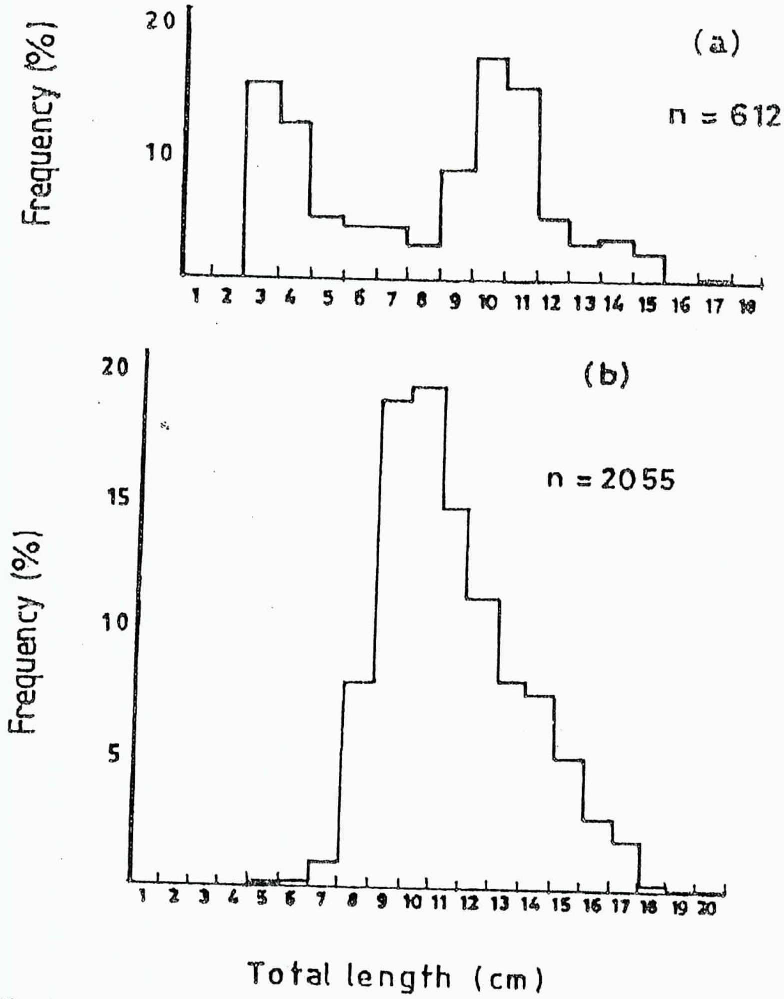

Fig. 1. Length-frequency distributions of *B. auritus* samples from (a) inshore (b) offshore commercial catches between November 1993 and October 1995.

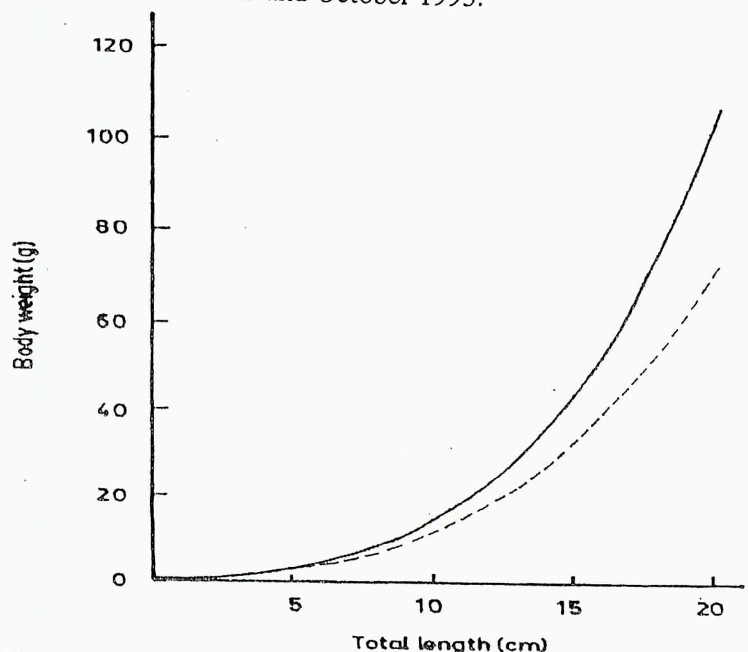

Fig. 2. Length-weight relationships for *B. auritus* populations in (. .. . . .) inshore and (__) offshore marine waters in Ghana.

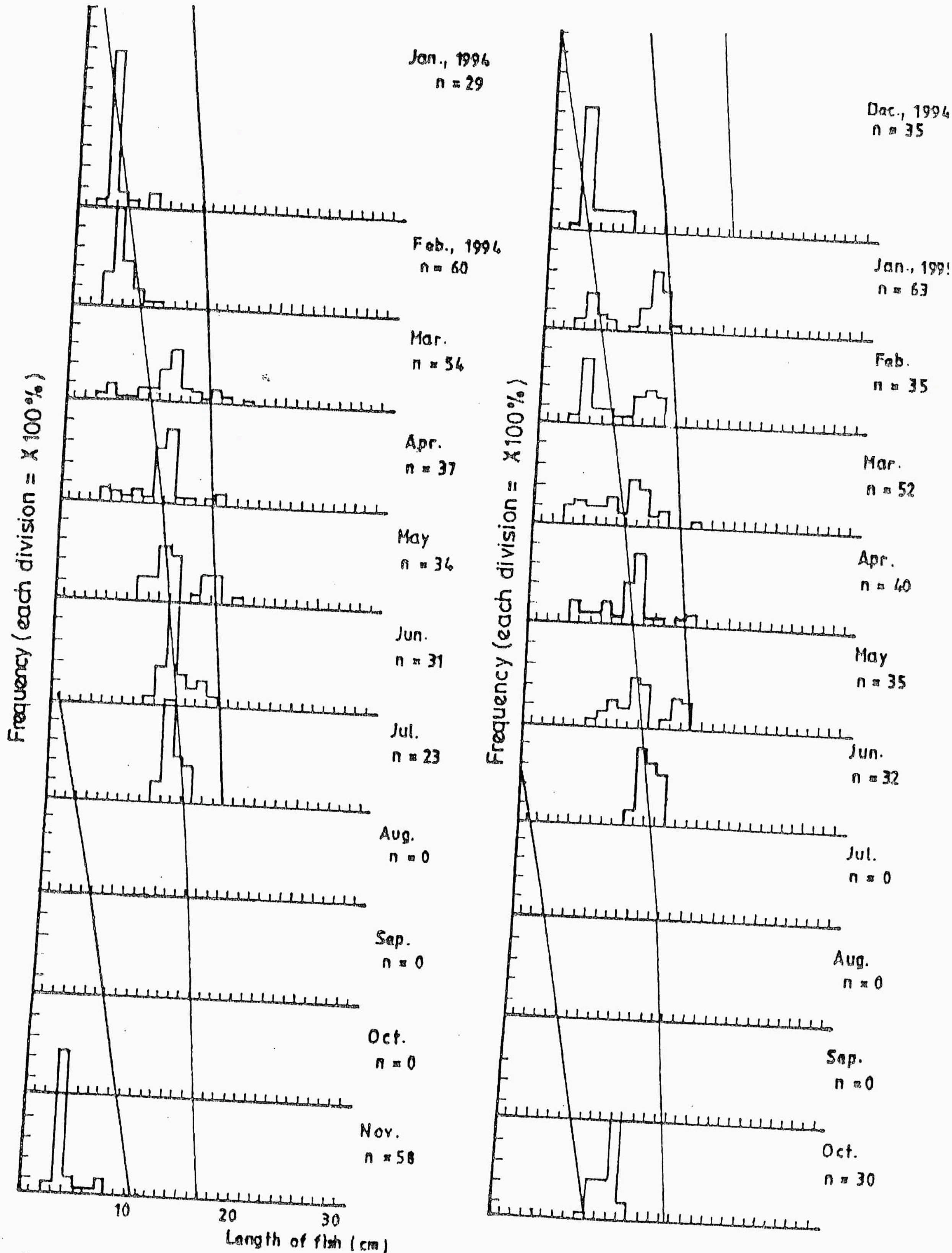

Fig. 3a. Monthly length-frequency distribution of (a) inshore *B. auritus* sampled off Cape Coast.

absent from the fishery. Specimens of the fish were absent from the fishery from August-October 1994. The fish, however, reappeared in the fishery in November with a primary mode at 3.0 -3.9 cm TL. This mode also shifted by 8 cm by June 1995 ...

mens were absent from the inshore fishery i July-September 1995 and reappeared in th October catches.

The growth parameter estimates derived from the samples were L_∞ = 23.0 cm TL, K ...

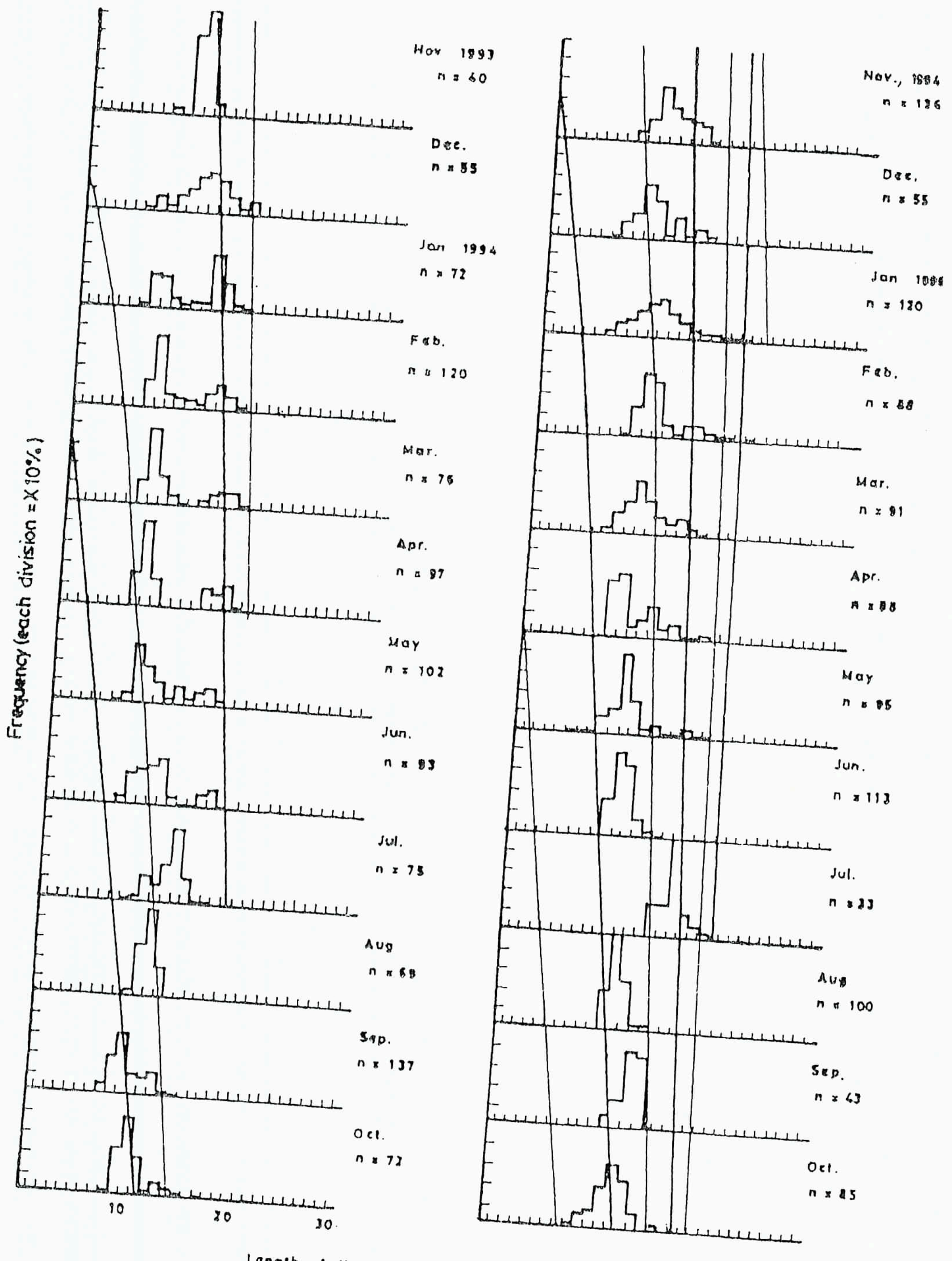

Fig. 3b. Monthly length-frequency distribution of offshore *B. auritus* sampled off Cape Coast.

t_o = -0.15 yr. By substituting the estimated growth parameters in the von Bertalanffy growth function, the following equations are obtained for the inshore and offshore *B. auritus* populations, respectively:

$$L_t = 23.0(1 - exp - 1.20(t + 0.14))) \quad (7)$$

and

$$L_t = 22.7(-exp(-1.16(t + 0.15))) \; cm \; TL \quad (8)$$

The corresponding growth curves for these equations by substituting arbitrary values are shown in Fig. 4.

The growth performance index (Φ'), which gives a reliable evaluation of growth

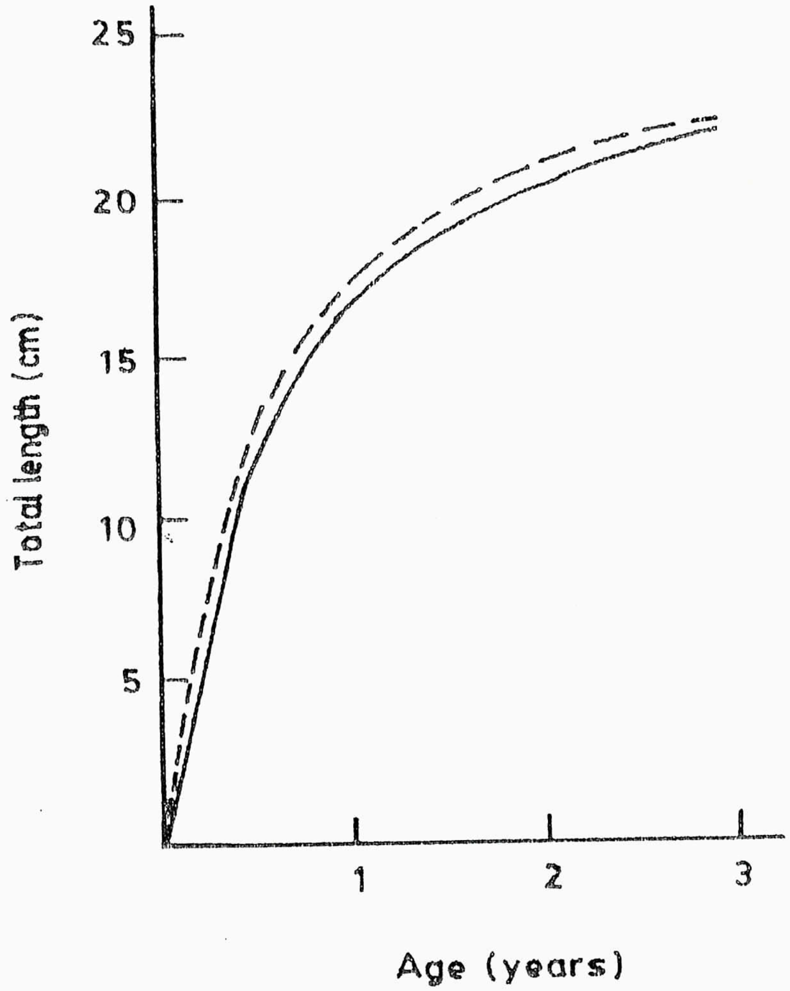

Fig. 4. Derived growth curves of *B. auritus* populations in the inshore (------) and offshore (_____) marine waters.

characteristics of fish of the same species inhabiting different ecological zones, was calculated as 2.80 for the inshore population and 2.78 for the offshore population.

Based on Pauly's (1983) equation:

$$t_{max} = 3 / K \quad (9)$$

the maximum attainable age (t_{max}) of *B. auritus* in the two ecological zones was approximately 3 years.

3.2 Mortality parameters

The coefficient of instantaneous total mortality (Z) of *B. auritus* was derived from the descending right arm of the length-converted catch curve (Fig. 5). For both the inshore and offshore populations, Z was 6.40 yr^{-1}. The points selected for estimating Z by

the relative ages at which *B. auritus* is lieved to be fully recruited into the fisheri and vulnerable to the fishing gears used in fisheries.

The coefficient of natural mortality (in the inshore and offshore regions w estimated as 2.14 and 2.10 yr^{-1}, respectiv Hence, the fishing mortality coefficient (F the populations were respectively, 4.26 4.30 yr^{-1}.

3.3 Mean length at first capture (L_{C50})

Curves illustrating the proportion o *auritus* missing at every length, as a resul gear selection, were generated from the cending part of the length-converted c curves. The mean length at first capture (L for the inshore *B. auritus* population was

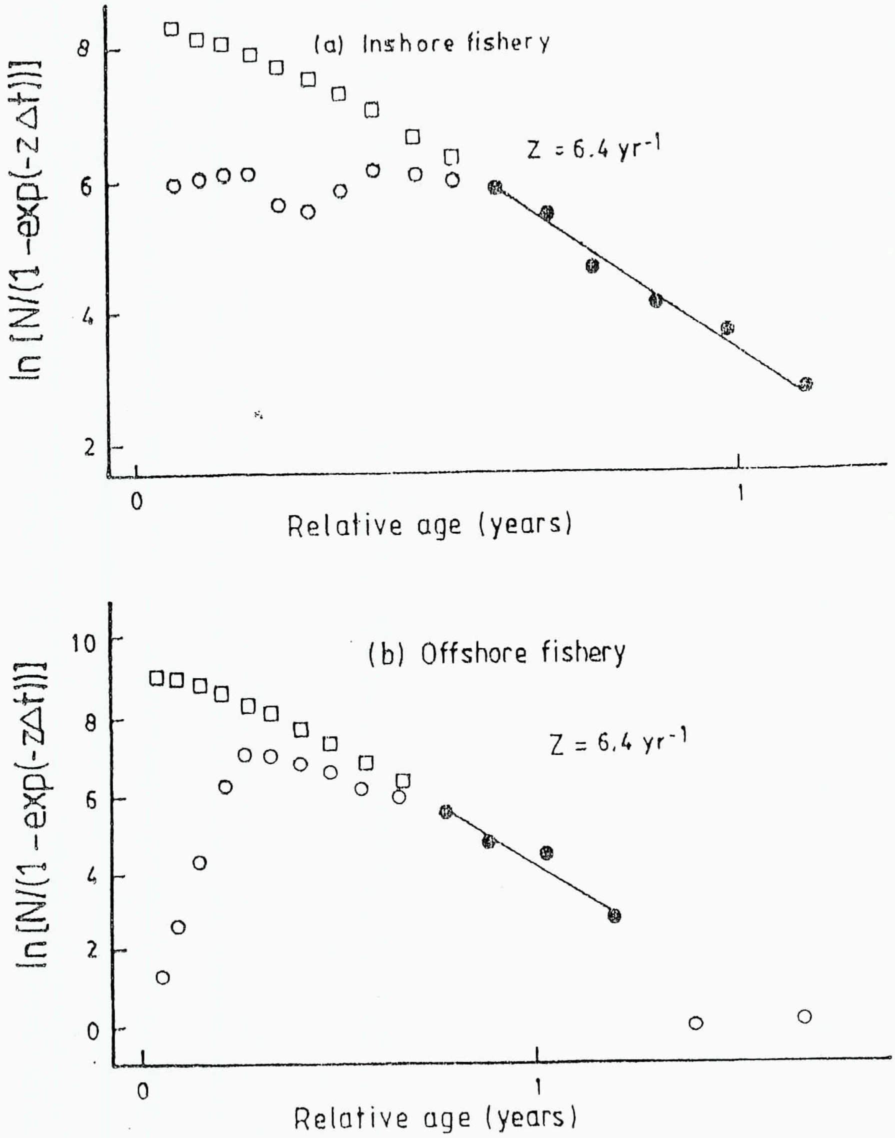

Fig. 5. Length-converted catch curves for *B. auritus* (a) inshore and (b) offshore populations in the Cape Coast area based on length-frequency data presented in Fig. 3 (Points used for regression analysis (•); points not used for regression analysis (○); points projected backward to estimate probability of capture (□).

estimate was 12.4 cm TL (Fig. 6). These lengths were, however, lower than the length at which fifty percent of the *B. auritus* populations matured (15.3 and 15.0 cm TL, for males and females, respectively (Asabere-Ameyaw, 1998).

3.4 Exploitation rate and relative yield-per-recruit

The exploitation rate (E = F/Z) was calculated as 0.67 for both the inshore and offshore *B. auritus* populations. However, based on the yield-per-recruit analysis the exploitation rate which can sustain the yield for the inshore and offshore *B. auritus* fishery was estimated at 0.46 and 0.57 (Fig. 7). These revelations are indications of over exploitation of the *B. auritus* populations.

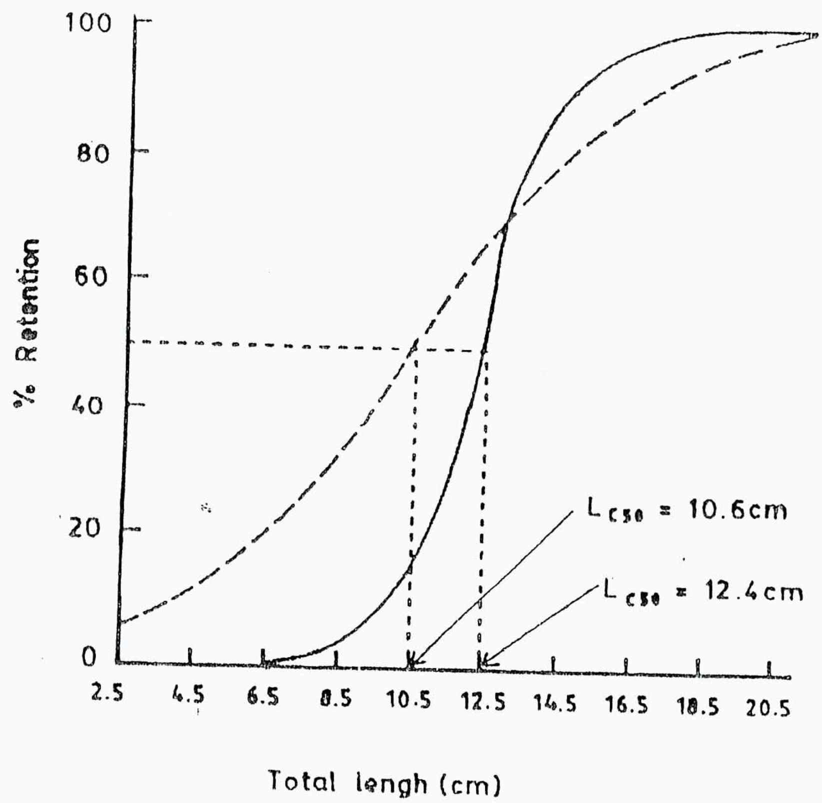

Fig. 6. Selection curves for *B. auritus* populations in the inshore (-----) and offshore (______) marine waters off Cape Coast.

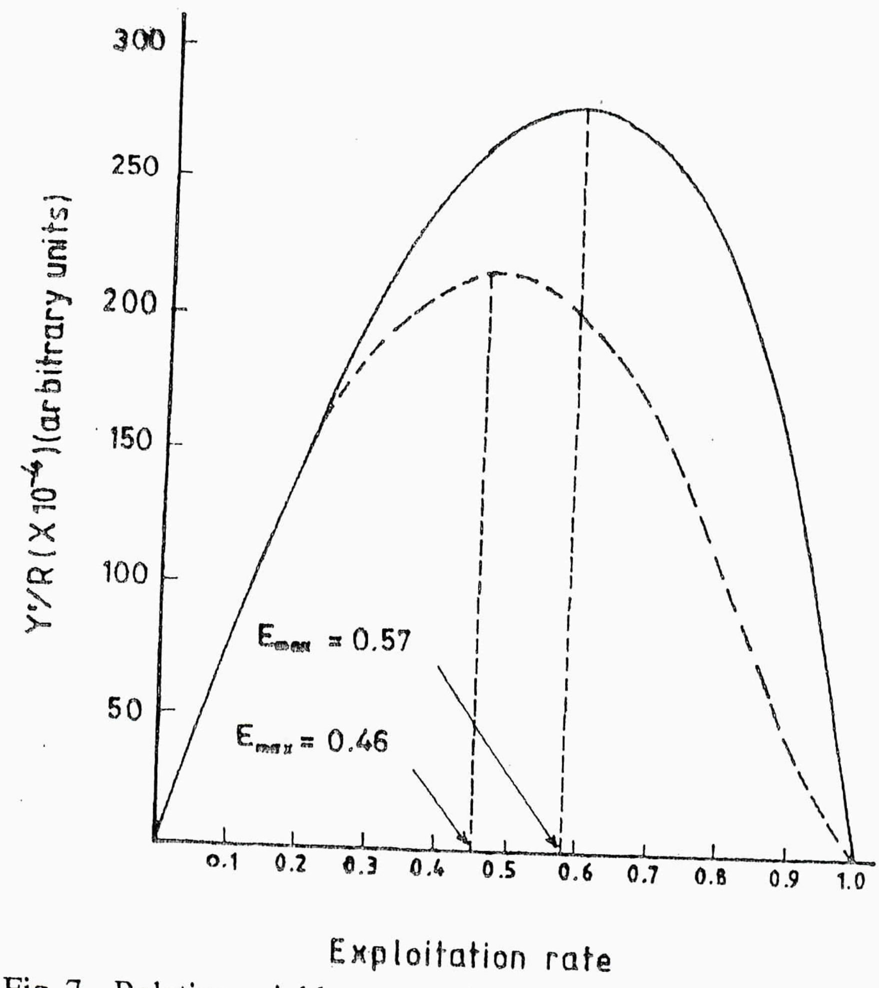

Fig. 7. Relative yield-per-recruit (Y'/R) as a function of

4. Discussion

The length-weight relationships for *B. auritus* in the marine waters off Cape Coast, Ghana, were exponential. The exponents were 2.59 and 3.01, for the inshore and offshore populations, respectively. For the inshore population, the exponent was statistically different from 3.0 ($b = 2.59 \pm 0.01$; $P < 0.001$), indicating a negative allometric growth form in that population. However, the offshore population had an exponent, which was statistically similar to 3.0 ($b = 3.01 \pm 0.08$; $P > 0.05$), suggesting an isometric growth. *B. auritus* is known to tolerate a wide range of ecological factors (Ofori-Adu and Koranteng, 1993). This is attested to by the similarity in the growth parameters and the growth performance indices of the species in the inshore and offshore regions. Presumably, growth in *B. auritus* is not significantly affected by ecological divergences. This, coupled with the fact that *B. auritus* is a short-lived and a fast growing species in the waters of Ghana might present the species as a good candidate for fish culture.

B. auritus appeared to use the shallow marine waters as a nursery, where within a period of five months (January-June), it increased in total length by about 8 cm. The absence of the species from the beach seine catches (inshore catches) from August-October 1994 and July-September 1995 could be attributed to the migration of the sub-adults from the nursery grounds into the adult population in deeper waters offshore. These months incidentally coincided with the major upwelling period in Ghanaian coastal waters, when food for the migrated sub-adults would be expected to be abundant in their new habitat. The motivating factor for the onset of the migration could be intrinsic, however, low ambient temperature during the upwelling season could be the determinant environmental cue for the initiation of the migratory process.

The present exploitation rate of *B. auritus* populations in the Cape Coast area, Ghana, ($E \approx 0.7$) far exceeds the optimum generated by the yield-per-recruit analysis for the inshore ($E_{max} = 0.46$) and offshore ($E_{max} = 0.57$) populations. These observations might suggest over-exploitation of the stocks. The large proportions of small sized *B. auritus* landed at the beaches of Ghana (personal observation) are attributable to the high exploitation rate and the smaller mean lengths at first capture. In the blackchin tilapia, *Sarotherodon melanotheron*, in the Fosu Lagoon, Ghana, an exploitation rate of 0.62 suggested an over-exploitation of the stock (Blay and Asabere-Ameyaw, 1993); however, the population was able to maintain a high annual yield despite its high fishery probably because of the high reproductive resilience of tilapia species. *B. auritus* has a high reproductive capability (Asabere-Ameyaw, 1998). This coupled with the fact that the species is a short-lived one in the area, and having a fast growth rate, suggests that the populations could sustain the high exploitation.

Though it has been speculated that the high exploitation of *B. auritus* stocks in Ghana might represent an active exploitation, rather than their over exploitation, this might seem true only for the offshore fishery. The current exploitation rate of the inshore *B. auritus* stock ($E = 0.67$) is far in excess of the 0.46 optimum generated by the yield-per-recruit analysis, and also greater than the maximum of 0.50 suggested by Gulland (1971) for a sustained yield.

A high total mortality coefficient observed in the carangid fish, *Selar boops*, in the Davao Gulf (Philippines) was attributed to high fishing mortality and probably migration of the sub-adults into deeper waters (Dy-Ali, 1988). In the inshore population of *B. auritus* the high total mortality could be the combined effect of high fishing mortality and migration of the sub-adults into deeper waters. The same, however, cannot be said for the offshore population, where there is no evidence of adult migrations. High exploitation rate, therefore, might have been the major cause of the high total mortality of the offshore population.

5. Conclusion

The yield-per-recruit analysis and the mean length at first-capture (L_{C50}) estimates suggest that the current exploitation of *B. auritus* in Ghanaian waters is above the sustainable level. Presently, the use of 1.0 to 1.5 cm mesh nets in the codend of beach seines in the coastal fisheries of Ghana is proving detrimental to the optimum development of the stocks. The species though appears capable of sustaining the high exploitation rates, because of its high reproductive capability and accelerated growth, the use of fishing gears which would select fish larger than the length at fifty percent maturity (about 15.0 cm TL) might improve the yield of the stocks in Ghana.

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