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Population dynamics parameters of Bigeye grunt *Brachydeuterus auratus* (Pisces, Haemulidae) from the continental shelf of Côte d'Ivoire (West Africa)

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Abstract

The population structure, growth, mortality, and exploitation rate of big-eye grunt *Brachydeuterus auratus* were examined from the continental shelf of Côte d'Ivoire (West Africa) between August 2016 and July 2018. This study provides results on fishery dynamics parameters to contribute to estimating the stock assessment of this fish species. Monthly length-frequency data were collected and analyzed using the Stock Assessment Tools-II (FISAT II) software. The total lengths ranged from 8.76 to 24.56 cm, the dominant length group ranged from 15 to 16 cm (16.9%). The length-weight relationship parameters were $W = 0.00872TL^{3.16}$ ($r^2 = 0.94$). Von Bertalanffy parameters were estimated at asymptotic total length (L_∞) = 24.68 cm, coefficient of growth rate (K) = 0.46 year^{-1}, growth performance index (Ø') = 2.45, time at which length equals zero (t_0) = -0.38 year. Mortality parameters were calculated as a total mortality rate (Z) = 1.84 year^{-1}, the natural mortality rate (M) = 1.10 year^{-1}, and fishing mortality rate (F) = 0.74 year^{-1}. The exploitation rate (E) = 0.40 year^{-1} was lower than the optimal level, indicating that the *Brachydeuterus auritus* fishery is not overexploited.

Keywords: *Brachydeuterus auratus*, Côte d'Ivoire, population dynamics, mortality, recruitment

Introduction

The big-eye grunt, *Brachydeuterus auritus* (Valenciennes, 1831) is a marine species, gregarious of the Haemulidae family (formerly Pomadasyidae). Demersal to semi-pelagic, it is very common on the Western coast of Africa from Mauritania to Angola. Occasionally, extending northwards to Morocco (FAO, 2020), it is a benthopelagic fish species that inhabits coastal waters. In inshore waters, inhabits soft, sandy, and muddy bottoms, its distribution ranges between 10 – 100 m in depth (Schneider, 1990) but it is most commonly found between 30 and 80 m (Adebiyi, 2013). This species feeds on invertebrates and small fishes (Ali et al., 2018).

Brachydeuterus auritus is one of the abundant and wildly distributed demersal and semi-pelagic fish species in Côte d'Ivoire coast waters (Sylla et al., 2017), it is also economically important in both the coastal artisanal fisheries and industrial fisheries.

National production practically decreased during the decade 2000 to 2010 compared to the decade 1990 to 2000. Indeed, this fell from 95,000 tons in 1990 to 81,000 tons in 2000 against the production of 49,737 tons in 2010 (DAP, 2011). Côte d'Ivoire average annual fish production was estimated at 60,000 tons, mainly pelagic fish, which accounted for 70% of catches (DAP, 2017).

According to the FAO study made on the state of the world's fisheries, the Eastern Central Atlantic with the Gulf of Guinea had displayed a high percentage (42%) of overexploited stocks (FAO, 2018). Several alarm signals, drawn by different experts asserted that the fish stocks decrease dramatically in the last 40 years and have predicted that the decline of fish stocks will continue into the future. According to them, no fish stocks are expected to be underexploited within 20 years (Daniel Pauly & Zeller, 2017). Good management of fisheries is needed to protect marine fish resources because many societies are dependent on these resources. The information on the dynamic, age, growth and reproductive biology of these fish is of great importance for the management and sustainable exploitation of fish stocks.

In many parts of West Africa and the Gulf of Guinea, several studies have already been undertaken on the ecology, biology, age, and growth (Abbey et al., 2017; Adebiyi, 2012a, 2012b, 2013; Ali et al., 2018; Amponsah et al., 2017; Asabere-Ameyaw, 2001; Samb, 2003; Sedzro & Jurado-ruzafa, 2018) of this species.

In Côte d'Ivoire no study on age and growth has been done since the work of (Barro, 1976) and there are few reports on stock assessment (Konan et al., 2015), reproduction (Sylla et al., 2016), and histology (Kouassi et al., 2017). In the Ivorian waters, commercial species fisheries management requires updated information but due to the lack of such data on the assessment of fisheries, it is important to undertake a study of the population dynamic of *Brachydeuterus auratus*. The present study aims to determine the population dynamics parameters of this species.

Information from this study will contribute to the sustainable management of this species within Côte d'Ivoire's coastal waters.

Materials and methods

The Ivorian oceanic zone (Fig. 1) is bordered to the north by the Gulf of Guinea Shoreline stretching from Cape Palmas and the Cape Three Points. The Ivorian fishing area is located between latitudes 3°N and 5°N and longitudes 2°W and 8°W. The shoreline is 550 km long with a narrow continental shelf of 10,200 km² and is characterized by a series of sandy beaches forming a wide arch on to the Atlantic Ocean (Le Loeuff et al., 1993). According to (Colin, 1988), coastal upwelling occurs seasonally along the shoreline from July to October (the major event) and from January to February (the minor event).

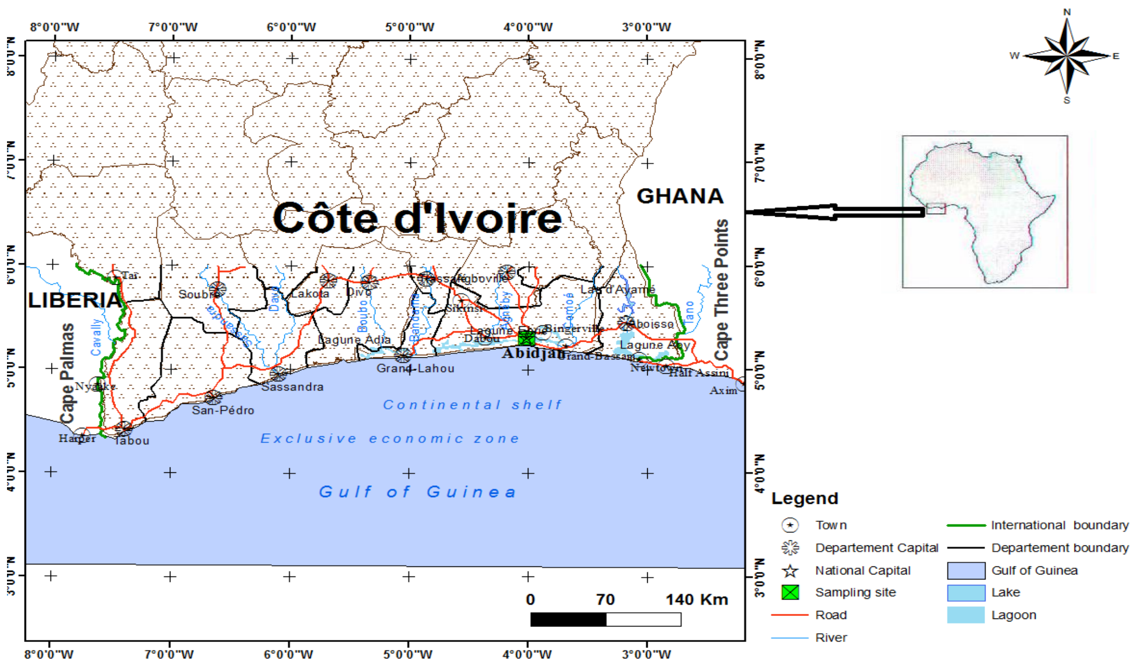

Figure 1. Map showing the Continental shelf of Côte d'Ivoire (Arra et al., 2020)

Data collection

Samples of *Brachydeuterus auritus* were purchased from industrial trawlers' catches and artisanal gill nets along the coast of Côte d'Ivoire. The specimens were sampled monthly from August 2016 to July 2018 at the fishing harbor of Abidjan and the artisanal fishery of Grand-Bassam. The Total length (TL) of the samples was recorded to the nearest 0.1 cm and the weight (W) was recorded to the nearest 0.1 0.01 g.

Length frequency distribution

The fish were grouped into different size classes of one (1) cm interval. And then, MS Excel 2016 was used for data treatment and to determine the length frequency. During the study, a total of 974 fish specimens of *Brachydeuterus auritus* were measured for the length-frequency data.

Estimation of the Length-Weight Relationship

The total length and body weight of fish was used for the length-weight relationship. The length-weight relationship was calculated using the regression equation (Froese, 2006):

$W = a * TL^b$

where W = total body weight of fish (g), TL = total length of fish (cm), "a" = regression constant, "b" = regression coefficient; it's also allometric growth coefficient. The value of "b" provides information on the fish growth type. The association degree between Length–Weight variables was calculated by the correlation coefficient (R^2) and its statistical significance level was estimated (Santos et al., 2002).

$\text{Log } W = \text{Log } a + b \text{ Log } TL$

If b = 3, it means that the growth is isometric and when $b \neq 3$, the growth is allometric (negative allometric if $b < 3$ and positive allometric if $b > 3$).

Estimation of Growth parameters

To estimate the growth parameters ($L\infty$, K and t_0) of *Brachydeuterus auritus*, The von Bertalanffy growth function was analyzed using the ELEFAN-I routine of FISAT II (FAO-ICLARM Stock Assessment Tools-II). The von Bertalanffy growth function (Gayanilo et al., 2005), is expressed as:

$TLt = TL\infty\ (1 – e^{– k(t-t0)})$

Where TLt is the predicted length at age t, $L\infty$, the asymptotic length, K, the grow coefficient and t0, the theoretical age at length zero calculated based on Pauly (1979) as:

$\text{Log}_{10}(– t_0) = – 0.392 – 0.275\text{Log}_{10} L_\infty – 1.038\ \text{Log}_{10} K.$

The growth performance index Phi (Ø') of the population in terms of the length according to the method of Pauly and Munro (1984) (Munro & Pauly, 1983) was estimated as:

$Ø' = \log_{10}K + 2\log_{10}L_\infty.$

The longevity (t_{max}) of *Brachydeuterus auritus* was calculated from the formula:

$t_{max} = 3/K + t_0$

Estimation of Mortality Rates

The total instantaneous mortality (Z) was calculated using the FISAT II software by a linearized length converted catch curve as defined by Pauly (1984):

$\text{Ln } (Nt / \Delta t) = a + bt$

where N is the number of individuals of relative age (t) and Δt is the time needed for *Brachydeuterus auritus* to grow through a length class i. The natural mortality rate (M) was computed using the empirical equation of Pauly (1980) at a mean surface temperature (T) of 26 °C (Konan et al. 2015):

$\text{Log}_{10} M = -0.0066 - 0.279 \log_{10} L\infty + 0.6543 \text{Log}_{10} K + 0.4634 \text{Log}_{10} T$

Fishing mortality (F) was obtained by subtracting M from Z and exploitation rate (E) was estimated using Beverton and Holt's equation (Guilland, 1971) as:

$E = F/Z = F/(F + M)$

An E close to 0.5 is considered to describe an optimal level of exploitation, whereas E > 0.5 refers to a state of over-exploitation (Tesfaye & Wolff, 2015). The biological reference points which were defined as a precautionary limit reference point (F_{limit}) were computed as $F_{limit} = (2/3) * M$ and the precautionary target reference point (F_{opt}) was calculated as $F_{opt} = 0.5*M$ (Patterson, 1992).

Recruitment Pattern

Recruitment is obtained using restructured data from a time series of length frequency. The recruitment model is obtained by projecting the length-frequency data back on the time axis using the VBGF growth parameters L_∞, K, and t_o (Moreau & Cuende, 1991).

Probability of capture

The length at first capture is obtained by plotting the cumulative probability of capture against mid-length, and a resultant curve was obtained. The length at first capture (L_c) is defined as the mean total length at which 50% of the fish entering the gill nets were caught, it was taken as corresponding to the cumulative probability at 50%. It was estimated by the procedures of and (Sparre & Venema, 1998), and it was determined by using the equation of Beverton and (Beverton & Holt, 1957):

$L_C = [TL - K(TL_\infty - TL')]/Z$

Where Lc is the length at first capture, TL' is the mean length of fish in the catch sample.

Virtual Population Analysis (VPA)

Length-structured virtual population analysis (VPA) was also carried out from relevant information produced and cohort analysis (Gayanilo et al., 2005).

Relative yield per recruit and relative biomass per recruit

Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) values as a function of E were calculated from the estimated growth parameters and the probability of capture by length (Pauly & Soriano, 1986). As a result, the maximum allowable limit of exploitation (E_{max}) giving maximum relative yield-per-recruit (MSY=Maximum Sustainable Yield), the exploitation rate at which the marginal increase in relative yield-per-recruit is $E_{0.1}$, (10% of its virgin stock) and $E_{0.5}$, the exploitation rate corresponding to 50% of the unexploited relative biomass per- recruit (B/R) (TRP=target reference point) were computed.

Results

Length Composition

The total length of *Brachydeuterus auritus* (N = 974) collected from August 2016 to July 2018 ranged from 8.76 (9.20 g total weight) to 24.56 cm (204.60 g total weight). The mean total length was 24.14 cm ± 0.23 cm. The length-frequency distribution showed unimodal distribution. The modal size class was [15-16] cm with 14.58% frequency (Fig. 2).

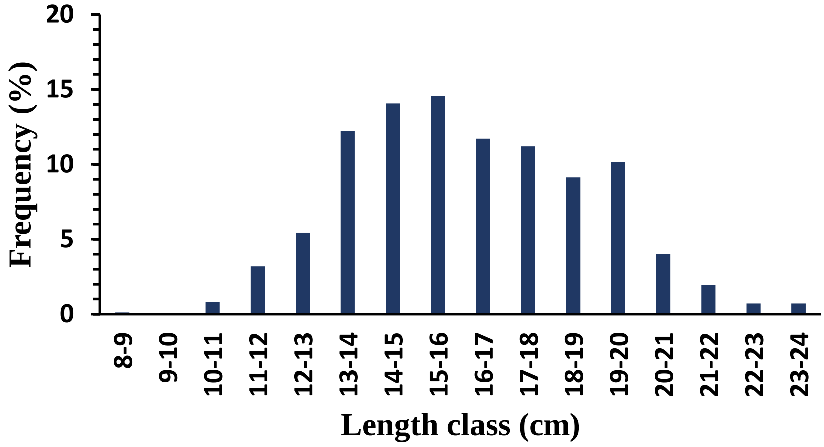

Figure 2. Length frequency distribution of *Brachydeuterus auritus*

Length-weight relationship

The graphic representation of the estimated length-weight relationship (Fig. 3) provided a good fit for *Brachydeuterus auritus* data as, $W = 0.0872TL^{3.16}$, ($r^2 = 0.94$). This study's results showed that the slope of the regression equation for this species was significantly different ($P < 0.05$) from the isometric value of 3 depicting a positive allometric growth.

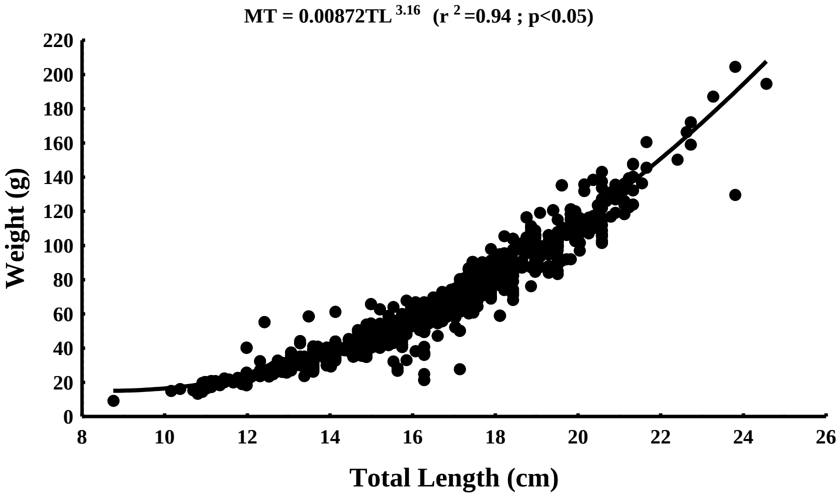

Figure 3. Length Weight Relationship of *Brachydeuterus auritus*

Growth parameters

Figure 4 the restructured length frequency of *Brachydeuterus auritus* growth curves. The asymptotic length (L_∞), and the annual growth coefficient (K) assessed through the K-scan technique ELEFAN I routine, were 24.68 cm and 0.46 $year^{-1}$, respectively. The growth performance index (Ø') was calculated to be 2.45, the age at zero length was estimated to be - 0.38 years and the longevity (t_{max}) was 6.15 years. The Von Bertalanffy equation for growth in length of *Brachydeuterus auritus* derived from the parameters obtained in the present study is written as follows:

$$TL_t = 24.68 * (1 - e^{-0.46(t-0.38)})$$

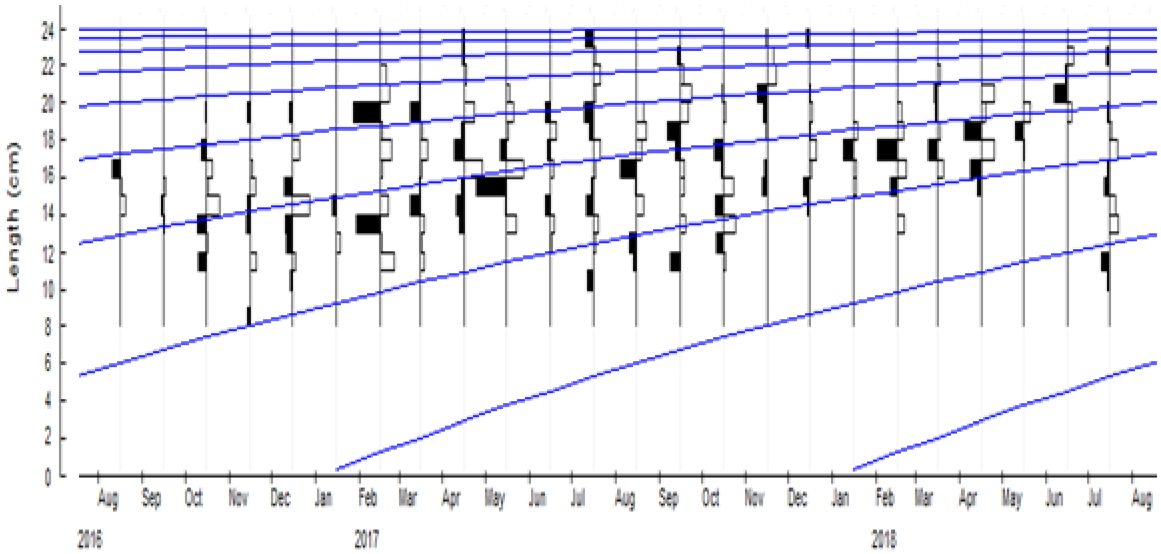

Figure 4. The length-frequency data and the growth curves for *Brachydeuterus auritus*

Mortality rates and Exploitation ratio

The total mortality rate (Z), natural mortality rate (M) and fishing mortality rate (F) were esteemed as respectively 1.84 $year^{-1}$, 1.10 $year^{-1}$ and 0.74 $year^{-1}$ (Fig. 5). The exploitation rate (E) was 0.40 which was lower than the E_{max} of 0.75 obtained from the selection curve, indicating under exploitation of the species *Brachydeuterus auritus*. The fishing mortality rate (F) was above the precautionary target reference point (F_{opt} = 0.55 $year^{-1}$) and slightly equal to the precautionary limit reference point (F_{limit} = 0.73 $year^{-1}$)

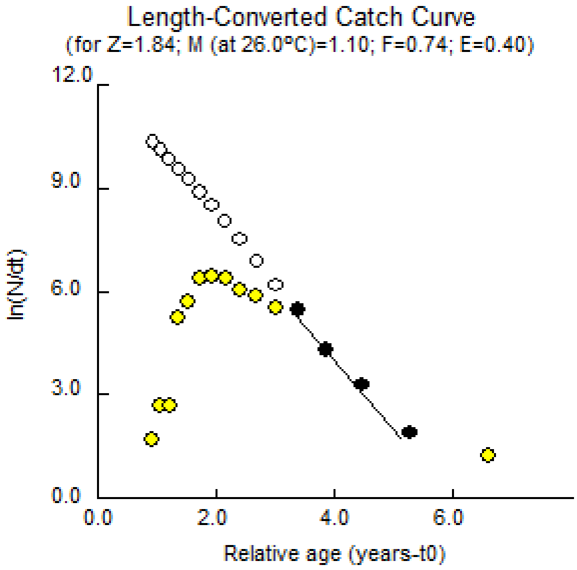

Figure 5. Length-converted catch curve output for *Brachydeuterus auritus*

Recruitment Pattern

The recruitment pattern showed that *Brachydeuterus auritus* was recruited continuously throughout the year in the fishery (Fig. 6). The major recruitment occurred from May to June peaking in June (18.24%) and the minor one was observed in August-September. The mid-length of the lower length class (8.5 cm) was used as a length at first recruitment (Lr) in the sampled data.

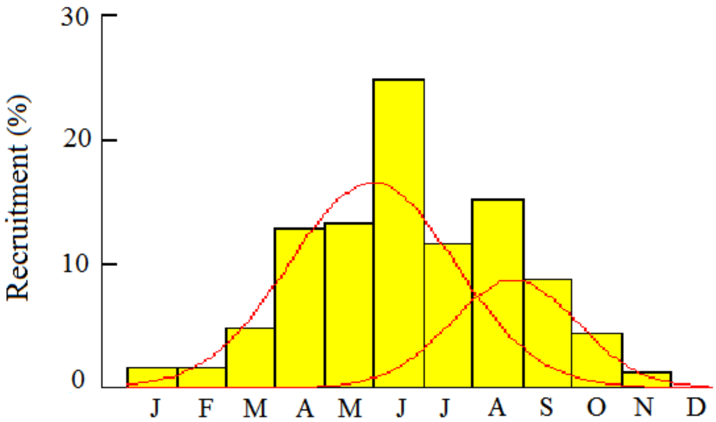

Figure 6. Recruitment pattern of *Brachydeuterus auritus*

Probability of capture

The length at first capture (L_c), length at 50% of catch probability was estimated at 15.28 cm, which corresponds to an age (t_c) of 1.60 years. The lengths at 25 % (Lc_{25}), 75 % (Lc_{75}) of catch probability were estimated as 14.43 cm, and 16.18 cm respectively (Fig. 7).

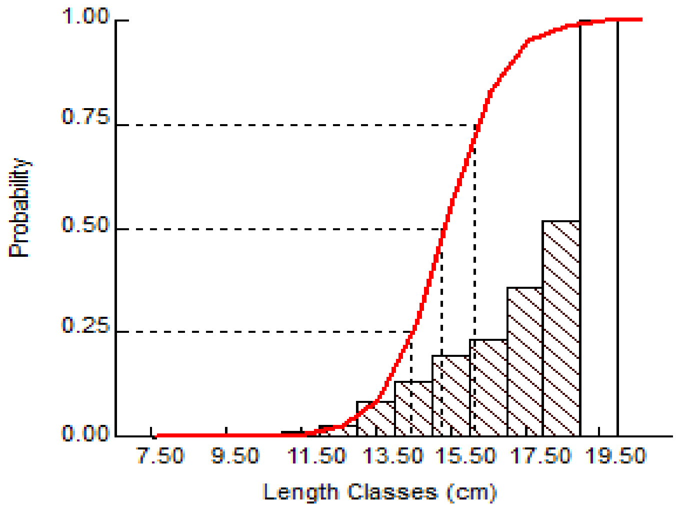

Figure 7. Probability of capture estimation of *Brachydeuterus auritus*

Virtual Population Analysis

The length-structured VPA (Fig. 8) computed by the FISAT program indicated that the main loss in the stock at 8 cm to 14 cm size was due to natural causes. Results revealed that the majority of *Brachydeuterus auritus* in the length group [19-21] cm was more vulnerable to the fishing gear, and the highest peak of fishing mortality (F = 1.07 $year^{-1}$) occurred at length 19.5 cm. The terminal fishing mortality was (Ft = 0.74 $year^{-1}$).

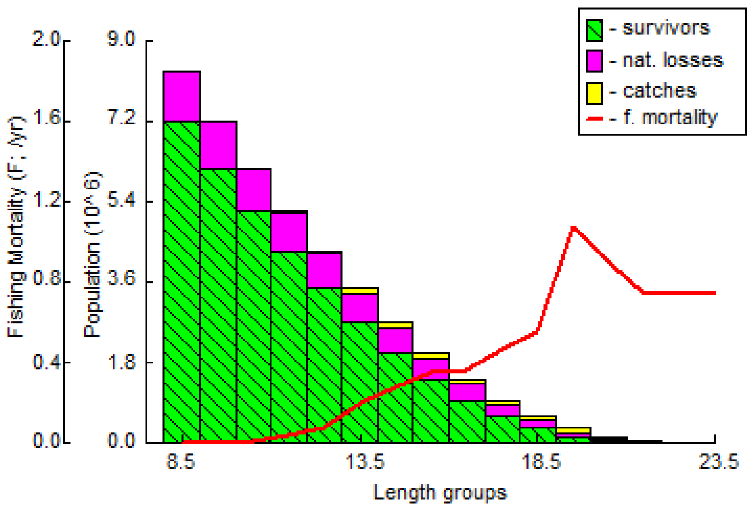

Figure 8. Virtual Population Analysis for *Brachydeuterus auritus*

Relative Yield and Relative Biomass per Recruit

Figure 9 shows the relative Y'/R and B'/R analysis estimated using $Lc_{50}/L\infty$ = 0.691 and M/K = 2.39 as input for the knife-edge selection procedure. The maximum allowable limit of exploitation level (E_{max}) that gives the maximum relative Y'/R was 0.75. The exploitation level ($E_{0.1}$) at which the marginal increase in relative yield per recruit is 10% of its value was 0.67 whereas the exploitation level ($E_{0.5}$) which corresponds to 50% of the relative B'/R of an unexploited stock was 0.40.

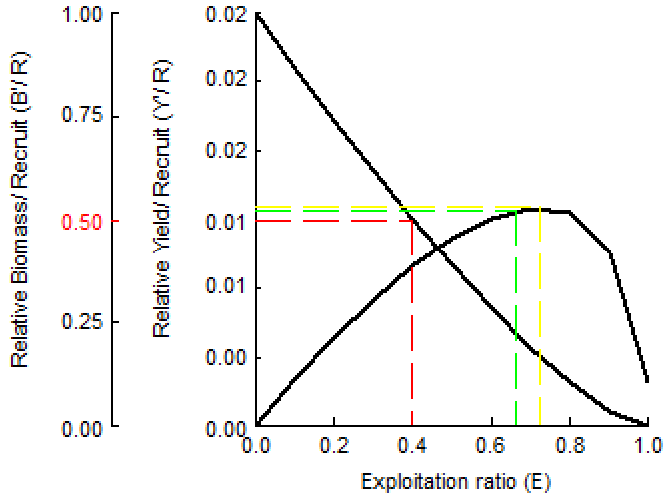

Figure 9. Yield-per-recruit and biomass-per-recruit for *Brachydeuterus auritus*

Discussion

The growth coefficient *b* of the length-weight relationship generally lies between 2.5 and 3.5 (Froese, 2006). Length-weight relationship in this study indicated that *Brachydeuterus auritus* showed positive allometric growth (b = 3.16). Fiogbe et al. (2003) obtained the same growth type from Benin waters for *Brachydeuterus auritus*, contrarily, (Konan et al., 2015) obtained isometric growth for the species in the coastal water of Côte d'Ivoire. However, Adebiyi (2013) in Nigeria and Amponsah et al. (2017) in Ghana reported negative allometric growth. This difference between the values of the allometric coefficient b could be explained by differences in the environmental factors, the physiological conditions of the fish at the time of sampling (gonad development and nutrient conditions), food competition in the ecosystems, and the different size ranges observed as underlined by Froese (2006); Kalhoro et al. (2014).

The length at infinity obtained in this study (24.68 cm) was lower than 25.3 cm and 25.2 cm recorded respectively by Barro (1968), and Konan et al.((2015) respectively in Côte d'Ivoire waters suggesting that the stock is relatively exploited at the small size. The length at infinity obtained was higher than the 21.53 cm and 22.30 cm reported by Amponsah et al. (2017) and Samb, (2003) from Ghana and Senegal respectively, indicating possible fishing pressure in these countries.

Further, the growth coefficient K obtained in this study (0.46 $year^{-1}$) is comparable to that obtained by Barro (1968) and Raitt and Sagua (1972), but lower values of K ranging from 0.58 to 0.73 $year^{-1}$ were reported in different study areas by other authors such as Konan et al. (2015); Bannerman and Cowx (2002), Fontana and Bouchereau (1976) and Raitt and Sagua (1972). Further, the growth performance index ($\emptyset' = 2.45$) recorded during the present study is close to those of Bannerman et Cowx (2002) in Ghana ($\Phi' = 2.41$), Samb (2003) in Senegal ($\emptyset' = 2.47$) and relatively lower than the estimate by Konan et al. (2015) and Fontana and Boucherau (1976) in Congo, possibly due to the difference in $L\infty$ and K computational procedure (Dinh et al., 2015). Many studies have documented differences in growth parameters of the same species in different geographical areas, which might be due to the heterogeneity of habitat and diversity of genetics (Parra et al., 2009; Wootton, 1998).

The total and natural mortality estimated in the present study were slightly different from those of Konan et al. (2015), 2.01 year^{-1} and 0.74 year^{-1} respectively, but these estimations were higher than those of Barro (1976) estimated as 1.56 year^{-1} and 0.35 year^{-1} respectively. However, these estimates were lower than those presented by Bannerman and Cowx (2002), Z = 2.58 year^{-1} and M = 1.43 year^{-1} using the same method. The exploitation rate (E) estimated in the present study is higher than the value estimated by Samb (2003) and slightly higher than the one recorded by Konan et al. (2015). However, it is slightly lower than the values estimated by Amponsah et al. (2016) and highly lower than Bannerman and Cowx, 2002. The reason for the variation in these values in different regions may be due to the ecological differences, physiological conditions of fish, feeding variability, fishing pressure, and data resources (Biswas, 1993).

The results obtained from the length-structured VPA analysis shows that the fishing mortality rate was highest for the largest length and low for small-sized fish species. The fishing mortality rates differed about the mean length and varied widely during the lifespan of the fish (Mirza et al., 2012).

Conclusion

This study provides information on the growth and exploitation parameters of *Brachydeuterus auritus* from the coastal waters of Côte d'Ivoire. The recruitment of this species takes place throughout the year. *Brachydeuterus auritus* is a short-lived species of fish with a maximum of 6.15 years. The exploitation rate of 0.40 indicated the stock is not overexploited. Effective measures are necessary to ensure sustainable management to avoid over-exploitation of the stock of this species.

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References

Abbey, L. D., Glover-Amengor, M., Atikpo, M. O., & Howell, N. K. (2017). Proximate and biochemical characterization of burrito (*Bachydeuterus auritus*) and flying gurnard (Dactylopterus volitans). Food Science and Nutrition, 5(3), 369–373. https://doi.org/10.1002/fsn3.401

Adebiyi, F. A. (2012a). Aspects of reproductive biology of big eye grunt Brachydeuterus auritus (Valenciennes, 1832). Nature and Science, 10(2), 19–24. https://doi.org/10.1007/s13398-014-0173-7.2

Adebiyi, F. A. (2012b). Dietary Items and Feeding Habits of Bigeye Grunt Brachydeuterus auritus (Valenciennes, 1832). Journal of Fisheries International, 7(1), 1–5. https://doi.org/10.3923/jfish.2012.1.5

Adebiyi, F. A. (2013). Growth pattern of the big eye grunt Brachydeuterus auritus (Valenciennes, 1832) off Lagos, Nigeria. Indian Journal of Fisheries, 60(3), 9–12. http://docsdrive.com/pdfs/medwelljournals/jfish/2012/1-5.pdf

Ali, F. A., Amponsah, S. K. K., Ofori-Danson, P. K., & Addo, S. (2018). Diets and feeding patterns of Bigeye grunt *Brachydeuterus auritus* Valenciennes, 1831 in Ghana. Elixir Fisheries Sciences, 117, 50425–50427.

Amponsah, S. K. K., Abdulhakim, A., Ofori Danson, P., & Ferni Anyan, K. (2017). Population dynamics of Bigeye grunt, Brachydeuterus auritus (Valenciennes, 1831) in Ghana and management implications. Fisheries and Aquaculture Journal, 08(04), 233. https://doi.org/10.4172/2150-3508.1000233

Amponsah, S. K. K., Ofori Danson, P. K., & Nunoo, F. K. E. (2016). Study of the population parameters of the bigeye grunt, *Brachydeuterus auritus* (Valenciennes, 1831) in Ghanaian coastal waters and its implications for management. International Journal of Fisheries and Aquatic Studies, 4(6), 413–419.

Arra, S., Sylla, S., Zan-Bi, T. T., Loukou, A. G., & Ouattara, M. (2020). Stock assessment and population dynamics of Senegal Jack, Caranx senegallus Cuvier, 1833, from industrial fishery of Cote d'Ivoire (West Africa). Agronomie Africaine, 32(1), 37–49.

Asabere-Ameyaw, A. (2001). Observations on the reproductive biology and recruitment of the bigeye grunt, *Brachydeuterus auritus* (Pisces: Haemulidae), in Ghana. Journal of the Ghana Science Association, 3(3), 14–21. https://doi.org/10.4314/jgsa.v3i3.17760

Bannerman, P. O., & Cowx, I. G. (2002). Stock assessment of the big-eye grunt (Brachydeuterus auritus, Val.) fishery in Ghanaian coastal waters. Fisheries Research, 59(1–2), 197–207. https://doi.org/10.1016/S0165-7836(01)00404-0

Barro, M. (1968). Première estimation sur la croissance des Brachydeuterus auritus (Val. 1834) en Côte d'Ivoire. In ORSTOM Document Scientifique Provisoire Centre d'Abidjan: Vol. N° 31 (Issue Novembre). http://www.documentation.ird.fr/hor/fdi:12929

Barro, M. (1976). Contribution à l'étude de la biologie et de la dynamique des populations de Brachydeuterus auritus, Val. 1831 (Téléostéen, Pomadasys) au large de la Côte d'Ivoire [Université Pierre et Marie curry Paris VI France]. http://www.sudoc.fr/042108349

Beverton, R. J. H., & Holt, S. J. (1957). On the Dynamics of Exploited Fish Populations. In Fisheries Investigation Series (Vol. 2, Issue 19).

Biswas, S. P. (1993). Manual of method in fish biology. South Asian Publishers Pvt. Ltd.

Colin, C. (1988). Coastal upwelling events in front of the ivory coast during the FOCAL program. Oceanologica Acta, 11(2), 125–138.

DAP. (2011). Annuaire des statistiques de l'aquaculture et des pêches.

DAP. (2017). Annuaire des statistiques de l'aquaculture et des pêches.

Dinh, Q. M., Qin, J. G., & Tran, D. D. (2015). Population and Age Structure of the Goby Parapocryptes serperaster (Richardson, 1864; Gobiidae: Oxudercinae) in the Mekong Delta. Turkish Journal of Fisheries and Aquatic Sciences, 15(2), 609–618. https://doi.org/10.4194/1303-2712-v15_2_17

FAO. (2020). Marine Resource fact sheets - Bigeye grunt - Côte d'Ivoire, Ghana, Togo and Benin. http://firms.fao.org/firms/resource/13799/en

Fiogbe, E. D., Sohou, Z., Gbaguidi, A., Hounkpe, C., & Dégbé, J.-B. (2003). Morphometric relationships of commercially important species from Benin. In Maria Lourdes Deng Palomares, B. Samb, T. Diouf, J. M. Vakily, & D. Pauly (Eds.), Fish Biodiversity: Local Studies as Basis for Global Inferences. (pp. 25–30). ACP-EU Fisheries Research Report 14.

Fontana, A., & Bouchereau, T. J. (1976). Croissance de Brachydeuterus auritus au Congo. Documents Scientifiques Du Centre ORSTROM de Pointe-Noire, 47, 9. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers11-05/08720.pdf

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22, 241–253. https://doi.org/DOI 10.1111/j.1439-0426.2006.00805.x

Gayanilo, F. C., Sparre, F., & Pauly, D. (2005). FAO-ICLARM Stock Assessment Tools II (FiSAT II). Revised version. User's guide. In FAO Computerized Information Series (Fisheries) (Rev. versi, Issue 8). WorldFish Center.

Gayanilo, J. F., Sparre, P., & Pauly, D. (2005). FAO-ICLARM Outils d'evaluation des stocks II (FiSAT II). Version revisee. Guide d'utilisation. http://agris.fao.org/agris-search/search.do?recordID=XF2016039406

Guilland, J. A. (1971). The fish resources of the ocean. In West Byfleet Survey, Fishing News (Books) Ltd, For FAO. https://doi.org/10.1016/0044-8486(72)90050-6

Kalhoro, M. A., Liu, Q., Waryani, B., Panhwar, S. K., & Memon, K. H. (2014). Growth and mortality of brushtooth lizardfish, saurida undosquamis, from Pakistani Waters. Pakistan Journal of Zoology, 46(1), 139–151.

Konan, K. J., Gnahoré, T. J. T., Sylla, S., Lianthuam, L., & Kumar, K. L. (2015). Stock assessment of the bigeye grunt Brachydeuterus auritus (Valenciennes, 1832) in the coastal water of Ivory Coast. International Journal of Agricultural Policy and Research, 3(5), 222–230. https://doi.org/10.15739/IJAPR.043

Kouassi, K. D., D'Almeida, M.-A., Miessan, J. J., Yao, S., N'Douba, V., & Gnahoue, G. (2017). Anatomie et histologie ee l'hepatopancreas chez le male du poisson Brachydeuterus auritus (Haemulidae, Valenciennes, 1831) En Cote D'ivoire. European Scientific Journal, ESJ, 13(24), 289. https://doi.org/10.19044/esj.2017.v13n24p289

Le Loeuff, P., Marchal, E., & Amon Kothias, J.-B. (1993). Environnement et ressources aquatiques de Côte-d'Ivoire. Tome 1, Le milieu marin. Editions de l'ORSTOM.

Mirza, Z. S., Nadeem, M. S., Beg, M. A., & Qayyum, M. (2012). Population status and biological characteristics of common carp, cyprinus carpio, in Mangla reservoir (Pakistan). Journal of Animal and Plant Sciences, 22(4), 933–938.

Moreau, J., & Cuende, F. xavier. (1991). On improving the resolution of the recruitment patterns of fishes. Fishbyte, 1, 45–46.

Munro, J. L., & Pauly, D. (1983). A simple method for comparing the growth of fishes and invertebrates. Fishbyte, The WorldFish Center, 1(1), 5–6. https://ideas.repec.org/a/wfi/wfbyte/38125.html

Parra, I., Almodóvar, A., Nicola, G. G., & Elvira, B. (2009). Latitudinal and altitudinal growth patterns of brown trout Salmo trutta at different spatial scales. Journal of Fish Biology, 74(10), 2355–2373. https://doi.org/10.1111/j.1095-8649.2009.02249.x

Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. Reviews in Fish Biology and Fisheries, 2(4), 321–338. https://doi.org/10.1007/BF00043521

Pauly, D. (1979). Theory and management of tropical multispecies stocks: a review, with emphasis on the Southeast Asian demersal fisheries (No. 1; ICLARM, ICLARM Studies and Reviews). https://digitalarchive.worldfishcenter.org/handle/20.500.12348/3693

Pauly, Daniel. (1980). On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. Journal Du Conseil International Pour l'Exploration de La Mer, 39(2), 175–192. https://academic.oup.com/icesjms/article-abstract/39/2/175/647984

Pauly, Daniel. (1984). Fish population dynamics in tropical waters: a manual for use with programmable calculators (Vol. 8). International center for living aquatic resources management, studies and reviews. 8. ICLARM.

Pauly, Daniel, & Soriano, M. L. (1986). Some Practical Extensions to Beverton and Holt ' s Relative Yield-Per-Recruit Model. In J. L. Maclean, L. B. Dizon, & L. . Hosillo (Eds.), The First Asian Fisheries Forum. Asian Fisheries Society (Issue Jones 1957, pp. 491–495). http://agris.fao.org/agris-search/search.do?recordID=PH8911123

Pauly, Daniel, & Zeller, D. (2017). Comments on FAOs State of World Fisheries and Aquaculture (SOFIA 2016). Marine Policy, 77, 176–181. https://doi.org/10.1016/j.marpol.2017.01.006

Raitt, D.S.F., & Sagua, O.V. (1972). Preliminary investigations on the biology of Brachydeuterus auritus (Val. 1831) in Nigeria waters. Proceeding of Symposium on the Oceanography on Fisheries Resources of the Tropical Atlantic, 397–401.

Samb, B. (2003). Contribution à la connaissance de la biologie de Brachydeuterus auritus des eaux sénégalaises. In M L D Palomares, B. Samb, T. Diouf, J. M. Vakily, & D. Pauly (Eds.), Fish biodiversity: Local studies as basis for global inferences (Issue 14, pp. 1–13). ACP-EU Fish Research Report.

Santos, M. N., Gaspar, M. B., Vasconcelos, P., & Monteiro, C. C. (2002). Weight–length relationships for 50 selected fish species of the Algarve coast (southern Portugal). Fisheries Research, 59(1–2), 289–295. https://doi.org/10.1016/S0165-7836(01)00401-5

Schneider, W. (1990). Field guide to the commercial marine resources of the Gulf of Guinea. FAO. http://www.fao.org/3/a-t0438e.pdf

Sedzro, K. M., & Jurado-ruzafa, A. (2018). Determination of the age and growth by Otolithometry of Brachydeuterus auritus off Togolese waters. Environmental and Water Sciences, Public Health & Territorial Intelligence, 2(2), 27–37.

Sparre, P., & Venema, S. C. (1998). Introduction to tropical fish stock assessment. Part 1: Manual. FAO Documento Técnico de Pesca. N° 306.1 Rev. 2.

Sylla, S., Kouakou, K. F., Tia, C. B., Yao, S. S., & Atse, B. C. (2017). The spatial distribution of coastal fish assemblage in Côte d'Ivoire's Exclusive Economic Zone (EEZ), West Africa.

Journal of Applied Biosciences, 108(1), 10519–10530. https://doi.org/10.4314/jab.v108i1.5

Sylla, S., Zan-Bi, T. T., Konan, K. J., Tia, C. B., Kabre, J.-A. T., & Kone, T. (2016). Reproductive biology of big-eye grunt Brachydeuterus auritus in Ivory coast fishery (West Africa). Scientific Journal of Biological Sciences, 5(5), 158–166. https://doi.org/10.14196/SJBS.V5I5.2209

Tesfaye, G., & Wolff, M. (2015). Stock assessment of fishery target species in Lake Koka, Ethiopia. Revista de Biologia Tropical, 63(3), 755–770. https://doi.org/10.15517/rbt.v63i3.16715

Wootton, R. J. (1998). Ecology of teleost fishes (2nd ed.). Kluwer Academic Publishers.