COMU J Mar Sci Fish 2023 6(1): 24-32
https://doi.org/10.46384/jmsf.1231226
e-ISSN: 2651-5326

COMU Journal of Marine Sciences and Fisheries

Journal Home-Page: http://jmsf.dergi.comu.edu.tr Online Submission: http://dergipark.org.tr/jmsf

RESEARCH ARTICLE

Population Dynamics of Seabreams (*Pagrus caeruleostictus, Pagellus bellottii, Dentex angolensis* and *Dentex congoensis*) from the Coast of Ghana, West Africa

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Received: 08.01.2023 /Accepted: 09.05.2023 / Published online: 04.07.2023

Key words:

Seabreams
Growth parameters
Mortality parameters
Fisheries management

Abstract: Stock assessment indicators of *Pagrus caeruloestictus, Pagellus bellotti, Dentex angolensis* and *Dentex congoensis* from Ghana's coastal waters were estimated between July 2018 and June 2019. Total length measurements of 2489 samples were collected from some selected coastal communities along the Greater Accra region of Ghana and analyzed using FISAT II Tool. The asymptotic length (L_∞) for *P. caeruleostictus, P. bellottii, D. angolensis* and *D. congoensis* was 39.9 cm, 31.5 cm, 31.5 cm and 28.4 cm, respectively. The growth rate (K) was 0.18 yr^{-1} for *P. caeruleostictus,* 0.36 yr^{-1} for *P. bellottii,* 0.75 yr^{-1} for *D. angolensis* and 0.83 yr^{-1} for *D. congoensis*. The current exploitation rate (E) for *P. caeruloestictus, P. bellotti, D. angolensis* and *D. congoensis* was above the optimum level of 0.5, indicating that these species are facing high fishing pressure. To ensure sustainable management of the overexploited fish species, the need for relevant management measures such extension of the closed fishing season, reduced fishing effort and others are urgently required.

Anahtar kelimeler:

Mercan balıkları
Büyüme parametreleri
Ölüm parametreleri
Balıkçılık yönetimi

Batı Afrika, Gana Kıyılarında Mercan Balıklarının (*Pagrus caeruleostictus, Pagellus bellottii, Dentex angolensis* ve *Dentex congoensis*) Popülasyon Dinamikleri

Öz: Gana'nın kıyı sularından *Pagrus caeruloestictus, Pagellus bellotti, Dentex angolensis* ve *Dentex congoensis*'in stok değerlendirme göstergeleri Temmuz 2018 ile Haziran 2019 arasında tahmin edilmiştir. Gana'nın Greater Accra bölgesi boyunca seçilmiş bazı kıyı topluluklarından 2489 bireyin uzunluk ölçümleri toplanmış ve FISAT II programı kullanılarak analiz edilmiştir. *P. caeruleostictus, P. bellottii, D. angolensis* ve *D. congoensis* için asimptotik uzunluk (L_∞) sırasıyla 39.9 cm, 31.5 cm, 31.5 cm ve 28.4 cm idi. Büyüme oranı (K) *P. caeruleostictus* için 0.18 $yıl^{-1}$, *P. bellottii* için 0.36 $yıl^{-1}$, *D. angolensis* için 0.75 $yıl^{-1}$ ve *D. congoensis* için 0.83 $yıl^{-1}$ idi. *P. caeruloestictus, P. bellotti, D. angolensis* ve *D. congoensis* için mevcut yararlanma oranı (E), bu türlerin yüksek avcılık baskısıyla karşı karşıya olduğunu gösteren optimum seviye olan 0,5'in üzerindeydi. Aşırı avlanan balık türlerinin sürdürülebilir yönetimini sağlamak için, kapalı balıkçılık sezonunun uzatılması, avlanma çabalarının azaltılması ve benzeri yönetim önlemlerine acilen ihtiyaç duyulmaktadır.

Introduction

The family Sparidae, which is also known as seabreams, is a member of the Perciformes order (Khalaf-Allah et al., 2016). In the Atlantic, Indian, and Pacific oceans in tropical and temperate latitudes, seabreams are rarely seen in brackish or freshwater (Khalaf-Allah et al., 2016; Parenti, 2019). They have an oval body with a well-compressed and elevated back. The teeth forms serve as the primary means of identification (Nelson, 1994). Sparid fishes are omnivorous, they eat seaweed and invertebrates (Parenti, 2019). As predators, they regulate how well the coastal environment functions. In 2014, they contributed 6703 tonnes of fishing catch (EUMOFA, 2015; FAO, 2015). In Europe and Africa, seabreams are valuable both ecologically and economically. From the coast of West

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How to cite this article: Amponsah, S.K.K., Asiedu, B., Amarquaye, N. C., Ofori-Boateng, E., Afranewaa, N.A., & Henneh, S. (2023). Population dynamics of Seabreams (*Pagrus caeruleostictus, Pagellus bellottii, Dentex angolensis* and *Dentex congoensis*) from the coast of Ghana, West Africa. COMU J. Mar. Sci. Fish, 6(1): 24-32. doi:10.46384/jmsf.1231226

Africa, species of the Sparidae family including *P. caeruleostictus* and *P. bellotii* are known to be overexploited (Konoyima and Seisay, 2021; Kouame et al., 2020). According to Nunoo et al. (2014), seabreams are one of the marine demersal species that are economically significant in Ghana. Seven species of seabreams, including *Dentex congoenis*, *Dentex angolensis*, *Dentex canariensis*, *Dentex gibbosus*, *Pagellus bellottii*, *Pagrus caeruleostictus* and others, have been identified from Ghana out of the approximately 30 genera and 115 known species (Edwards et al., 2001; Nelson et al, 2016). Although they are highly-priced, seabreams are an important food fish that are frequently consumed by low-income households in disadvantaged urban regions in Ghana (USAID, 2009). In Ghana, seabreams are mostly harvested using artisanal fishing gears such as set gillnets, beach seines, hooks and lines, and long lines (Edwards et. al., 2001). Despite the huge economic and ecological importance of seabreams, there are surprisingly few studies done on the dynamics of their population such as growth and mortality parameters. These include findings from studies such as Asabere-Ameyaw, (1996); Amponsah et al, (2016); *Lazar, (2017); and Clottey (2020). Given the importance of these species to food security and the economic well-being of dependent fishing households, this paper aimed at providing more scientific evidence to complement already existing studies by researchers (e.g.Kouame et al. 2020) in other countries for the sustainable management of the assessed species in the sub-Saharan West Africa.

Material and Methods

Study area

The study focused on five important fishing communities along the Greater Accra region of Ghana. These are Kpone, Prampram, Tema, Sakumono and Nungua as shown in Figure 1. Sampling sites were selected based on a two-stage sampling criterion that included geographical isolation and the level of fishing activities. These sampling locations are noted for fishing with fishing activities contributing over 50% as a primary occupation.

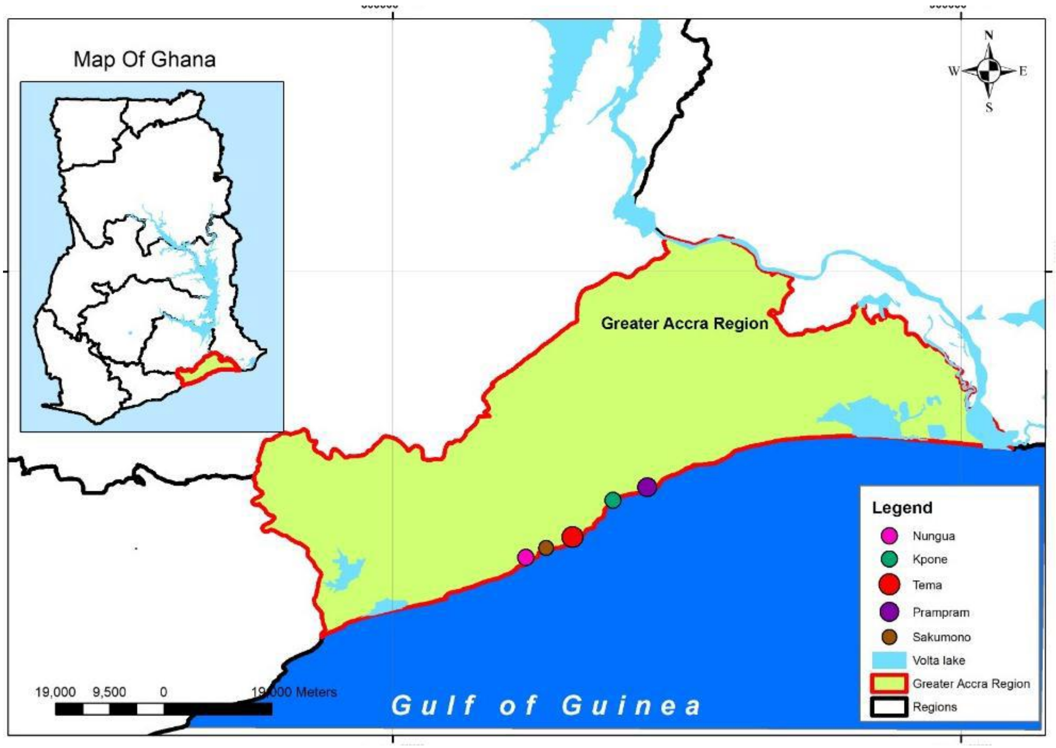

Figure 1. A map of the study area showing sampling areas

Collection of specimens and sampling

The species at the various sampling locations were identified to the species level using the identification keys by Fischer et al. (1981). Samples of *P. caeruloestictus, P. bellotti, D. angolensis* and *D. congoensis* were then collected monthly from randomly selected fishermen who use multifilament fishing gears from fish landing sites for twelve (12) months (i.e., from July 2018 to June 2019). These fishermen predominantly use set gillnets and trawl nets. The samples collected were preserved on ice and transported to the laboratory where measurement for total length (0.1 cm) in centimeters and body weight (0.01g) in grams using a measuring board and electronic scale respectively, was undertaken.

Growth Parameters

Growth parameters including growth rate (K) and asymptotic length (L_∞) which followed the Von Bertalanffy Growth Function (VBGF) were estimated using the ELEFAN option in FiSAT Tool Estimation of longevity (T_{max}) of the species was done using the method:

$T_{max} = 3/K$ (Anato, 1999)

The growth performance index was calculated using the formula:

$\Phi' = 2\log L_\infty + \log K$ (Pauly and Munro, 1984)

The theoretical age at length zero (t_0) followed the equation:

Log 10 (-t0) = -0.3922 – 0.2752 log 10 L∞ - 1.038log 10 K (Pauly, 1979)

Mortality Parameters

The linearized length converted catch curve was utilized in calculating the total mortality (Z) (Pauly and David 1981; Sparre and Venema 1992).

The natural mortality rate (M) was calculated using the procedure:

$M = 4.118\ K^{0.73}\ L_\infty^{-0.333}$ (Then *et al.*, 2015).

Fishing mortality (F) was calculated as;

F= Z – M (Qamar *et al.*, 2016).

The exploitation rate (E) was computed using:

E= F/Z (Georgiev and Kolarov, 1962)

Data analysis

The length distribution frequency of the assessed fish species was pooled together at 1 cm interval. The pooled length data was inserted into the FISAT II Tool for the assessment of the population parameters of specimens of *P. caeruloestictus, P. bellotti, D. angolensis and D. congoensis* that were encountered during the study period (Sparre and Venema 1992).

Results

Length frequency distribution

Tables 1 to 4 show the length distribution of the assessed fish species with an interval of 1 cm. The minimum and maximum lengths for *D. congoenisis* was 12 cm and 27 cm respectively (Table 1). For *P. caeruleostictus*, 6 cm and 38 cm were the minimum and maximum lengths (Table 2). The recorded minimum and maximum lengths for *P. bellottii* was 13 cm and 30 cm respectively (Table 3) while for *D. angolensis*, 14 cm and 30 cm were the recorded minimum and maximum length (Table 4). Overall, the total number individuals for *D. congoensis*, *P. caeruleostictus, P. bellottii* and *D. angolensis* recorded during the study period was 661, 553, 872 and 403, respectively.

Table 1. Monthly length distribution of *D. congoenisis*

Length Class	2018-01-07	2018-03-08	2018-05-09	2018-01-10	2018-07-11	2018-02-12	2019-04-01	2019-05-02	2019-05-03	2019-02-04	2019-04-05	2019-01-06
12	0	0	0	0	0	0	0	1	0	0	0	0
13	0	1	1	1	0	0	6	8	0	0	1	0
14	0	0	2	2	2	0	12	12	0	1	2	0
15	1	4	2	5	3	1	3	3	0	2	0	1
16	2	8	13	12	2	12	0	2	0	2	11	3
17	10	10	9	12	9	12	1	1	0	4	15	17
18	15	5	5	11	10	14	0	0	0	4	6	13
19	8	7	14	12	11	13	0	0	1	9	4	8
20	8	7	10	10	13	9	0	0	5	6	15	22
21	5	9	7	11	8	3	0	0	5	4	7	13
22	4	7	2	2	5	2	0	0	4	0	3	7
23	1	2	1	1	3	1	1	0	0	0	2	3
24	2	1	1	0	0	0	4	0	0	0	1	2
25	1	0	0	0	0	0	4	0	0	0	0	0
26	0	0	0	0	0	0	1	0	0	0	1	0
27	0	0	0	0	0	0	1	0	0	0	0	0

Table 2. Monthly length distribution of *P. caeruleostictus*

Length Class	2018-01-07	2018-03-08	2018-05-09	2018-01-10	2018-07-11	2018-02-12	2019-04-01	2019-05-02	2019-05-03	2019-02-04	2019-04-05	2019-01-06
6	2	0	0	0	0	0	0	0	0	0	0	0
7	2	0	0	0	0	0	0	0	0	0	0	0
8	7	0	0	0	0	0	0	0	0	0	0	2
9	2	0	0	0	0	0	0	0	0	0	0	1
10	3	0	0	0	0	0	0	0	0	0	0	0
11	3	0	0	0	1	0	0	0	0	0	0	2
12	2	0	0	0	0	0	0	0	2	0	0	1
13	4	1	5	1	1	0	0	0	1	0	0	4
14	1	0	2	1	0	0	2	0	0	4	0	1
15	1	0	4	18	4	2	3	1	1	2	0	0
16	0	1	5	9	3	2	1	0	3	0	0	0
17	1	0	4	6	1	3	1	1	4	0	1	0
18	0	0	9	3	2	4	0	0	6	4	1	1
19	1	1	2	3	8	4	2	0	2	3	2	2
20	1	0	3	4	5	4	6	2	3	4	4	1
21	0	1	0	10	3	6	0	5	5	7	5	1
22	7	1	4	3	2	4	1	4	0	2	1	2
23	0	0	4	4	4	4	2	2	0	3	4	3
24	5	3	4	3	2	9	4	1	3	3	7	3
25	5	2	3	3	1	1	8	0	3	1	4	3
26	4	1	4	4	2	2	2	0	1	3	1	3
27	5	1	2	2	0	0	2	1	2	1	1	0
28	4	2	0	1	1	0	1	2	3	2	0	2
29	5	0	1	1	0	2	4	1	3	3	2	1
30	3	1	0	1	1	0	0	0	3	0	0	1
31	4	0	0	0	0	0	0	2	1	0	0	1
32	1	3	0	0	0	0	0	0	1	1	1	0
33	1	1	0	0	0	0	0	3	0	2	0	0
34	1	0	0	0	0	0	0	2	0	1	0	0
35	0	3	0	0	0	0	0	0	0	0	1	0
36	0	0	0	0	0	0	0	1	0	1	0	0
37	0	1	0	0	0	0	0	0	0	1	0	0
38	1	0	0	0	0	0	0	0	0	0	1	0

Table 3. Monthly length distribution of *P. bellottii*

Length Class	2018-01-07	2018-03-08	2018-05-09	2018-01-10	2018-07-11	2018-02-12	2019-04-01	2019-05-02	2019-05-03	2019-02-04	2019-04-05	2019-01-06
13	0	0	2	0	0	0	2	0	0	0	0	0
14	0	0	1	2	0	0	2	0	1	0	0	0
15	1	1	1	0	2	0	3	2	3	0	1	1
16	0	6	1	3	3	0	2	0	6	4	4	1
17	5	12	2	6	6	1	2	5	7	8	18	12
18	6	20	2	19	14	4	8	7	6	6	25	14
19	8	7	4	22	15	9	9	4	13	11	4	19
20	7	8	6	18	12	6	9	7	4	8	9	15
21	10	10	9	9	8	7	11	2	2	10	14	20
22	9	8	9	1	11	14	16	1	2	4	3	10
23	4	9	10	2	6	12	13	0	0	5	2	6
24	3	3	1	2	3	5	2	0	0	4	6	3
25	4	5	0	3	2	5	0	0	1	0	0	3
26	2	1	1	1	3	6	0	0	0	3	1	1
27	0	1	0	0	5	6	0	0	0	2	0	2
28	1	1	0	0	1	2	0	1	0	0	0	0
29	0	0	0	0	0	1	0	0	0	0	1	0
30	0	0	0	0	0	1	0	0	0	0	0	0

Table 4. Monthly length distribution *of D. angolensis*

Length Class	2018-01-07	2018-03-08	2018-05-09	2018-01-10	2018-07-11	A2018-02-12	2019-04-01	2019-05-02	2019-05-03	2019-02-04	2019-04-05
14	0	0	0	0	1	0	0	0	0	0	1
15	0	1	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	1	1
17	1	0	0	0	1	0	0	0	0	4	1
18	0	5	0	2	1	5	0	0	0	1	4
19	3	5	2	2	1	6	0	0	2	7	3
20	6	7	3	3	0	5	1	0	2	6	4
21	8	6	1	0	0	5	4	5	7	6	26
22	6	2	1	2	8	11	2	7	6	6	16
23	7	1	1	3	10	6	4	0	1	4	3
24	4	2	4	1	7	6	2	0	2	3	0
25	4	1	2	1	6	5	7	0	1	3	0
26	4	2	5	0	3	3	6	0	1	0	0
27	4	1	0	0	2	1	3	0	3	1	1
28	5	0	0	0	8	1	0	0	5	0	0
29	0	1	1	0	1	0	0	0	1	0	2
30	1	2	0	0	1	0	0	0	0	0	0

Growth parameters

The restructured length-frequency for the four species with superimposed growth curves is shown in Figure 2. The asymptotic lengths (L_∞) for *P. caeruleostictus*, *P. bellotti*, *D. angolensis* and *D. congoensis* were 39.9 cm, 31.5 cm, 31.5 cm and 28.4 cm, respectively (Table 1). The growth rates (K) were recorded as 0.18 yr^{-1}, 0.36 yr^{-1}, 0.75 yr^{-1} and 0.83 yr^{-1} for *P. caeruleostictus*, *P. bellotti*, *D. angolensis* and *D. congoensis* respectively. The growth performance index (Φ′) was 2.50, 2.76, 2.60 and 2.80 for *P. caeruleostictus*, *P. bellotti*, *D. angolensis* and *D. congoensis* respectively. The age at zero length (t_0) was -0.87, - 0.45, - 0.20 and - 0.21 for *P. caeruleostictus*, *P. bellotti*, *D. angolensis* and *D. congoensis*, respectively.

Length at capture

The estimated length at first capture (Lc_{50}) for *P. caeruleostictus*, *Pagellus bellotti*, *D. angolensis* and *D. congoensis* was 17.3 cm, 16.2 cm, 17.9 cm and 16.3 cm respectively (Figure 3).

Mortality parameters

The instantaneous total mortality rate (Z) was estimated using the linearized length-converted catch curve as shown in Figure 4. The total mortality rate (Z), fishing mortality rate (F), and natural mortality rate (M) for *P. caeruleostictus* were 1.03 yr^{-1}, 0.68 $yr^{-1}$and 0.35 yr^{-1} respectively. Estimates of total mortality rate (Z), fishing mortality rate (F), and natural mortalityrate (M) for *P. bellotti* were 1.42 yr^{-1}, 0.80 $yr^{-1}$and 0.62 yr^{-1}, respectively (Table 1). For *D. angolensis*, total mortality rate (Z), fishing mortality rate (F), and natural mortalityrate (M) were 2.24 yr^{-1}, 1.19 yr^{-1} and 1.05 yr^{-1}, respectively. For *D. congoensis*, total mortality rate (Z), fishing mortality rate (F), and natural mortality rate (M) were 3.65 yr^{-1}, 2.47 yr^{-1} and 1.18 yr^{-1} respectively. The current exploitation rate (E) for *P. caeruleostictus*, *P. bellotti*, *D. angolensis* and *D. congoensis* were 0.66, 0.56, 0.53 and 0.68, respectively (Table 5).

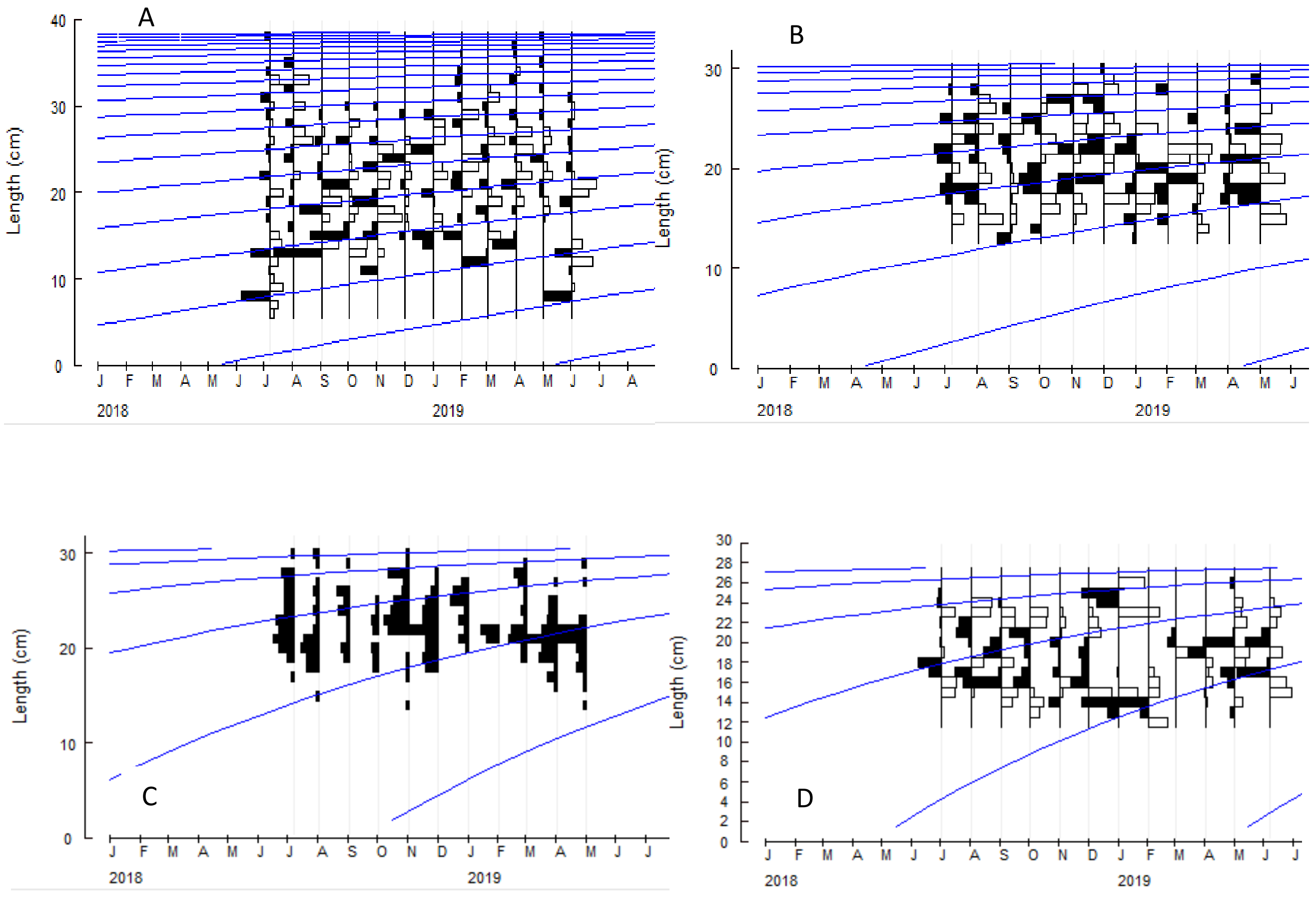

Figure 2. Reconstructed length-frequency distribution with growth curves for A) *Pagrus caeruleostictus*, B) *Pagellus bellotti* C) *Dentex angolensis* and D) *Dentex congoensis* (July 2018 – June 2019, Ghana)

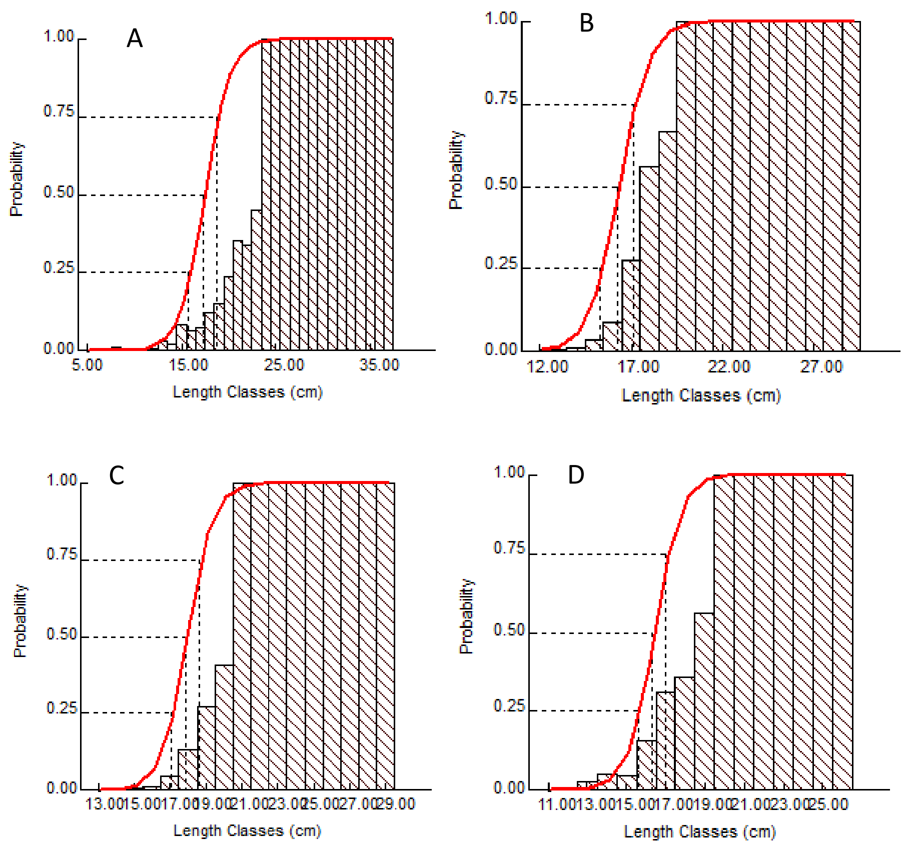

Figure 3. Length at first capture for A) *Pagrus caeruloestictus*, B) *Pagellus bellotti*, C) *Dentex angolensis*, and D) *Dentex congoensis* (July 2018 – June 2019, Ghana).

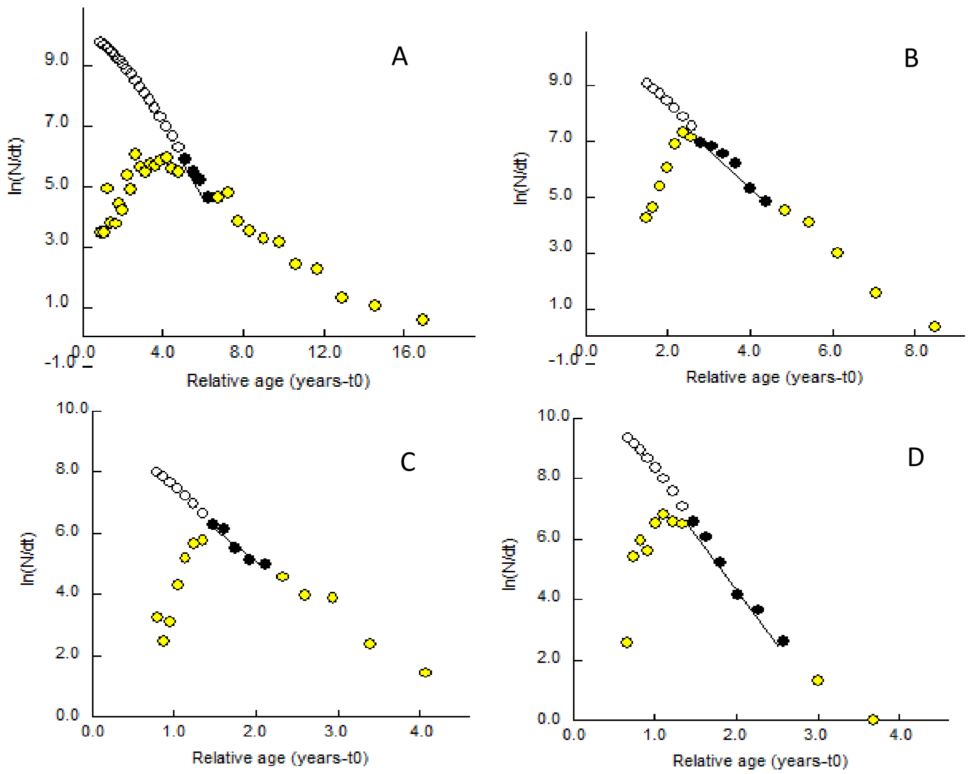

Figure 4. Linearized length-converted catch curve for the estimated total mortality A) *Pagrus caeruloestictus*, B) *Pagellus bellotti*, C) *Dentex angolensis and* D)*Dentex congoensis* (July 2018 – June 2019, Ghana).

Discussion

There has not been much information on the population dynamics of Sparidae species in the marine waters of Ghana. The present study provides information for sustainable management of these species within the Sparidae family. The growth rates for *P. caeruleostictus* and *P. bellottii were* less than 0.5 yr^{-1} that implies that these species showed signs of slow growth, while the growth rate for *D. congoensis* and *D. angolensis* was higher than 0.5 yr^{-1} that also implied that these species are of fast growth. The growth rate of *P. bellottii* recorded from the other studies such as Kuaome et al. (2021) and Amponsah et al., (2016) (both recorded K = 0.42 yr^{-1}), compared favourably with estimates from the current study (i.e. K = 0.45 yr^{-1}). However, Asabere-Ameyaw and Blay (1999) recorded a higher growth rate of K = 0.53 yr^{-1} than obtained from the present study. For *P. caeruleostictus*, Clottey (2020) documented a growth rate of 0.52 yr^{-1} respectively from the coastal waters of Ghana, which was higher than the estimate recorded from the current study. In addition, the asymptotic length of *P. bellottii* recorded from the current study ($L\infty$ = 31.5 cm) was lower than estimates by Asabere-Ameyaw and Blay, (1999) and Kouame et al. (2021) who obtained $L\infty$ to be 34.2 cm and 31.7 cm respectively, but higher than the estimate recorded by Amponsah et al., 2016 (i.e. $L\infty$ = 19.4 cm). Clottey (2020) estimated a relatively high asymptotic length ($L\infty$= 52.7 cm) for *P. caeruleostictus* than obtained from the current study. The growth parameters may have been affected by factors such as the genetic makeup of the species, which determines its growth potential, diet type and its utilization, and overfishing (Park et al., 2013; Sambo & Haruna, 2012).

The fishing mortality for all the assessed fish species in the present study was higher than the corresponding natural mortality rate (M). Findings by Kouame et al (2020); Amponsah et al. (2016) and Asabere & Blay (1996) revealed similar observation, which suggest the superiority of fishing activities as the main predictor of decline in the population of these fish species. Furthermore, the exploitation rate (E) of all the species from the current study was above the optimum level of 0.5, indicating that these species along the coast of Ghana are overexploited. Likewise, *Asabere & Blay (1999) and *Kouame et al. (2020) observed overexploitation of *P. bellottii* with E values of 0.70 and 0.67, respectively.

Conclusion

The study assessed some aspects of population dynamics of commercially important species of seabreams in Ghana. *P. caeruloestictus* and *P. bellottii* exhibited slow growth while *D. angolensis* and *D. congoensis* portrayed fast growth. The current exploitation rate for all the species was higher than the threshold for sustainable fishing. Given this, there is the need for the implementation and enforcement of relevant fisheries management measures such extension of the closed fishing season, reduced fishing efforts and enhanced compliance to these relevant measures by appropriate authorities. Furthermore, there is a need to conduct further studies on the biology of these and other sparids in the coastal waters of Ghana for effective regional and national management.

Acknowledgement

The authors are grateful to ESL Ltd for permitting the use of the data obtained.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

Samuel K.K Amponsah: conception and design of the study, supervision, data collection, manuscript preparation, critical revision of the article. Berchie Asiedu, Nii Amarque Commey and Nana Ama Afranewaa: Critical revision of the article, manuscript preparation, data analysis and interpretation. Samuel Henneh and Emmanuel Ofori-Boateng: data analysis and interpretation.

Ethics Approval

Ethics committee approval is not required for this study.

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