Sex Ratio, Spawning Cycle, and Size at Maturity of Bluespotted Seabream (Pagrus Caeruleostictus, Val 1987) From the Coast of Ghana

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Abstract

A reproductive study was carried out on 558 individuals of Bluespotted seabream,*Pagrus caeruleostictus* from the coast of Ghana, aiming to enhance understanding of some aspects of their reproductive biology. These specimens were sampled monthly and analysed for sex ratio, spawning cycle and size at first maturity. Among the individuals, 391 (70.07%), were males and 167 (29.92%) were females, indicating a skewed sex ratio of 1 female to 1.29 males. Analysis of maturity stages frequency revealed that both male and female individuals was characterized by five distinct stages (I-V). The highest spawning peak for females was in March, whereas the highest spawning peak observed for the males was in April. Additionally, males dominated the larger size classes which confirms the protogynous nature of *P. caeruleostictus*. The size at first maturity was 30.0 cm and 27.2 cm for females and males respectively. From the study, minimum landing size of the species enshrined in Fisheries Regulation of Ghana should be revised. This would enhance the sustenance of the species within the marine waters of Ghana.

Running title: Reproductive biology of Bluespotted seabream.

Keywords: Sparidae, maturity stages, population dynamics, fisheries management, reproductive biology.

Introduction

Reproductive studies play a crucial role in understanding the biology and ecology of a species, which is essential for effective fisheries management and conservation (Lowerre-Barbieri et al. 2011). Reproductive studies provide insights into the population dynamics, including aspects such as age at sexual maturity, spawning frequency, and reproductive output. Understanding these parameters is vital for estimating population growth rates and predicting the sustainability of the population under different fishing pressures (Lowerre-Barbieri 2019). The reproductive biology of marine organisms is a fundamental aspect of their life history strategies, influencing population dynamics, genetic diversity, and overall ecosystem health. Among these marine organisms, seabream (Sparidae family) play a crucial role in both commercial fisheries and marine ecosystems (Correia et al. 2012). The seabream species in Ghana are exploited by the artisanal, semi-industrial, and industrial fisheries, using gears such as the set-nets, hook and line (“lagas”), beach seines, and trawl nets (Koranteng 2001; Nunoo et al. 2014). The artisanal fisheries use the hook-and-line method which accounts for a greater percentage of the landings due to the inability to conduct trawling in a sizeable part of the continental shelf because of its rocky nature (Ayode 2011). They are rated as one of the major commercially important and high-valued demersal fishes that are exploited by the semi-industrial and artisanal fleets, contributing significantly to local fish supply in the country and the national economy by providing livelihood support, and poverty reduction, employment, food security, fishery product exports and foreign exchange earnings, and GDP (BoG 2008). Despite their ecological and economic significance, several knowledge gaps persist regarding the reproductive biology of seabream species in Ghana. This lack of understanding hinders effective conservation and management efforts, which are essential to maintain sustainable populations and safeguard marine biodiversity (Kuoami et al. 2018).

Materials and Methods

Study Area

The Tema Harbour, located in Ghana, is one of the large harbors in West Africa and has a long history of urbanization and industrialization within its catchments (Botwe et al 2018). The port of Tema was built in 1952 and has an entrance of 800 feet wide with a depth of at least 35 feet. The area of enclosed water in the main port is 410 acres with a Fishing Harbour adjacent to the port at the eastern end. It also handles trade for industrial and commercial companies that import and export various goods such as petroleum, cement, food, metals, and textiles (Khadi, 2015). The study focused on three offshore stations, with coordinates 05°40'32.91"N, 000°09'57.94"E, 05°35'32.78"N, 000°04'12.38"E and 05°34'54.59"N, 000°02'31.64"W as shown in Figure 1.

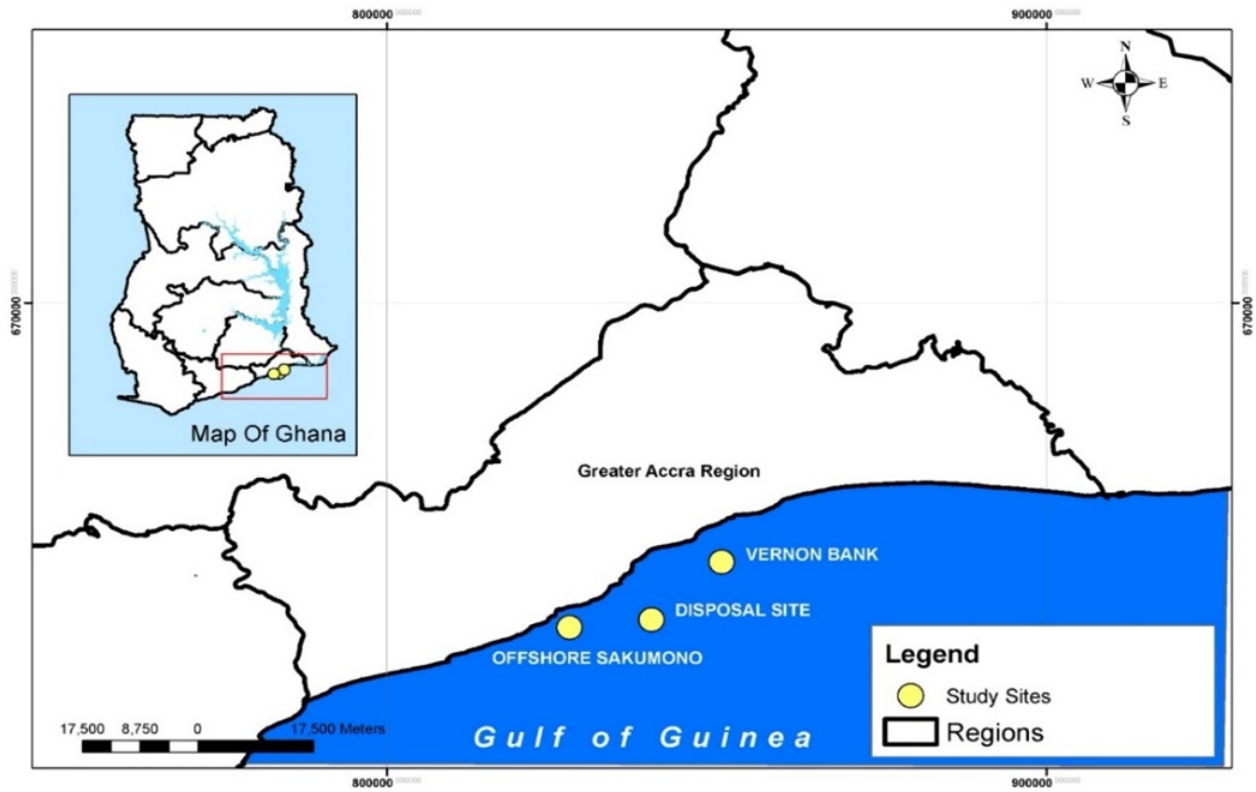

Figure 1. Sampling areas around Tema harbor.

Data collection

In total 558 samples of *P. caeruleostictus* were collected through experimental fishing using a trawling vessel with a bottom trawl made of a multifilament net of cod-end mesh size of 1 inch (0.25 cm) (diagonal stretch) between January to December 2019. The samples were sorted out according to species using Kwei & Ofori-Adu (2005) identification keys, and thereafter transported on ice to the laboratory at the Department of Marine and Fisheries Science University of Ghana for further analysis. At the laboratory, each specimen was measured for total length (TL) to the nearest millimeter, total weight (TW) and gonad's weight to the nearest 0.01g. Sex was recorded after opening the abdominal cavity and maturity stages were determined.

Methods

Sex ratio of males and females was monthly calculated according to the following formula:

$$\text{Sex ratio } F = (F/(F+M)) \times 100 \text{ and } M = (M/(F+M)) \times 100,$$

where F: number of females, M: number of males. The Chi-square test (χ^2) was performed to determine whether there were statistically significant differences between female and male ratios (Heithaus 2001).

The maturity stages of gonads in female individuals were determined macroscopically based on morphology and color of gonads according to (Holden & Raitt 1975) as follows: stage I, immature; stage II immature or in resting phase; stage III, pre-spawning; stage IV, spawning; stage V, post-spawning. To determine the spawning cycle, the Gonadosomatic Index (GSI) was calculated as follows:

GSI = (gonad weight * 100)/ body weight × (King 1995).

Size at first maturity (Lc_{50}) was estimated for females from the percentages of mature individuals (stage III, IV) and the proportion of mature individuals in each size class (1 cm intervals) was calculated. A logistic function relating the proportions of mature individuals to total length of the fish (Ghorbel et al 2002) was used. This function of sigmoid shape is expressed as follows:

P = 1/ 1 + e-(b + aTL) (Ghorbel 2002)

where P: proportion of mature individuals; a and b: constants. TL: total length in cm.

Results

Sex ratio

The overall sex ratio was 1:1.29 in favor of females which was significantly different from the theoretical sex ratio 1:1 (χ^2, $P<0.05$). Males were dominant in all the months with high percentage in May, 2019 (Fig. 2). The highest number of female individuals was observed in August 2018, November 2018 and July 2019.

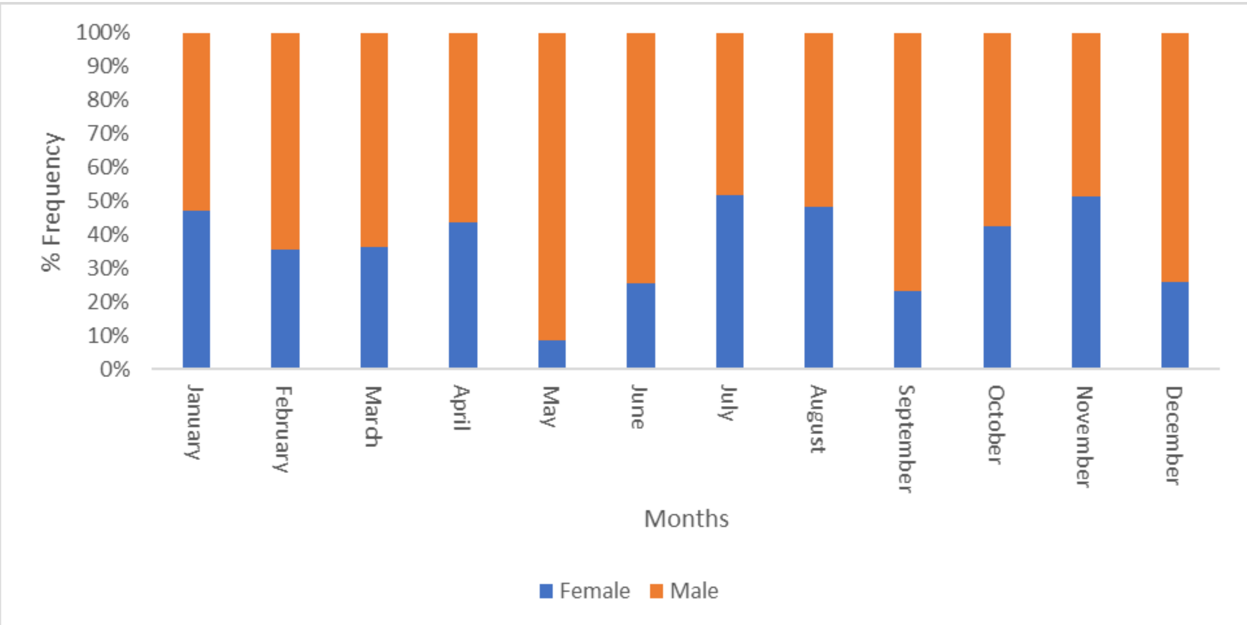

Figure 2. Monthly variation of male and female individuals of *Pagrus caeruleostictus*, Ghana

Table 1. Chi-square analysis of sex ratio based on length measurement

Length interval/cm	M	F	X^2	df	p-value
10	3	0	-	-	-
15	51	15	19.64	1	< 0.01
20	105	48	21.24	1	< 0.01
25	119	81	7.22	1	0.01
30	58	41	1.15	1	0.28
35	11	20	0.62	1	0.43
40	4	2	0.68	1	0.41
45	0	1	-	-	-
50	0	0	-	-	-
55	0	1	-	-	-

Maturity stages

From Fig. 3, the mature and immature stages (I & II) were found throughout the period of this study for both sexes. The highest percentages were recorded in males than female individuals. The maturity stage III and IV were recorded with the highest percentage in females than males for this study whereas highest percentage of maturity stage V was recorded in male individuals of the species (Fig. 3).

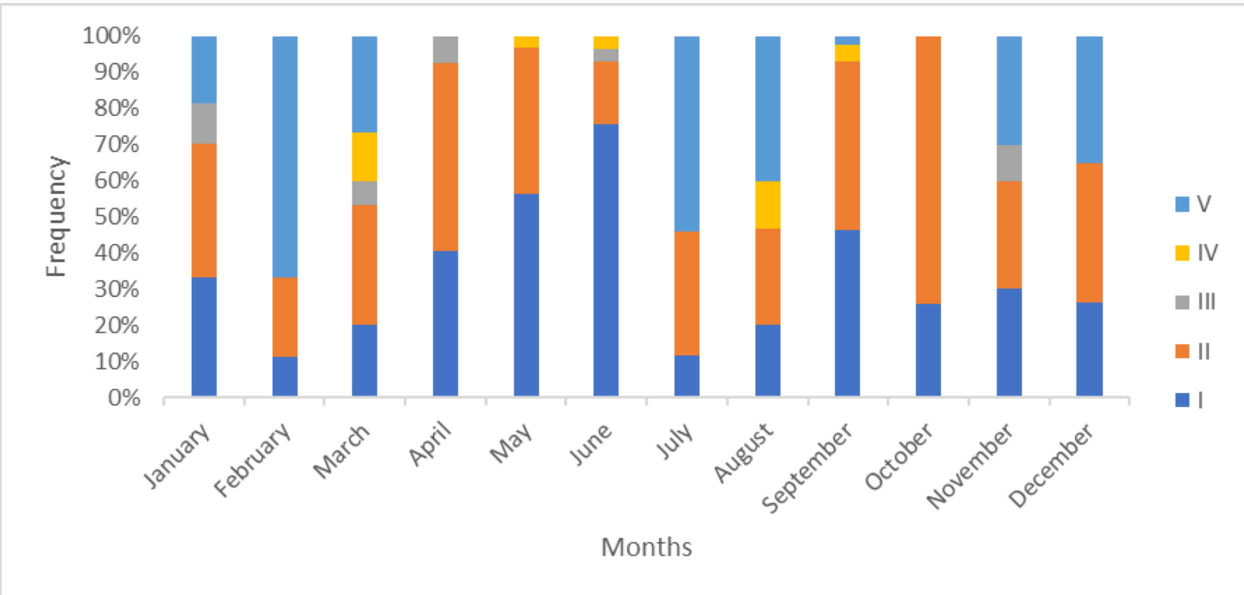

Figure 3. Monthly percentage of maturity stages of male individuals of *P. caeruleostictus,* Ghana

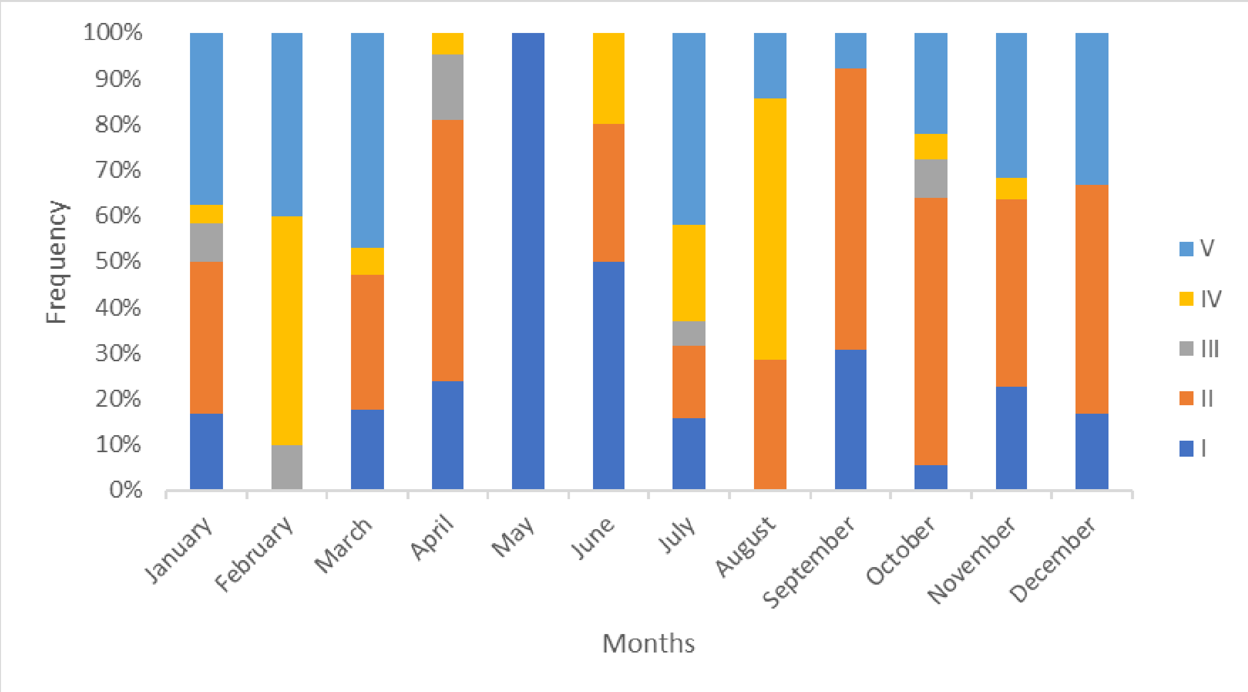

Figure 4. Monthly percentage of maturity stages of female individuals of *P. caeruleostictus*, Ghana

Spawning cycle

For female individuals, the monthly values of GSI ranged between 0.57 and 2.85 in females. From January to May, the mean values reached the highest value in March, a second peak was observed in August between June and September for female individuals. However, GSI values were low from September to December (Fig. 5). A third spawning period was observed from October to December with a peak in October. For male individuals, the monthly values of GSI ranged between from 0.25 to 1.33. From January to June, the mean values reached the highest value in April, a second peak was observed in September between July and October. However, GSI values were low from September to December (Fig. 6). The evolution of mean GSI of males and females shows similar patterns.

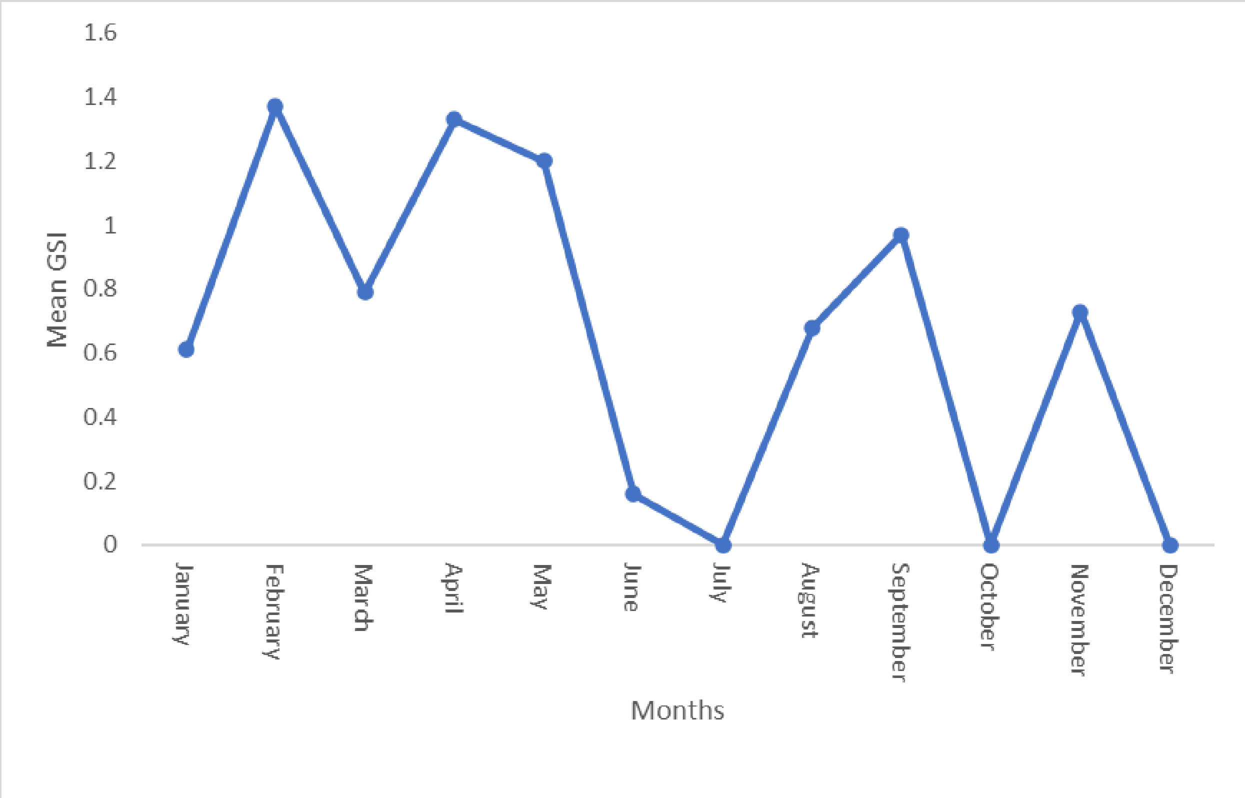

Figure 5. Mean GSI of male individuals *P. caeruleostictus*, Ghana

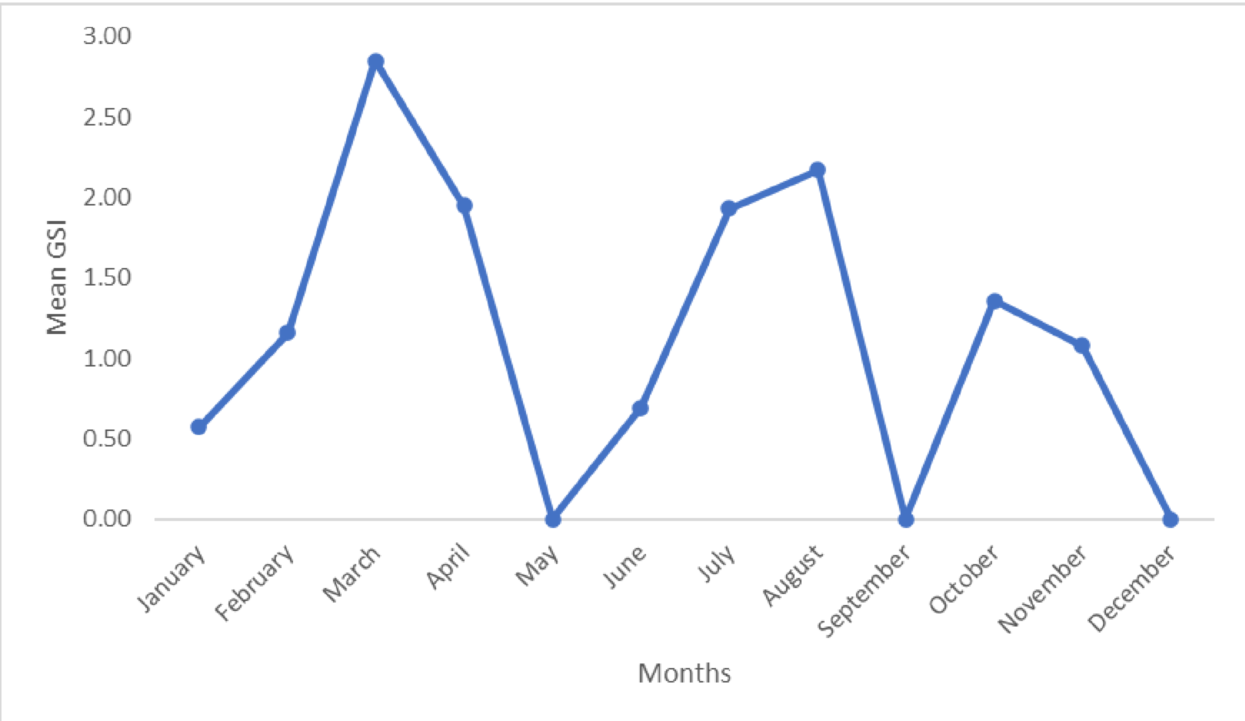

Figure 6. Mean GSI of female individuals *P. caeruleostictus*, Ghana

Size at first maturity

The height at which 50% of the males and females of *P. caeruloestictus* reached maturity was estimated at 27.2 cm (Fig.

7) and 30.0 cm (Fig. 8) respectively.

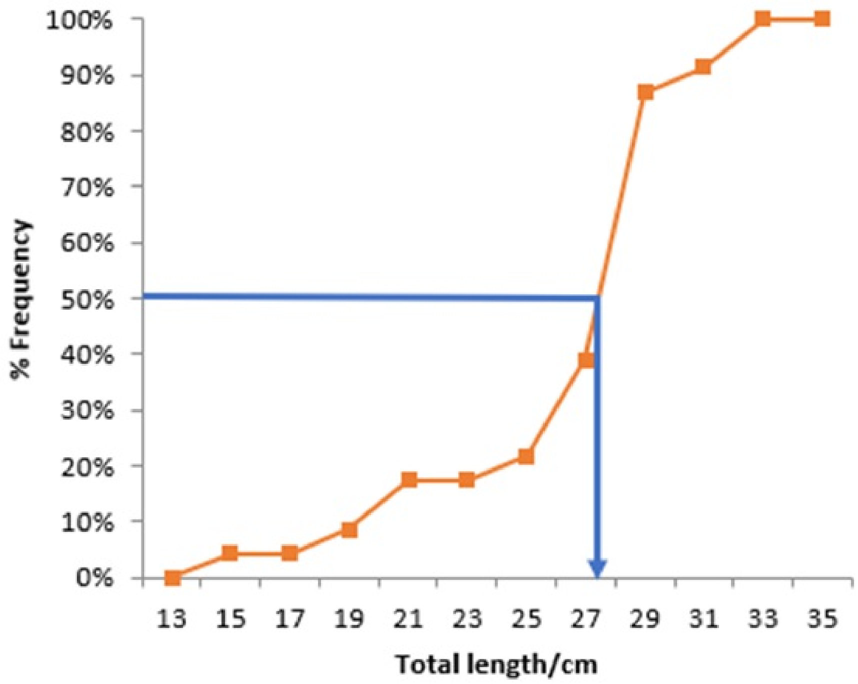

Figure 7. Size at maturity for male individuals of *P. caeruleostictus*

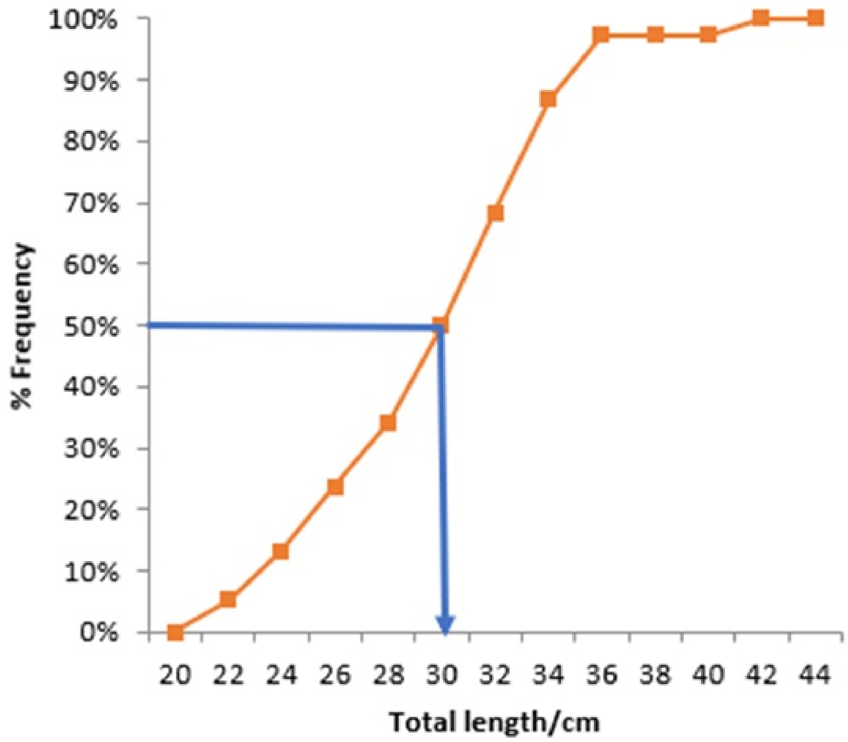

Figure 8. Size at maturity for female individuals of *P. caeruleostictus*

Discussion

From the study, males were numerically more than females, leading to a violation of the theoretical ratio of 1:1 for males and females. Different observation was reported for *P. caeruleostictus* in Tunisia and Ghana in which females were more dominant in small class samples (Clottey 2020; Ismail et al. 2018). However, from the Mauritian waters, Gandega et al. (2022) documented a similar observation where males were more than female individuals of *P. caeruleostictus.* Sex ratio result indicates that males dominated the large sizes (> 15 cm) which was similar to findings by Clottey (2020). This observation is known to be a characteristic of protogynous species where the females should be smaller than the males (Chakroun-Marzouk & Kartas 1987; Ismail et al. 2018).

Maturity stages play a significant role in understanding the reproductive biology of species and provide valuable information about timing and extent of reproduction within their population (Uehara et al. 2022). Frequency distribution of various maturity stages through the annual reproductive cycle indicated the presence of five separated developmental periods for both males and females. Similar finding was generated by Ismail et al. (2018). This assertion has been confirmed by researchers including Ismail et al. (2018) and Chakroun- Marzouk & Kartas (1987). GSI is a physiological factor widely used as an indicator of the reproductive success, it also offers an insight into the spawning behavior of a species (Moslemi-aqdam et al. 2016). GSI results from the study showed three spawning periods including a long spawning period and two short ones. This is contrary to report by Ismail et al. (2018) from the waters of Egypt who indicate that spawning seasons of *P. caeruleostictus* notably occurs twice in a year with the major one in September. Also, Clottey (2020) and Owusu-Boateng (1994) from the waters of Ghana reported that two spawning periods. The existence of the third sampling period may connote the presence of favorable environmental conditions that may support the hatching and larval development for longer periods (El-Sayed & Abdel-Bary 1993; Hadj Taieb et al. 2012). Furthermore, GSI studies from the study showed a higher average GSI value for females than males suggest that *P. caeruleostictus* are of pair spawning (Buxton 1990).

Size at first maturity is essential in estimating mesh size for proper management of fisheries resources (Mehanna 2007). Clottey (2020) from the coastal waters of Ghana revealed 28.0 cm and 36.2 cm for females and males. Also, Owusu Boateng (1994) reported 18.4 cm and 17.2 cm as the size at maturity for male and female individuals respectively from the coast of Ghana. Ismail et al. (2018) from the coast of Egypt recorded length at first maturity of female and male individuals of *P. caeruleostictu*s to be 27 cm and 29 cm respectively. Gandega et al. (2022) from the Mauritanian coast recorded 28.4 cm and 28.6 cm as the length at first maturity for female and male individuals. This observation maybe in variance to finding from the study which could be attributed to changes in environmental conditions, fishing pressure, food quality and availability, variation in sample size and the sizes of the individuals used in computational procedures (Clottey 2020; Saoudi et al. 2017). The differences in the sexual maturity of the sexes could also be attributed to their hermaphroditic behavior and the growth pattern of male and female individuals (Hadj Taieb et al. 2012).

In conclusion, the present work focused on key reproductive aspects of*P. caeruleostictus* from the coast of Ghana. Maturity stages first time using histology in *P. caeruleostictus*. The sex ratio was shifted towards the dominance of males, prolonged spawning seasons with three spawning periods with males maturing earlier than females. Based on size at maturity, the need to revise the minimum landing size through mesh size regulation is essential for the sustenance of this commercial species in the coastal waters of Ghana.

Statements and Declarations

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Authour contribution

Samuel K.K. Amponsah: Conceptualization, methodology, investigation, writing – review and editing. **Berchie Asiedu, Selorm Gbedemah and Henry Apochie**: Writing – review and editing: **Nii Amaquaye Commey**: Investigation, project administration.

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