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ORIGINAL PAPER

Fish catch assessment of hook and line fisheries in Ghana

Évaluation des captures de poissons de pêche à la ligne au Ghana

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Abstract Catch composition is essential for the sustainable management of species. However, studies on hook and line fisheries in Ghana are limited. Given this paucity of information, the study aimed to assess the catch composition of hook and line fisheries along the coast of Greater Accra, Ghana. Data collection was done monthly from August, 2018 – July, 2019 and analyzed for species composition, length frequency distribution and diversity indices using Primer 6 and Microsoft Excel Tool. From the study, 24 species were recorded with *Lutjanus fulgens* and *Brachydeuterus auritus* as the dominant species (i.e. in terms of numbers) due to their eurybathic and other physiological behaviours. Dominant (i.e. in terms of numbers) from the 18 taxonomic families included Sparidae and Carangidae. The mean total length of *Pagrus caeruleostictus*, *Lutjanus fulgens*, *Lethrinus atlanticus*, *Brachydeuterus auritus*, and *Pagellus bellottii* was 19.7 ± 0.4 cm, 16.1 ± 0.2 cm, 16.0 ± 0.2 cm, 16.8 ± 2.3 cm and 19.0 ± 0.2 cm respectively which showed the vulnerability of large-sized individuals to hook and line gears. Based on the findings, there is a need to promote hook and line fishing gear as sustainable fishing gear, as this will ensure the sustenance of valuable marine fish species in Ghana.

Key words : Abundance, Composition, Diversity indices, Fisheries management, Mean length

Résumé La composition des captures des poissons est essentielle pour la gestion durable des espèces. Cependant, les études sur la pêche à la ligne au Ghana sont limitées. Compte tenu de ce manque d'informations, l'étude visait à évaluer la composition des prises des outils de pêche à la ligne et à l'hameçon le long de la côte du Grand Accra, au Ghana. La collecte de données a été effectuée d'août 2018 à juillet 2019 et analysée pour la composition des espèces, la distribution de la fréquence de la longueur et les indices de diversité à l'aide de Primer 6 et de l'outil Microsoft Excel. À partir de l'étude, 24 espèces ont été enregistrées, *Lutjanus fulgens* et *Brachydeuterus auritus* étant les espèces dominantes en raison de leurs comportements eurybathiques et d'autres comportements physiologiques. Ce sont les Sparidae et les Carangidae qui dominent parmi les 18 familles taxonomiques. La longueur totale moyenne de *Pagrus caeruleostictus*, *Lutjanus fulgens*, *Lethrinus atlanticus*, *Brachydeuterus auritus* et *Pagellus bellottii* était respectivement de 19,7 ± 0,4 cm, 16,1 ± 0,2 cm, 16,0 ± 0,2 cm, 16,8 ± 2,3 cm et 19,0 ± 0,2 cm, ce qui montre la vulnérabilité des individus de grande taille aux outils de pêche à l'hameçon et à la ligne. Sur la base de ces résultats, il est nécessaire de promouvoir les outils de pêche à la ligne et à l'hameçon en tant qu'outils de pêche durables, car cela assurera la subsistance d'espèces de poissons marins précieuses au Ghana.

Mots clés : Abondance, Composition, Indices de diversité, Gestion des pêches, Longueur moyenne

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Introduction

Fishing gear is an integral component of fishing without which fisherfolks will not be effective in their fishing activities leading to low fish production for dependent households (Akongyuure *et al.,* 2015). Fishing gears have been grouped into 11 classes, including surrounding nets, seine nets, trawl nets, hooks and lines, gill nets, grapping gears, and wooding gears (He *et al.,* 2021). The application of these gears in the aquatic environment relies on the size and target species, specific habits, and habitat variations and seasons (Bankole *et al*., 2003; Tagago & Ahmed 2011). Fishing gear used in capturing fish from any water bodies in many tropical environments involves traps, hooks and lines, gill nets, trawls, seine nets, lift nets, clap nets, spears, cast nets, entangling nets, and drift nets (Nuhu & Yaro 2005; Davies & Kwen 2012). These tools for harvesting fish in the past were aimed at increasing production, but currently, their usage has played a key role in the overexploitation of stocks which calls for catch assessment studies (Nyemah *et al*., 2017).

In Ghana, hook and line fishing gears are used by fisherfolks in fishing communities such as Dixcove, Anomabo, James Town, Keta, and Kpando Torkor with *Ablennes hians, Brachydeuterus auritus, Dentex angolensis, Dentex congoensis, Dentex gibbosus, Engraulis encrasicolus, Elagatis bipinnulata*, and *IIisha africana* as some of the landed fish species. There are about 1,345 hook and line canoes in Ghana, with sizes ranging from 12.5 m to 16.6 m (FSSD 2022). Hook and line fishing gears use hooks of varying sizes to harvest fish through hooking of the mouth with baited hooks, or by piercing their flesh with unbaited hooks (He *et al.,* 2021). In Ghana, the line unit is used either at one time or in large numbers, targeting large demersal fishes (FSSD 2022). However, studies on the catch assessment including species composition and length variation of dominant species of hook and line fisheries in Ghana are limited.

The paucity of species composition and length-based information from hook and line fishing gears can lead to stress on particular size groups of fish species, facilitate low recruitment of these fish stocks, overfishing, and collapse of these commercially important fish species. Also, an update on the total catch composition of hook and line fisheries will provide information for identifying the potential impacts of this fishing gear and formulate measures to manage the marine fishes of Ghana (Cerbule *et al.* 2022; Dankwa *et al.,* 2014). Therefore, the main objectives of the study were to i) assess the catch composition, ii) the length frequency distribution of dominant species, and iii) diversity indices of hook and line fishing gears in Ghana. Information from the study will aid in the protection of fisheries resources and maximize the economic and nutritional benefits of hook and line fisheries in Ghana.

Materials and Methods

Location of the Study

The study focused on two fishing communities along the coast of Greater Accra region, Ghana, namely Kpone and Tema (Figure 1). Tema serves as the administrative capital of the Tema Metropolitan Assembly and is situated 25 kilometers east of Accra, the national capital. The metropolis shares common boundaries with the Accra Metropolis on the west, the Ga Municipality on the northwest and the Dangme West District on the northern and eastern borders respectively. The main occupation of inhabitants varies from commerce, tourism, hoteliers and fishing. Within the metropolis, Tema fishing port lands annually over 4,000 mt in the past 5 years. There are 7292 fishermen and 682 canoes present (FSSD 2022). Kpone which is a new district was carved out of the Tema Municipal Assembly. The majority of the populace are mainly fishermen (i.e. 410 fishermen) with 118 canoes specializing in the hook and line method of harvesting large demersal species (FSSD 2022). These two sampling locations were selected based on the intensity of hook and line fishing activities as well as geographical isolation. Table 1 shows the coordinates of the two fishing communities used for the study.

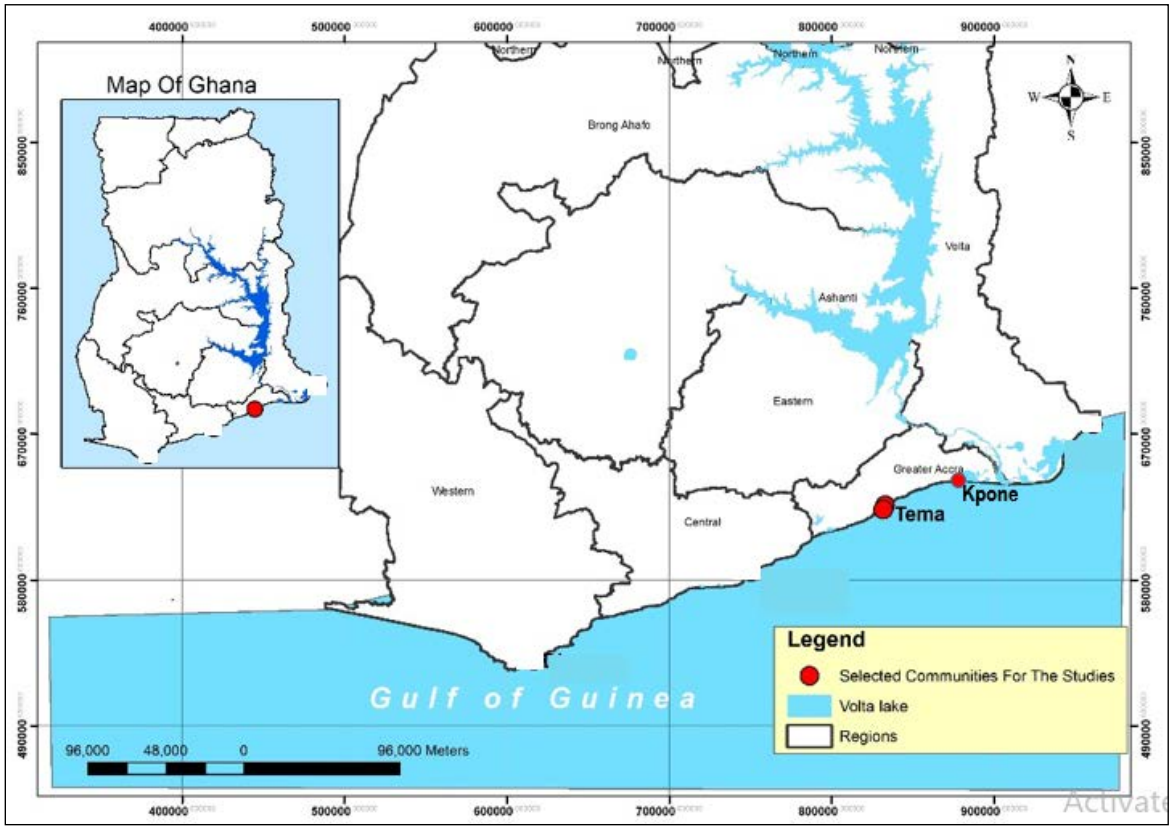

Figure 1. Map showing the sampling areas.

Table 1. Sampling locations and coordinates

Sampling/landing beach location	Location coordinates	
	Latitude	Longitude
Tema Canoe Beach	5°38'39.48"N	0°00'59.50"E
Kpone	5°41'26.84"N	0°03'52.76"E

Data collection

Fish samples were collected from fishermen who deployed the hook and line fishing gear in Kpone and Tema sampling locations from August 2018 to July 2019. Fish samples were identified in-situ using Kwei & Ofori-Adu (2005) identification key. The total length (TL) of individual fish species was measured to the nearest 0.1 using a 100 cm graduated wooden measuring board. No sampling was done in September due to challenges in logistics.

Data treatment and analysis

Relative abundance indicates how rare or common a species is relative to other species in a defined location. This was expressed in percentage, following Akongyuure *et al.* (2015): (Number of species) / (Total number of species) * 100

Diversity indices are traditional metrics that give a quick and simple picture of global pattern and these indices include species richness index (SRI), species evenness index (SEI) and Shannon Weiner index (SWI). Species richness index (SRI) is the number of different species represented in an ecological community. Margalef index was used to determine the species richness (Margalef 1963) with the following expression;

$$d=(S-1)/\ln N$$

Where S is the number of different species represented in the sample and N is the total number of individual organisms in the sample.

Species evenness index (SEI) refers to how close in numbers of each species in an environment. Pielou's evenness index (Pielou 1966) was used to calculate the evenness of the fish species in the sample using the following expression:

$$J'=H'/H'max$$

Where H' is the number derived from Shannon diversity index and H'max is the maximum possible value of H' (if every species was equally likely).

Shannon-Wiener index (SWI) is that the diversity of a community is similar to the amount of information in a code or message (Shannon & Weaver 1963). It is calculated in the following way:

$$H'= -\Sigma\ pi \ln pi$$

Where pi is the proportion of individuals found in species i. For a well-sampled community, this proportion can be estimated as pi = ni/N, where ni is the number of individuals in species i and N is the total number of individuals in the community.

Samples from commercial catches were analyzed for species composition, total abundance, and length measurement. Differences in length measurement of dominant fish species were assessed with Mood's median test. A significant difference was taken at a confidence interval of 95% and p-value of 0.05. Before multivariate analysis, the data were square root transformed.

The similarity in species composition based on the abundance was studied by calculating the Bray-Curtis coefficient (Cluster analysis). These analyses were performed using PRIMER software (Clarke & Warwick 2001). Outputs from the data analyses were presented graphically using a Microsoft Excel Software spreadsheet in the form of tables and charts.

Results

Species composition and abundance

The catches of hook and line fisheries were dominated by Bigeye grunt, *Brachydeuterus auritus* (26 %); Atlantic emperor, *Lethrinus atlanticus* (19 %); Golden African snapper, *Lutjanus fulgens* (12 %); Blue spotted seabream, *Pagrus caeruleostictus* (11 %) and Red pandora, *Pagellus bellottii* (11 %) as shown in Figure 2. A total of eighteen (18) fish families were recorded, dominated by Carangidae contributing about 37 % of the catch, followed by Sparidae, contributing 27 % of the catch (Figure 3). The least represented family contributed 4 % of the catch, including Clupeidae and others (Table 2).

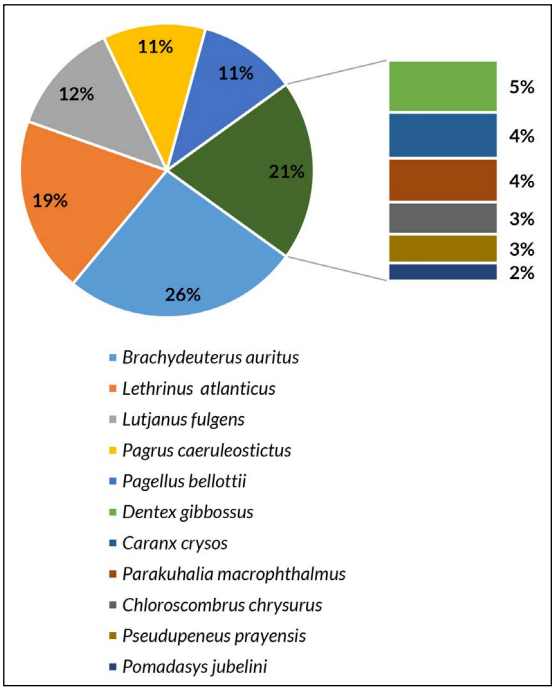

Figure 2. Percentage abundance of species from hook and line fishery from the coast of Ghana (excluding species with abundance < 2 %)

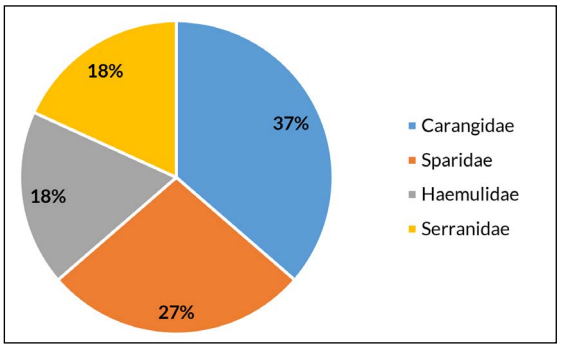

Figure 3. Composition of family of species from hook and line fishing gears along the coast of Greater Accra, Ghana (excluding families with only one species)

A total of twenty-four (24) species were recorded with the highest number of taxa in November (i.e. 10 taxa) and the lowest recorded in August (i.e. 4 taxa) as shown in Table 2. *Dentex gibbosus, L. fulgens* and *P. caeruleostictus* were the most represented species throughout the sampling period (Table 2). In terms of abundance, 836 specimens were recorded from the catches of hook and line fisheries with the highest number of specimens in June (i.e. 220 specimens) and the lowest recorded in August (i.e. 19 specimens) as seen in Table 2. *Dentex gibbosus, L. fulgens* and *P. caeruleostictus* were the species that recorded the highest specimens throughout the sampling periods (Table 2). The Sparidae family recorded three species, namely *D. gibbosus, P. bellottii* and *P. caeruleostictus* and the Carangidae family recorded four species, *C. hippos, C. crysos, C. chrysurus and D. punctatus*. The remaining fish family records only one species. The taxonomic families Carangidae and Sparidae were the dominant families encountered in the study.

Diversity indices

From Figure 4, the species evenness index (SEI) ranged from 1.0 in August, 2018 to 2.8 in November, 2018 with a mean value of 1.95 ± 0.15. June recorded the lowest SEI (0.8) with the highest value (1.0) of SEI recorded in August 2018 and mean value of 0.91 ± 0.02. The Shannon Weiner index (SWI) recorded the highest value (2.1) in December 2018 and the lowest value (1.4) in August 2018 with a mean value of 1.74 ± 0.07.

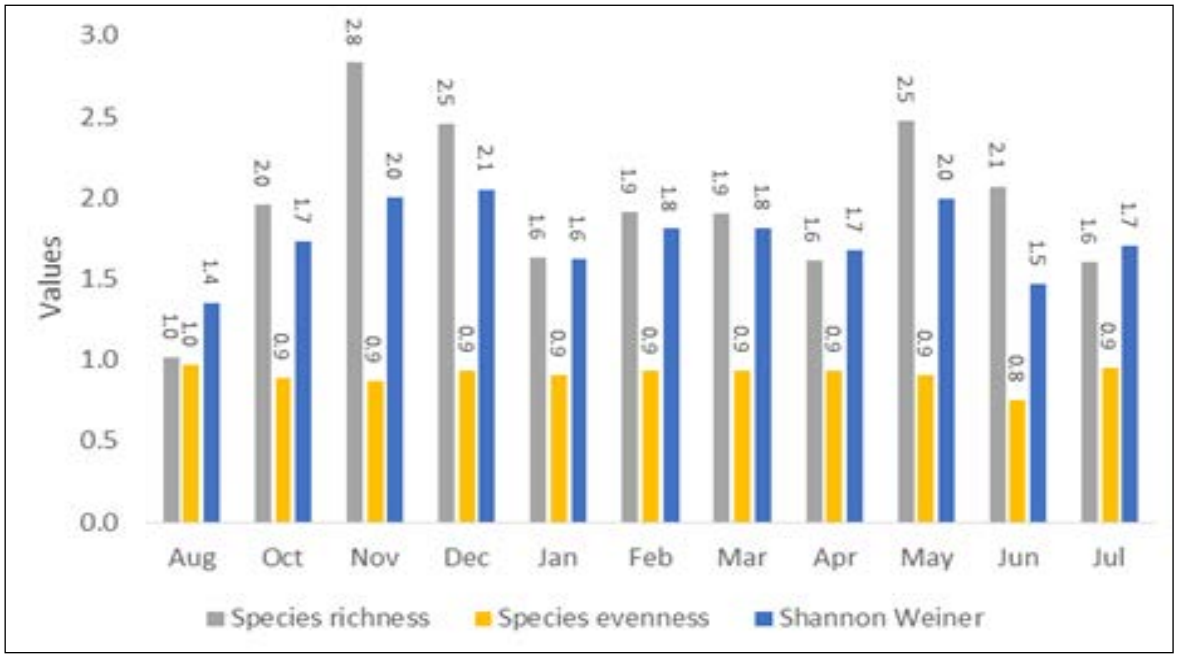

Figure 4. Diversity indices estimated from the August 2018 to July 2019 study period

Table 2: Species abundance of catches from hook and line fishing recorded during the study period (August, 2018 – July, 2019)

Species	Family	2018					2019						
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Brachydeuterus auritus	Haemulidae	0	0	0	56	0	0	0	0	0	0	154	0
Caranx crysos	Carangidae	0	0	0	0	0	0	0	0	0	25	0	8
Caranx hippos	Carangidae	0	0	0	0	0	3	0	1	0	1	0	0
Cephalopholis nigri	Serranidae	0	0	1	3	1	0	0	0	0	1	0	0
Chaetodipterus lippei	Ephippidae	0	0	0	0	0	0	0	1	0	0	0	0
Chloroscombrus chrysurus	Carangidae	0	0	0	2	0	0	0	0	0	7	0	0
Chromis limbata	Pomacentridae	0	0	0	0	0	0	2	0	0	0	0	0
Coris julis	Labridae	0	0	0	1	0	0	0	0	0	0	0	0
Decapterus punctatus	Carangidae	0	0	0	1	0	0	0	0	0	0	0	0
Dentex gibbosus	Sparidae	8	0	1	3	8	2	6	8	2	1	0	0
Ephinepelus aeneus	Serranidae	2	0	0	0	0	0	0	0	1	0	0	0
Ephippion guttifer	Tetraodontidae	0	0	2	2	1	0	0	0	0	0	0	0
Galeoides decadactylus	Polynemidae	3	0	0	0	0	0	0	0	0	0	1	0
Hemiramphus brasiliensis	Hemiramphidae	0	0	0	0	0	0	0	0	0	0	1	0
Lethrinus atlanticus	Lethrinidae	0	0	2	46	5	23	34	13	20	9	0	13
Lutjanus fulgens	Lutjanidae	0	0	35	7	2	0	3	5	8	17	0	15
Pagellus bellottii	Sparidae	0	0	6	0	7	0	0	0	0	28	48	2
Pagrus caeruleostictus	Sparidae	6	0	0	2	25	0	16	13	15	0	0	8
Parakuhlia macrophthalmus	Parakuhalidae	0	0	0	0	0	28	3	0	0	1	14	0
Pomadasys jubelini	Haemulidae	0	0	0	0	0	13	0	0	0	0	0	0
Priacanthus arenatus	Priacanthidae	0	0	0	0	1	0	0	0	0	0	0	0
Pseudupeneus prayensis	Mullidae	0	0	6	0	4	1	3	1	5	0	0	1
Sardinella maderensis	Clupeidae	0	0	0	0	0	0	0	0	0	0	1	0
Sphyraena sphyraena	Sphyraenidae	0	0	0	0	0	0	0	0	0	0	1	0
Total		19	0	53	123	54	70	67	42	51	90	220	47

Multivariate analysis

From the cluster analysis, two main groups were obtained at a similarity level of 8% (Figure 5). Group 1 consisted of *G. decadactylus, E. aeneus, S. maderensis, S. sphyraena and H. brasiliensis* while Group 2 consisted *L. atlanticus, L. fulgens, P. bellottii, D. gibbosus, C. crysos, P. prayensis, P. macrophthlamus, C. hippos, P. jubelini, C. chrysurus, C. nigri, E. guttifer, D. punctatus, C. julis, P. arenatus, B. auritus* and *C. lippei.* Only *C. limbata* was without a group.

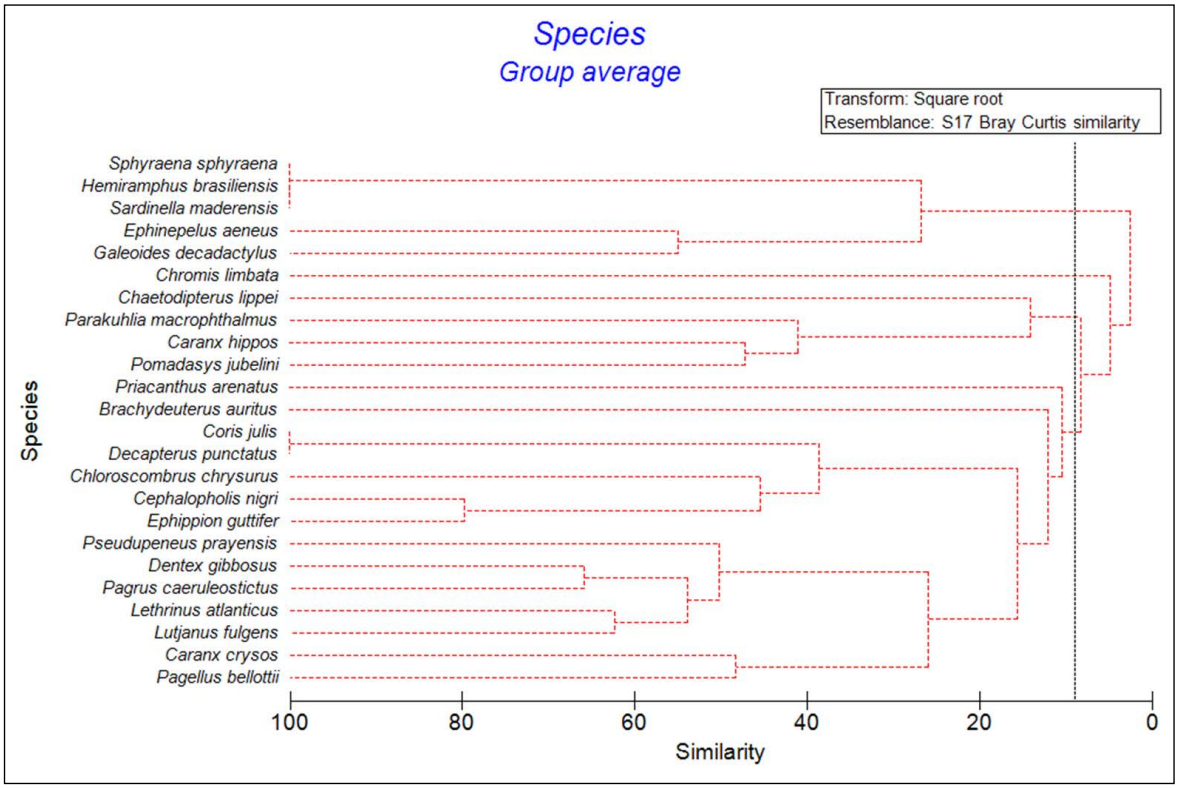

Figure 5. Cluster analysis of individual fish hook and line catches based on species level data. Dark line indicates clusters at a similarity index of 9 %.

Length distribution of dominant species

The range of length for *P. caeruleostictus, L. fulgens, L. atlanticus, B. auritus,* and *P. bellottii* was 14.6 cm to 29.5 cm, 14.3 cm to 21.2 cm, 12.4 cm to 22.2 cm, 11.1 to 23.4 and 15.0 to 24.0 respectively (Table 3). *P. caeruleostictus* recorded a significant difference in length measurement during the study period [Mood's median test, df = 7, p-value = 0.001]. *L. fulgens* recorded no significance difference in length measurement during the study period [Mood's median test, df = 1, p-value = 0.222]. *L. atlanticus* recorded a significant difference in length measurement during the study period [Mood's median test, df =8, p-value = 0.000]. *B. auritus* recorded a significant difference in length measurement during the study period [Mood's median test, df = 7, p-value = 0.00]. *P. bellottii* recorded no significant difference in length measurement during the study period [Mood's median test, df = 4, p-value = 0.341].

Table 3. Overall mean, minimum and maximum length (cm) distribution of dominant fish species

Species	Mean	SD	Minimum	Maximum	Skweness	Kurtosis
Pagrus caeruleostictus	19.7	0.4	14.4	42.0	2.72	11.8
Lutjanus fulgens	16.1	0.2	11.2	22.3	0.38	0.73
Lethrinus atlanticus	16.0	0.2	12.0	22.3	0.53	-0.68
Brachydeuterus auritus	16.8	2.3	11.1	23.4	0.25	0.06
Pagellus bellottii	19.0	0.2	15.0	24.0	0.42	-0.59

Discussion

Species composition and abundance

The monthly variation in abundance and composition of species during the study period could be assigned to factors such as the depth at which the hooks were set and the fishing grounds. According to Osei *et al.* (2021), the presence and absence of demersal species in the catches of fishermen depends on the fishing grounds and depth of fishing. Feng *et al.* (2022) indicated that variation in the abundance of demersal fishes is reliant on the nature of the fishing area, where demersal fishes mostly operate at depths greater than 40 m and are characterized by cooler, less oxygenated and with more saline conditions. Bianchi (1996) reported that salinity, depth, bottom and dissolved oxygen (DO) affect marine assemblages. Similarly, the variation in diversity indices (i.e. SWI and SRI) may be linked to the migratory nature of species to shallow or deeper waters for physiological activities such as spawning and feeding. However, the relatively similar SEI throughout the study period is potentially due to the homogenous composition of demersal fishes in the coastal waters (Ukwe *et al*., 2006; Koranteng & Pauly 2004).

Studies by Cook *et al*. (2021) indicated that most of the species recorded from the current study form part of important demersal fishes in Ghana. Aheto *et al*. (2012) and Amador & Aggrey-Fynn (2021) also reported *Lutjanus* sp., *Dentex* sp., *Pagrus caeruleostictus*, and *Pagellus bellottii* as prominent catches from hook and line fishing gears which conforms to the observation from the current study. *Brachydeuterus auritus, L. fulgens, L. atlanticus,* and *P. bellottii* are viewed as indicator species for demersal fishes in Ghana (Lazar 2017). Hence, the presence of these indicator species suggests the conducive condition of the coastal waters of Ghana.

The dominance of taxonomic families from the study may be due to the depth at which hook and line fishing was carried out. Koranteng (1998) indicated that demersal fishes of the families Sparidae, Haemulidae and others are found within 40 m to 300 m depth. In addition, Bianchi (1992) documented that at depths > 20 m and < 30 m, Carangids dominate over other taxonomic families. The taxonomic families including Lutjanidae, Sparidae and Scianidae from the study have been reported by Lazar (2017) as families with high economic value in Ghana, making them essential to hook and line fisheries in Ghana (Adewumi 2020). However, Koranteng & Pauly (2004) revealed that these taxonomic families are hugely affected by temperature and salinity variation in the coast of Ghana. As such there is a need to develop and implement measures necessary for the sustenance of their stock.

Multivariate analysis

Mensah & Quaatey (2002) reported six demersal communities in the coastal waters of Ghana, namely; Sciaenid Community, Lutjanid Community, Coastal Sparid Community, Deep Water Sparid Community, Deep Shelf Community and Continental Slope Community. According to depth, these six demersal fish communities have been grouped into three categories, namely; Sciaenid and Lutjanid Communities containing fish species below 40 m depth, Coastal Sparid and Deep Water Sparid Communities within 40 m – 100 m and Deep Shelf and Continental Slope Communities beyond 100 m depth (Koranteng & Pauly 2004).

From the study, Group 1 species were mainly within the Sciaenid Community of fish species. Nonetheless, species like *S. maderensis* and *H. brasiliensis* which are largely inshore fishes may have been targeted solely as bait for the hook and line fishing activities. For Group 2, most of the demersal fishes comprised of the Lutjanid Community and the two Sparids communities (i.e. Coastal Sparid Community and Deep Water Sparid Community) because these species can be found between 40 m to 100 m depth and even beyond 100 m due to their eurybathic nature (Bianchi 1992).

Furthermore, the cluster analysis revealed the presence of pelagic fishes (e.g. *C. chrysurus, T. lepturus, Sphyraena sp.*) within the assemblages of demersal fishes. Similarly, Ukwe *et al.* (2006) indicated that both pelagic and demersal fishes are exploited within the coastal waters of Ghana by artisanal hook and line fisherfolks. According to Bianchi (1992), the mixture of both pelagic and demersal fishes could be assigned to the migratory nature of pelagic fishes to depths greater than the intermediate depth (i.e. 40 m) and shallow depth (< 30 m).

Length distribution

The mean size of the dominant species from the study was higher than the allowable maximum length enshrined in the Fisheries Act 625 (Ghana Fisheries Regulations 1991). The legal minimum landing size of *P. caeruleostictus* is 18 cm TL, lower than the mean length recorded from the study. Similarly, the mean length of *L. fulgens* was slightly higher than the

minimum legal landing size of 16 cm. The relatively higher mean length of species from the catch may be due to the vulnerability of large size individuals to the hook fishing gear. Furthermore, fishing in deeper waters (i.e. > 40 m depth) may have resulted in the catching of large-sized fishes (Ayivi 2012). Conservatively, this suggests that small-sized species are less vulnerable to the hooks used by fishermen in the coastal waters of Ghana. Given this, the use of hooks and line fishing gear could be promoted as sustainable fishing gear for the conservation of marine fish species.

Conclusion

In summary, the study aimed to assess the catch composition of hook and line fishing gears in some selected fishing communities along the coast of Greater Accra, Ghana. From the study, *B. auritus, P. caeruleostictus, L. fulgens, P. bellottii* and *L. atlanticus* were the dominant species to hook and line fishing gears in Ghana. Sparidae and Carangidae were the most dominant taxonomic families to hook and line fisheries in Ghana. Fish assemblages of hook and line fishing gears fell in two groups with one predominantly Sciaenid community and Group 2 comprising of both Lutjanid and Sparid communities. Large-sized demersal and pelagic species were exploited by hook and line fisheries from the coast of Ghana. According to the study, hook and line fishing gear should be promoted as sustainable fishing gear for the conservation of marine fish species. There is a need for measures to be developed and implemented for the sustenance of Sparidae and Carangidae stock through relevant stock assessment studies.

Acknowledgement

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Conflict of Interest

The authors declare no conflict of interest.

Authours' Contribution

SYA and AA planned and coordinated the study. **SKKA and SYA** obtained the field data. **SKKA, MA and SYA** analysed the data and wrote the manuscript. All authors read and approved the final manuscript.

Data Availability Statement

The data that support the findings of this study are available on request to the corresponding author.

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