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Population structure and some aspects of biology of *Pseudotolithus senegalensis* and *Pseudotolithus typus* within the coastal waters of Liberia

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Abstract
The study evaluated the population structure and biology of two sciaenids within Liberia's coastal waters. A total of 177 and 152 samples of *P. senegalensis* and *P. typus* respectively were collected from two landing sites in two coastal counties of Liberia from July, 2016 to December, 2016. Each individual fish specimens was measured for standard length, weight and analysed using FiSAT II software and Excel Analysis Toolpak. Spawning periods of the two fish species were determined following the monthly variation of the mean gonadosomatic index. Fish condition factor for both genders of *P. senegalensis* and *P. typus* was influenced by the sea surface temperature (SST). Based on the monthly GSI's variation, the two species spawned doing the hydrological seasons. The length-weight relationship of both species shows negative allometric growth. There were dominants of males to females for the two assessed species. From the results urgent management interventions in form of close seasons are needed to safeguard these commercially important fish species from possible stress in the future to avert natural mortality dominants.

Keywords: liberia, *pseudotolithus senegalensis, pseudotolithus typus,* population structure and biology

1. Introduction

P. senegalensis (Valenciennes, 1833) [29] and *Pseudotolithus typus* (Bleeker, 1863) are widely distributed along the coast of West Africa from Senegal to Angola (Edwards *et al*., 2001) [11]. Sciaenids constitute a large and varied family of fishes closely related to snappers but differing in that the spinous dorsal fin is short and the adipose tissue is much longer than the anal fin, which has only one or two spines (Edwards *et al*., 2001) [11]. *P. typus* has long head and body, a compressed body with the top of the head slightly concave, supra-lateral eyes and large mouth with lower jaw projecting, while *P. senegalensis* head and body moderately long, profile of head and snout convex with lateral eyes (Boesman, 1963 and Longhurst, 1969) [6, 18].

P. typus and *P. senegalensis* are among the top commercially fish species that is widely consumed locally by Liberian because of it flesh and abundances on the local market. Pseudotolithus species were among the highest landed catch in 2004 and with a decline in 2005 (Togba, 2008) [27]. And also the total marine landed catch for Liberia was estimated at 1,570.82 tonnes in 2013 excluding artisanal catch and drop speedily to 204 tonnes in 2014. This drastic decline maybe alluded to poor data collection from the artisanal fisheries and limited human resources to cover even half of the 114 artisanal fish landing site (MRAG, 2014 & BNF, 2014) [19, 5].

Hughes, S., *et al.* (2012) [15] reported that Liberia very vulnerable to a decline in fisheries due to its low adaptive capacity and the importance of fish from a food security perspective. Liberia annual per capita fish consumption is among the lowest in the region and has decreased over time due to damage to fisheries infrastructure during the civil war, over-exploitation of resources in some areas, and a shift from subsistence to trade-based fisheries.

However, in Liberia, information on the biology and growth pattern of important commercial fishes are either limited or inadequate, despite the importance of fish to food security, particularly in fishing households. Such limitation of scientific information on fish biology and growth pattern renders fisheries management options geared toward sustainable exploitation of commercial fishes in Liberia ineffective. In view of this, the objective of the study was to evaluate some aspects of biology and growth pattern of *P. typus* and *P. senegalensis*. Information gained from this study will not only fill knowledge gap but ensure sustainable management of this commercially important fish species resident in Liberia's coastal waters.

2. Materials and Methods

2.1 Study Area

Liberia is a relatively small coastal state located in West Africa with geographical coordinates as 6.4281º N, 9.4295º W. The coastline of Liberia is 579 kilometers comprising of relatively warm waters and low nutrient contents (BNF, 2014) [5]. However, the study focused on two fish landing sampling stations (ELWA, N 06.23355º and W 010.69365º; and Marshall, N 06.13833º and W 010.38171º) within two coastal counties along the coastline of Liberia (Figure 1). These fish landing sampling coastal counties include Margibi and Montserrado. Selection of the two fish landing sampling sites was based on the level of fishing activity and geographical location. The main source of livelihood for the majority of the inhabitants residing within the selected two fish landing sampling stations is fishing and its related activities such as fish processing and fish trade. However, a few of the indigenes are engaged in alternative forms of livelihoods including farming, driving, and others.

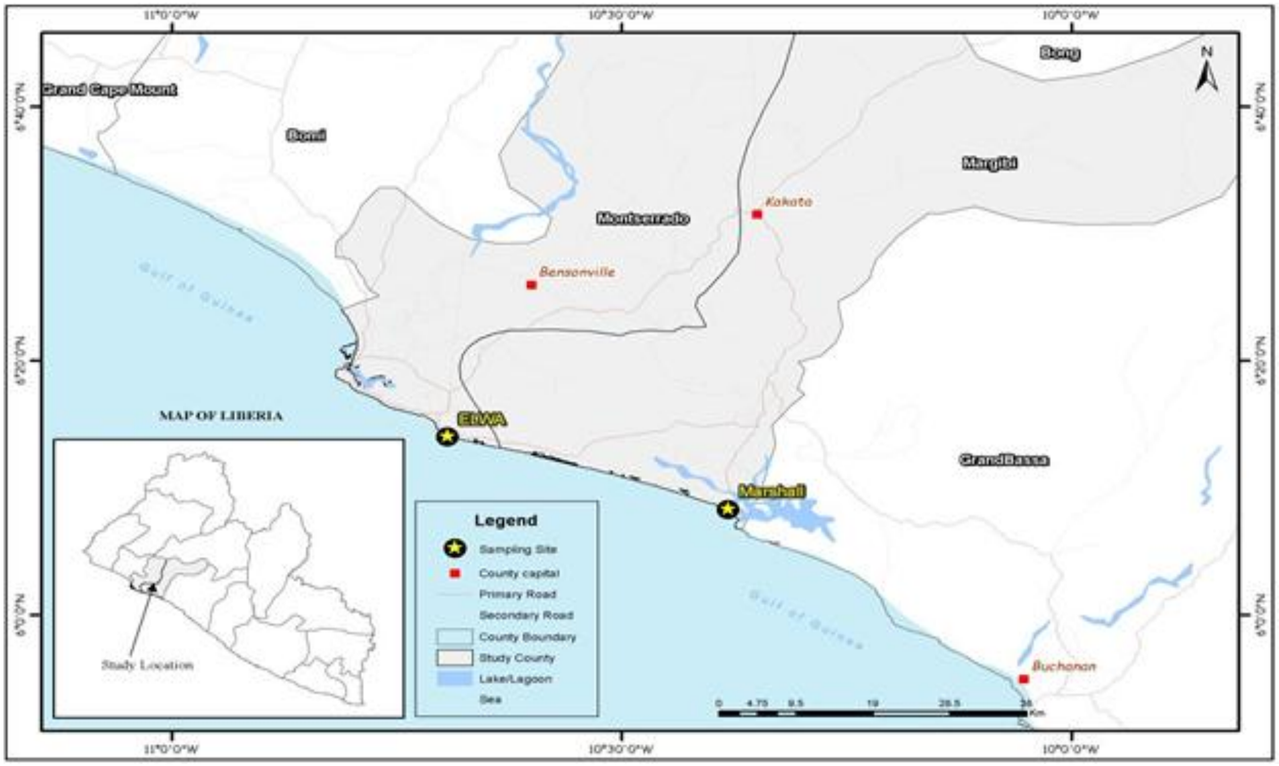


Fig 1: Map showing the sampling sites and Liberia map

2.2 Methodology

2.2.1 Data collection

Monthly fish samples were collected from artisanal fishermen who operated with multifilament gears from the selected fish landing stations. Fish sample collection was performed from July, 2016 to December, 2016 (six months). Morphometric measurements of the obtained fish samples including standard length and weights were recorded in the lab at the Bureau of National Fisheries. The standard length was measured using the 100cm Measuring Board to the nearest 0.1cm, whereas the weight was measured using the electronic weighing scale to the nearest 0.01g. Fish samples were identified to the species level using fish identification keys by Schneider (1990) [25]**.** In all, a total of 177 and 152 specimens of *Pseudotolithus senegalensis* and *Pseudotolithus typus* respectively were sampled.

2.2.2 Length frequency distribution

Monthly length frequency (standard length to the nearest centimeter) data was compiled from length measurement of fish collected from the two sampling sites and the frequency distributions determined at 1.0 cm length intervals to determine the length classes or cohort of fish that are predominantly capture by artisanal fishers.

2.2.3 Gonadosomatic index (GSI)

The gonadosomatic index (GSI) is often used to describe the maturity state of the female, and it is traditionally defined as the ratio between the gonad weight (GW) (g) and the total weight (W) (g) of the fish. The maturity stages were determined within five categories, based on morphological characteristics of the ovaries and testes, modified by Gerritsen *et al*., (2003) [14]: stage 1: virgin, stage 2: developing virgin, stage 3: mature, stage 4: ripe or running, and stage 5: recently spent. The spawning period was graphically determined for both sexes by the monthly variation of mean values of the gonadosomatic index (GSI) as:

GSI= 100*Wg /W

2.2.4 Sex Ratio

The fluctuations of the sex ratio according to fish size provide a useful tool to examine the biological characteristics of the fish species, such as sexual inversion, longevity in relation to sex, vulnerability to fishing gear and the spatial, seasonal and even daily distribution of species. With the numerical abundance by sex, the following ratio was computed:

Sex-ratio S-R = 100 x number of males/number of females (Anato, 1999) [2].

2.2.5 Length weight relationship

To establish the length-weight relationship, the formula by Ricker (1975) [22] model was applied. $W= aL^b$. where W is the weight (g), L is the standard length (cm) and a and b are constants. The length- weight relationship was used to determine the growth pattern of the fish species, whether allometric or isometric.

2.3 Data Analysis

The size frequency distribution was analyzed using 1 cm class interval (standard length) to plot a histogram to determine the type of distribution, which characterizes the fish population. Sex ratio was calculated for different months and size groups of fish. The sex ratio was tested for equality for different months using Chi-square test. The Gonadosomatic Index (GSI) was used to determine the spawning period. The length-weight relationship was analysed using the FISAT II statistical tools (Gayanilo *et al*., 2005) [12]. MS excel spreadsheet was used in generating graphs and tables. The significance of parameters was statistically tested at p-value of 0.05 using the

MS excel statistical tool Pac.

3. Results

3.1 Length Frequency Distribution

The monthly pooled length frequency data from 177 specimens of *Pseudotolithus senegalensis* and 152 specimen of *Pseudotolithus typus* were grouped into one-centimeter interval. Figure 2.1 to 2.6 shows the length frequency distribution in standard length by gender of the two assessed species with the means, standard deviation and total population (N). Figure 2.1 to 2.3 shows the modal class interval for *P. senegalensis* by gender which were: both sex, 33.5 cm SL; males, 32.5 cm SL and females, 33.5, 35.5 & 37.5 cm SL. While the modal length of 34.5 cm SL (both sex), 36.5 cm SL (males) and 34.5 cm SL (females) for *P. typus* are presented in Figure 2.4 to 2.6. The size range was 14 cm - 63 cm for *P. senegalensis* for both sex and 20 cm - 63 cm for *P. typus* both sex (Table 1). The Mean ± SE and range for the two assessed species are also presented in Table 1. Comparison of the lengths of *P. senegalensis* with *P. typus* modal class interval showed no significant difference (t-test, $p>0.05$).

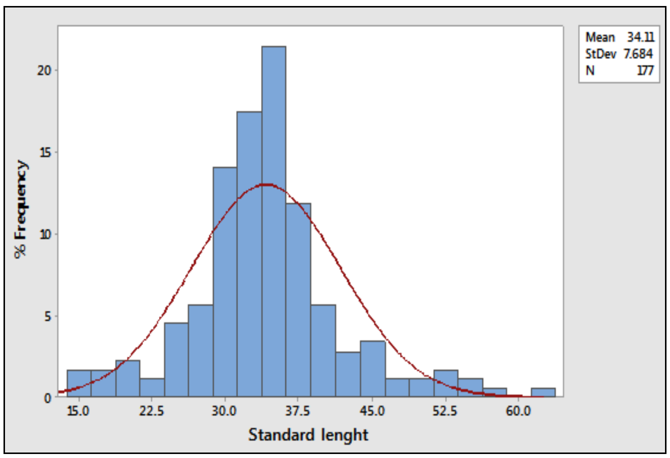


Fig 2.1: Length frequency distribution of *Pseudotolithus senegalensis* both sex.

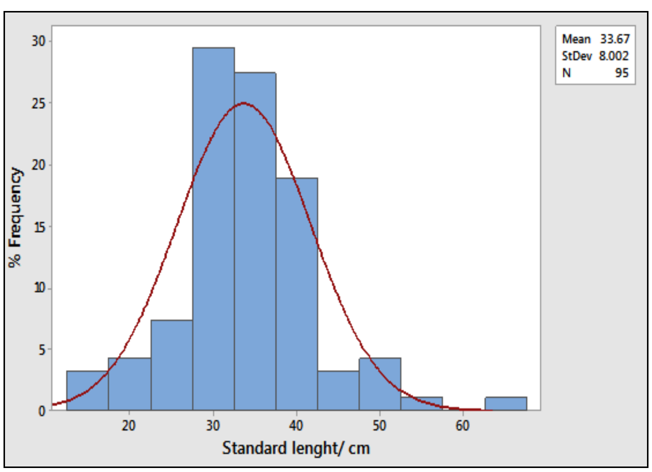


Fig 2.2: Length frequency distribution of *Pseudotolithus senegalensis* males.

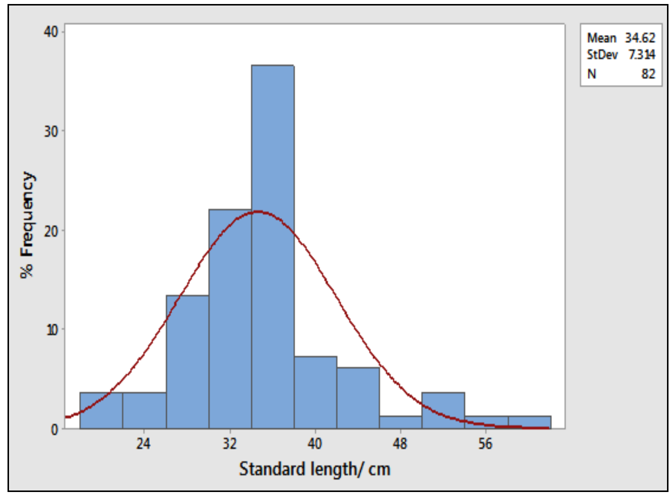


Fig 2.3: Length frequency distribution of *Pseudotolithus senegalensis* females.

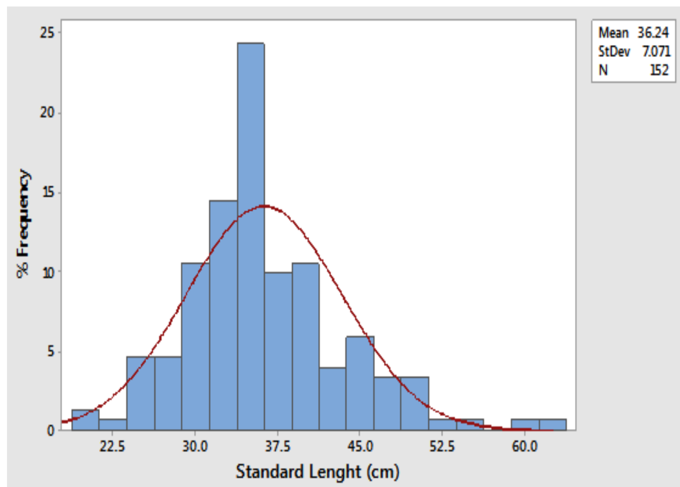


Fig 2.4: Length frequency distribution of *Pseudotolithus typus* both sex.

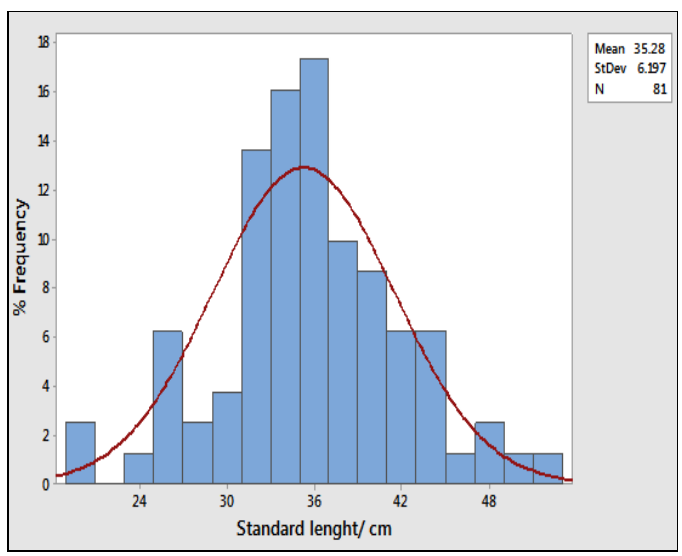


Fig 2.5: Length frequency distribution of *Pseudotolithus typus* males.

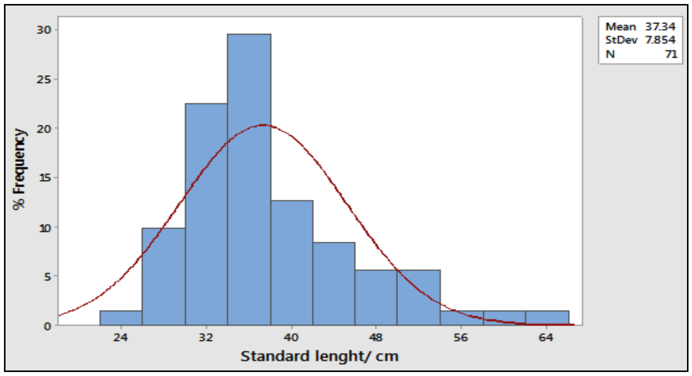


Fig 2.6: Length frequency distribution of *Pseudotolithus typus* females.

Table 1: Summary of the length frequency distribution of P. senegalensis and P. typus in Liberian fisheries waters.

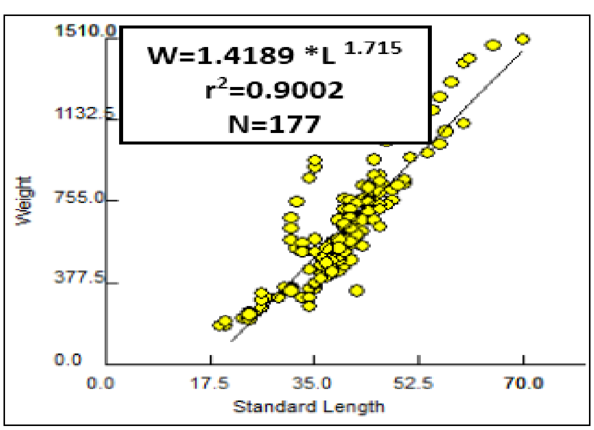
Species	N	Mean ± SE	Modal	Minimum	Maximum	Range
P. senegalensis	177	34.11 ± 0.58	33.5	14	63	49
P. senegalensis male	95	33.67 ± 0.82	32.5	14	63	49
P. senegalensis female	82	34.62 + 0.81	33.5,35.5, 37.5	19	58	39
P. typus	152	36.24 ± 0.57	34.5	20	63	43
P. typus male	81	35.28± 0.69	36.5	20	52	32
P. typus female	71	37.34 ± 0.93	34.5	24	63	39

3.2 Length-Weight relationship and Condition Factor (K)

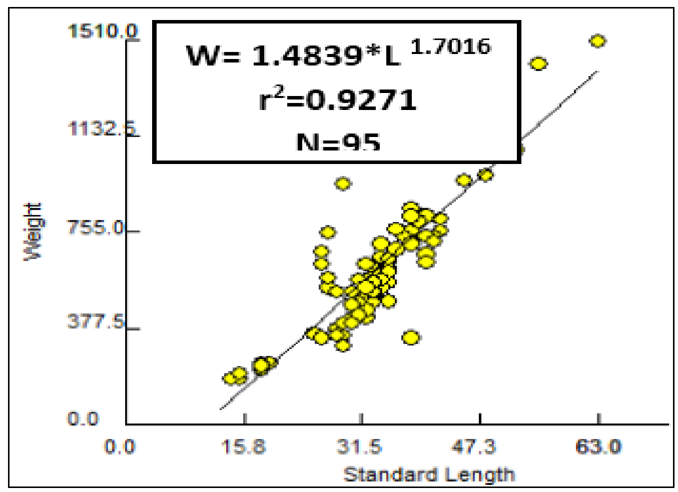
Figures 3.1 and 3.2 show the respective length-weight relationship by gender of *P. senegalensis* and *P. typus*. From Figures 3.1 and 3.2, the length-weight relationship coefficient a and b were estimated for the two species by genders as follow: for *P. senegalensis* a ranges from 1.0221-1.4839 and b from 1.7016-1.7221; and for *P. typus* the ranges of a and b were 0.7704- 0.9118 and 1.8012-1.8377 respectively (Figures 3.1 and 3.2).

The weight of the fish strongly correlated with the standard length (SL) and total length (TL) (r^2 range 0.9002-0.9450 SL and 0.9050-0.9503 TL) for *P. senegalensis* (both sex, males and females). For *P. typus*, the body weight of the fish also strongly correlated with the standard length and total length with r^2 ranging from 0.9248-0.9596 SL and 0.9195-0.953 TL.

The expected range of the exponent b in all cases lies in between the range of 2.5-3.5 reported for most fish (Carlender, 1969, 1977) [7, 18, 8] and is closest to 3 indicating isometric growth. Contrary to this assertion, the exponent b for both species by gender in this study were significantly different (t-test, $p<0.05$) below 2.5 indicating negative allometric growth; meaning these two species in Liberian waters are not growing as the weight equals the cube of the length.



(a)



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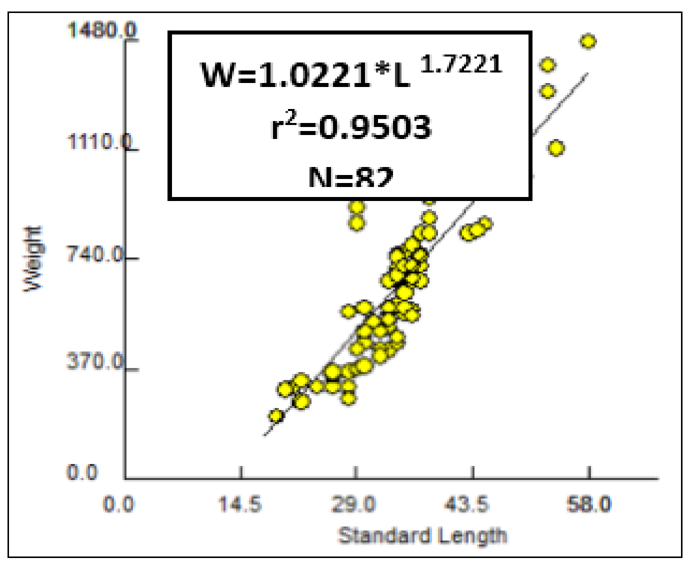
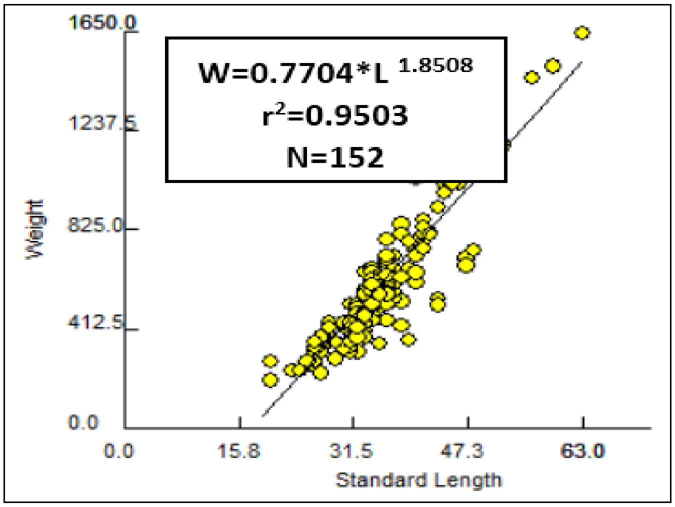
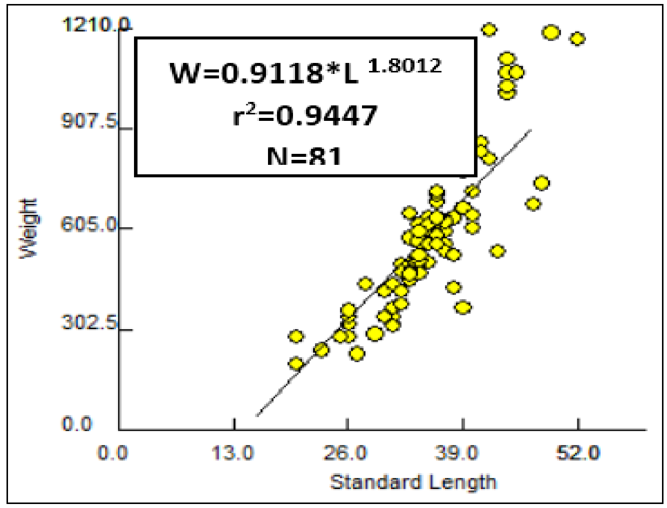


(c)

Fig 3.1a-c: FiSAT II output of the Length-Weight relationship of *P. senegalensis* (both sex, a; male, b; female, c).



(a)



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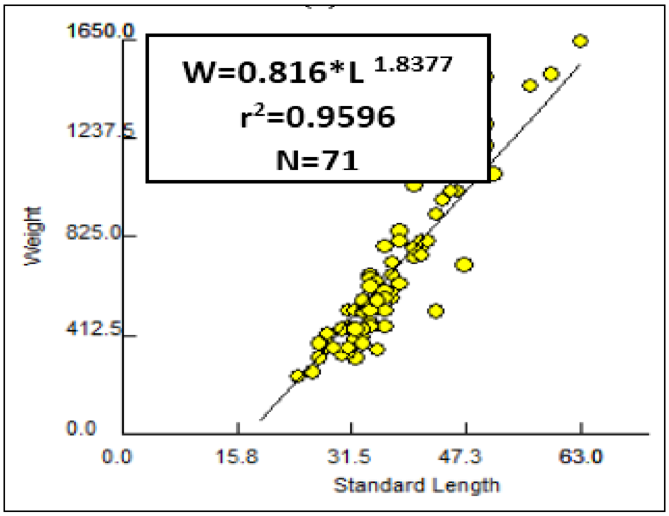
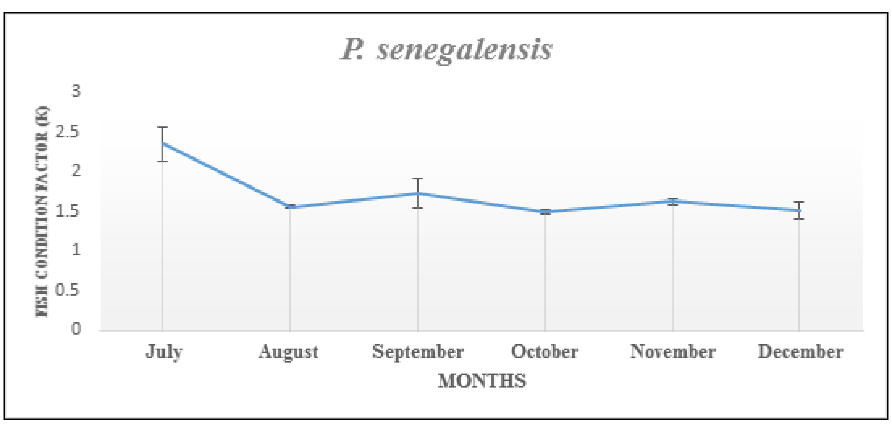


(c)

Fig 3.2a-c: FiSAT II output of the Length-Weight relationship of *P. typus* (both sex, a; male, b; female, c).

Figure 3.3 below present the monthly averages of fish condition factor (CF) computed for the two species to indicate if environmental factors influence this biological parameter. The monthly condition factors for *P. senegalensis* and *P. typus* showed variation throughout the study period with different pattern. *P. senegalensis* has the highest condition factor coefficient in July and continue to decrease up to December, but it was the reversed for *P. typus* (highest in December with a decrease up to July). The K-value however increases with increase in fish size for the combined sexes. In comparison with the sea surface temperature (SST) (Figure 4.2) *P. senegalensis* has highest CF in July with the lowest SST. Whereas *P. typus* CF was concurrent with the SST.



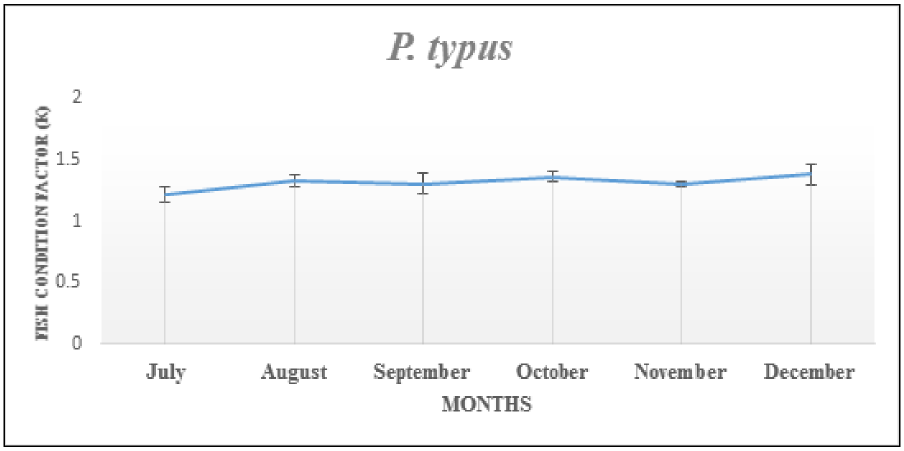
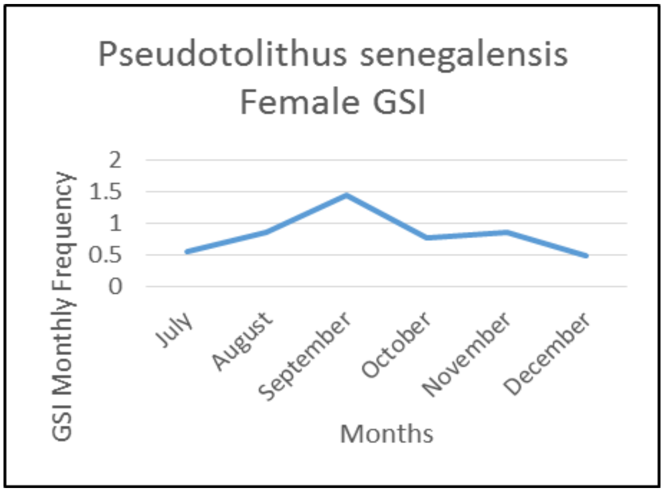
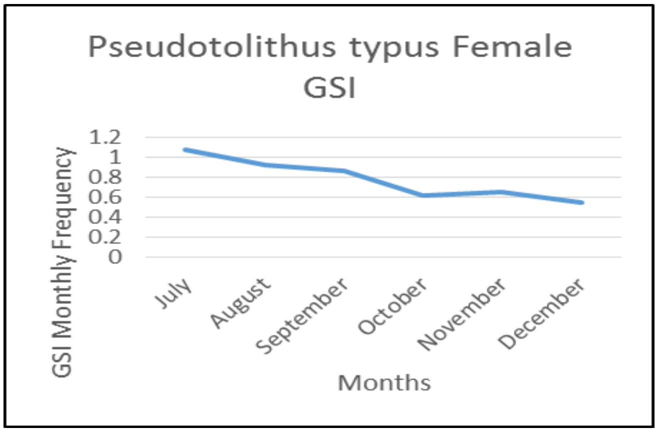


Fig 3.3: Monthly variation of fish condition factor (K) of *P. senegalensis* and *P. typus*

3.3 Gonadosomatic Index (GSI)

The monthly values of GSI for both sexes for the two species are presented in Figure 4.1. Males showed a maximum GSI of 0.679 in August and minimum of 0.197 in December while females showed a maximum of 1.459 in September and minimum of 0.498 in December for *P. senegalensis*. The maximum GSI of *P. typus* males and females were 0.593 and 1.084 both in August with minimum GSI of 0.163 and 0.55 both in December respectively. Mean values from this study ranged from 0.197 and 1.459 for *P. senegalensis* and 0.163 and 1.084 for *P. typus*. The highest SST was recorded in September concomitant with the highest GSI recorded for female *P. senegalensis*. The minor peak in temperature was recovered in December which was simultaneous with the minimum GSI recorded for both species. This could be a probable indication of spawning. There is weaker correlation between temperature and GSI of *P. senegalensis* (Females, r^2= 0.192 and Males, r^2= 0.023). Whereas, *P. typus* has slightly strong correlation between the temperature and GSI (females, r^2= 0.422 and males, r^2= 0.307).





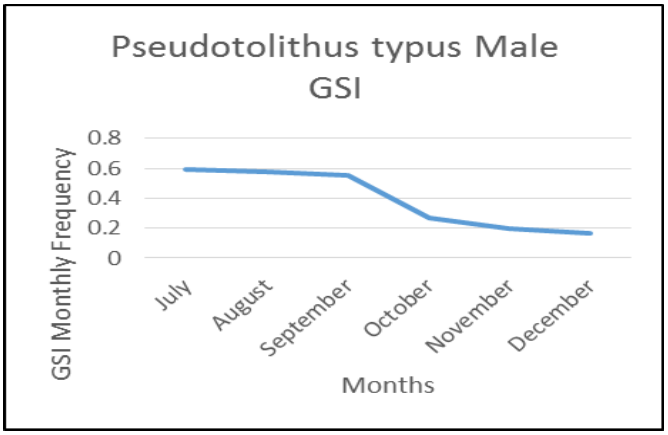


Fig 4.1: Gonadosomatic indices trend of *P. senegalensis* and *P. typus* from the fisheries waters of Liberia.

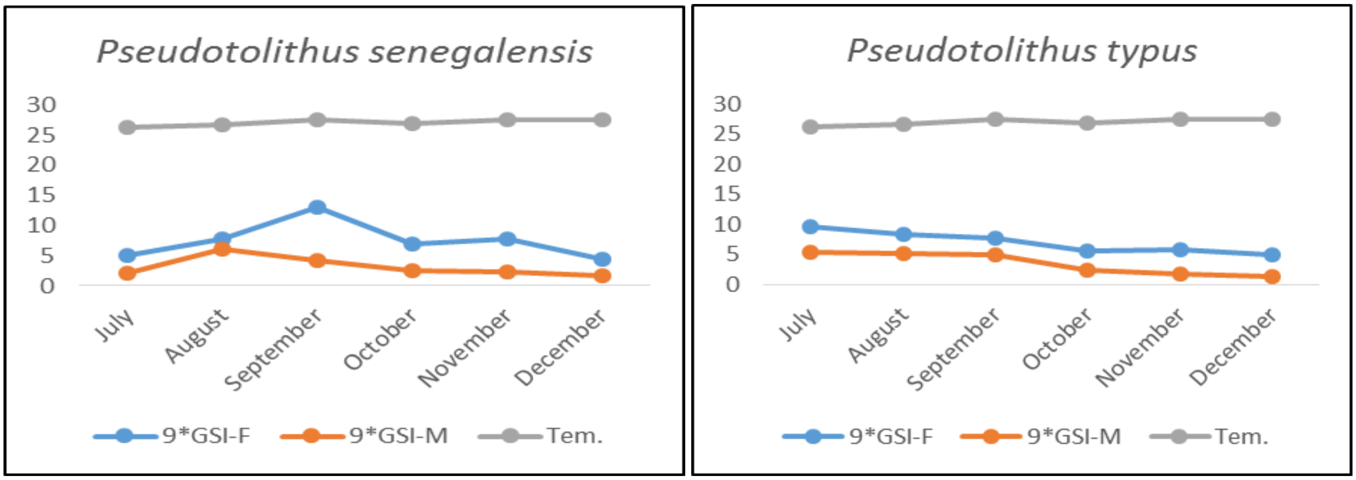


Fig 4.2: Gonadosomatic indices and temperature (degree celsius) trend of *P. senegalensis* and *P. typus* from the fisheries waters of Liberia.

3.4 Sex Ratio

The data on sex ratio is presented in Table 2. A sex ratio of 1.16:1 males to females showed a dominance of males for *P. senegalensis* with no significant deviation from the 1:1 expected ratio (X^2= 2.7417, *p* >0.7397). Similarly, the sex ratio of *P. typus* was 1.14:1 males to females, also showed no significant deviation from the 1:1 expected ratio (X^2= 6.6009, *p* >0.2521). Although there were variation in the monthly pooled data but the Chi-square test show no significant difference ($P > 0.05$).

Table 2: Monthly variations in sex ratios of P. senegalensis and P. typus from Liberian fisheries waters between July and December 2016.

Month	Total No.	No. of Males	No. of Females	Ratios: M:F	Chi-square(X^2)
Pseudotolithus senegalensis					
July	31	17	14	1.21:1	0.0170
August	21	13	8	1.63:1	0.5724
September	42	23	19	1.21:1	0.0201
October	23	9	14	0.64	1.9560
November	26	15	11	1.36	0.1690
December	34	18	16	1.13	0.0073
Total	177	95	82	1.16	2.7417
Pseudotolithus typus					
July	34	15	19	0.79	1.1491
August	28	19	9	2.11	2.3872
September	25	11	14	0.78	0.8667
October	15	6	9	0.67	1.0643
November	17	11	6	1.83	0.8901
December	33	19	14	1.34	0.2436
Total	152	81	71	1.14	6.6009

4. Discussions

The population structure for *P. senegalensis* and *P. typus* showed that small specimens are more vulnerable to artisanal gears. This is supported by the small modal length irrespective of the sex. The dominant lengths for *P. senegalensis* ranged from 33.5 cm and *P. typus* 34.5 cm. The current modal class size of the current study for the both species is greater than what was reported by Sossoukpe (2011) [26] from Benin. This could probably be due to the type of gears used in these localities and the areas in which these species were caught. In Benin, beach seine was used, while ring nets was used by artisanal fishers for the current study. Gbaguidi (1999) [13] from Benin reported that 72% of individuals of *Pseudotolithus* species caught by beach seine were juveniles. Nunoo (2003) [21] also reported for the Ghanaian stocks that 90% of individual of fish assemblages were juveniles in the beach seine throughout the year indicating the dependence on the near shore as a nursery for juveniles.

P. senegalensis and *P. typus* in the present investigation showed a negative allometric growth with b values less than 3, which implies that the fish's length increase rapidly than its weight (Ricker, 1975) [22]. However, this negative allometric growth pattern reported in the current study does not agree with the results reported by other authors Table 3. They reported isometric growth, which implies that the fish length increases in equal proportion with it body weight. The "b" values found by these authors were higher than those in the present study, perhaps due to the dominance of juveniles in the artisanal gears. These changes are due to sex, maturity, season and even the time of day due to stomach content (Bagenal, 1978) [3].

Table 3: Length-Weight relationship from the current study compared to other authors.

Species	L-W relationship	Authors	Countries
P. senegalensis	$W = 0.00389L^{3.224}$	Djama & Pitcher (1989)	Cameroon
	$W = 0.0041L^{3.206}$	N'Jock (1990)	Cameroon
	$W = 0.0080TL^{3.022}$	Sidibe (2003)	Guinea
	$W = 0.0968SL^{2.380}$	Sossoukpe (2011)	Benin (site 1)
	$W = 0.0257SL^{2.803}$	Sossoukpe (2011)	Benin (site 2)
	$W = 0.1519SL^{1.715}$	Current study	Liberia
P. typus	$W = 0.0039L^{3.164}$	Djama (1988)	Cameroon
	$W = 0.00636L^{3.030}$	N'Jock (1990)	Cameroon
	$W = 0.0072TL^{2.970}$	Sidibe (2003)	Guinea
	$W = 0.04675SL^{2.598}$	Sossoukpe (2011)	Benin (site 1)
	$W = 0.04675SL^{2.877}$	Sossoukpe (2011)	Benin (site 2)
	$W = -0.1133L^{1.851}$	Current study	Liberia

The condition factor values are useful in comparing the healthiness of fish from different habitats or to indicate the sustainability of the environment in which the fish are caught. The mean condition factors for both species was greater than 1, this implies that the species are physiologically well or sound. Sossoukpe (2011) [26] made similar report for the species encountered in the waters of Benin. The physiological wellbeing of the species could be linked to the notable change in the environment (Sossoukpe, 2011) [26]. Further, the mean condition factor was size and gender specific where large sized female fishes had higher condition factors as compared to small sized male fishes.

The reproductive cycle in fishes involves large changes in the weight of gonads which are usually reported in terms of the gonadosomatic index (GSI) expressed in terms of the gonadal weight as a percentage of the whole body weight. There have been numerous studies in which GSI has been used as an indicator of gonad development, i.e. ovary and testis in terms of maturity and denotes the phase of the reproductive cycle. Gonadosomatic index is generally used for the study of maturation and spawning biology. It is also used to assess the degree of ripeness of the ovary. From the current study, the Gonadosomatic index of *P. senegalensis* showed a major peak in September and a minor peak in August and November. The minor peak in November confirmed the spawning period reported by Sossoukpe (2011) [26] from Benin. Significant rise in Gonadosomatic index was observed in the month of September (1.459) and declined in October which indicates the onset of spawning (Sossoukpe, 2011) [26]. The higher peak in August and November (0.87) indicates maturation of another small fraction of the population. The highest peak in September coincided with warm temperature whereas the commencement of spawning in November coincided with the rising temperature. From literature, it was reported by Sossoukpe (2011) [26] from Benin that the first spawning occurs during the major hydrological warm season in Benin (February - May) and the second including the minor hydrological warm season (in November). This assertion was confirmed by Longhurst (1966) [17] who stated that in Nigeria *P. typus* spawn mainly during the warm season in waters where temperature is high or equal to 27.5˚C.

There were a slight dominance of males over females. Contrary to this assertion sex ratio is most often near 50% until a certain size, from which it increases in favor of females to adjoin the 100% in adult individuals. According to Lauer *et al.* (2008) [16], fishing tends to remove selectively the largest individuals in a population. The catchability may result in skewed sex ratios (Adams *et al.* 2000, Rowe and Hutching 2003) [1, 23]. In this study it is suggested that males were more vulnerable to fishing pressure, resulting in skewed sex ratios, with males dominating in the catches. Dominance of females over males was recorded in studies by Sidibe (2003) [24] and Troadec (1971) [28].

5. Conclusions

The present study has revealed that *P. typus* and *P. senegalensis* population within Liberia's coastal waters shows negative allometric growth which could be alluded to intense fishing pressure. These two species spawning is associated with the hydrological seasons. Therefore, urgent management interventions in form of close seasons are needed to safeguard these commercially important fish species from possible stress in the future.

6. Acknowledgement

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