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Health status of sciaenid species following mass fish kills in coastal waters of Niger Delta, Nigeria

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Abstract

The length-weight relationship, condition factor, and hepatosomatic index of three of the most abundant and commercially valuable croaker (Sciaenidae) species in the coastal waters of Nigeria were examined following mass fish kills. A total of 489 individuals of *Pseudotolithus* were sampled, and *Pseudotolithus elongatus* formed the bulk of the catch, comprising 67.55% by numbers, followed by *P. typus* and *P. senegalensis,* which represented 23.15% and 22.56%, respectively. LWRs were estimated to be BW = $0.0133TL^{2.38}$ for *P. typus,* BW = $0.0537TL^{2.86}$ for *P. senegalensis, and* BW = $0.00391TL^{3.00}$ for *P. elongatus*. The condition factors recorded ranged from 0.64±0.04 to 1.93±0.03 for *P. typus*, 0.74±0.04 to 1.85±0.05 for *P. senegalensis,* and 0.73±0.03 to1.61±0.01 for *P. elongtatus.* The HSI values for *P. typus* ranged from 0.64±0.04 to 1.93±0.03, 0.74±0.04 to 1.85±0.05 for *P. senegalensis,* and 0.73±0.03 to 1.61±0.01 for *P. elongtatus.* In conclusion, the results of this study would be very useful to execute specific management for the Sciaenid fishery in other coastal waters in Nigeria to achieve its sustainability.

Keywords: Length-weight; Condition factors; Hepatosomatic index; Sciaenid species; Coastal waters

1. Introduction

The relationship between fish length and weight (LWR) plays an essential role in evaluating the growth and biomass of a fish population (Phan et al., 2021). The length-weight relationship is a useful biological tool for understanding the changes in aquatic environment (Shah et al., 2013) and is widely used in planning a better management strategy for fisheries resources (Huang et al., 2018).The length-weight relationship provides a means for finding out the condition factors that indicate the "wellbeing of the fish" (Olopade et al., 2018). The length-weight relationship (LWR) and Fulton's condition factor (K) are accepted as an indicator of the healthiness of fish stocks (Brosset et al., 2017). The condition factor can be used as an index to assess the level of disturbance in an aquatic ecosystem that is strongly influenced by environmental parameters.

The hepatosomatic index which is the ratio of liver to body weight is also used to evaluate well-being or fitness (Bolger and Connoly, 1989) as well as the energy reserves of fish. Since the liver is an important storage for energy reserves in non-fatty fish (Chellappa et al., 1995). However, the index also indicates liver hypertrophy that can be caused by pollutants (Bervoets et al., 2009). Health indices of fish such as weight, length, condition factor, and hepatosomatic index (HSI) can indicate stress in aquatic ecosystems and are therefore often examined in relation to pollution (Güngördü et al., 2012).

Fish kills have been reported from coastal waters in Nigeria, particularly in the Niger Delta region, on many occasions. In late March 2020, a massive fish kill event occurred again within 2 nautical miles of the region, and this time masses of dead and dying fish of the family Sciaenidae were reported in various locations. This family comprises croakers,

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drums, meagres, and weakfishes and is one of the most diverse perciform families in terms of the number of species and distribution Sciaenids or croakers (Genus: Pseudotolithus), are among the commercially important fish in the Nigerian inshore waters (Anyanwu, 1983). They are exploited by both the artisanal fishery (Uwe-Bassey, 1988) and the industrial fishery (Löwenberg and Künzel, 1991). Croakers are important food fish for Nigeria, as they constitute about 40% of the total fish landing on the Nigerian coast (Gaffer, 1994).

The health of fish is paramount to understanding and protecting the finfish resource; the concept of health has evolved to be defined as a state of equilibrium between an organism and its environment that is compatible with the full functional activity of that organism (Last, 1998). Health indices of fish such as weight, length, condition factor, and hepatosomatic index (HSI) can indicate stress in aquatic ecosystems and are therefore often examined in relation to pollution (Güngördü et al., 2012). This study aims to estimate relevant population parameters and assess the stock of sciaenid species in one of the coastal waters of Nigeria following fish kills.

2. Material and methods

The Niger Delta region of Nigeria is blessed with inshore waters and bounded in the south by offshore waters of the Atlantic Ocean, with a massive sedimentary basin of about 350 kilometers and approximately 670 kilometers of coastline. The study was carried out in Niger Delta coastal waters located on the Atlantic coast of southern Nigeria. The climate is mainly tropical, with two distinct seasons: the dry season, which lasts from November to April, and the rainy season, which lasts from May to October. The average monthly temperature of the region is 27° C, with an annual rainfall ranging from 3000 to 4500 mm. Fish specimens were sampled monthly, from January 2021 to December 2021, from the catches of small scale commercial fishermen using beach seines, cast nets, gillnets, and trammel nets at the landing sites: Bonny water way, Koluama, and Gbaramatu in the southern coastline of Nigeria. The collected fish specimens were preserved in the icebox and immediately transported to the laboratory at the Department of Fisheries, University of Port Harcourt, Nigeria. Then, fish total length (TL) was measured using a ruler to the nearest 0.1 cm, and fish weight (W) was weighted using an electric scale to the nearest 0.01 g. Specimens were dissected, and the livers were carefully removed with the aid of forceps after dissection. The livers were weighed separately to the nearest 0.5g. Length–weight relationships ($W = aL^b$) were estimated for each of the species (Anderson and Neumann, 1996). The condition factor (K) was estimated by Bagenal and Tesch (1978) as K = 100* W/L3, where W is the total weight, and L is the total length (TL). The hepatosomatic index (HSI) will be calculated: HIS = 100 X (liver weight g/total body weight g).

3. Results and discussion

A total of 489 fish specimens, comprising three species, were sampled, and *P. elongatus* formed the bulk of the catch, comprising 67.55% by numbers. This was followed by *P.typus* and *P. senegalensis* which represented 23.15% and 22.56%, respectively. The most economically important and dominant species in the Nigerian coastal waters are *Pseudotolithus elongatus, P. senegalensis and P. typus*, (Anyanwu, 1983). Troadec (1971) reported that the dominant species are *Pseudotolithus elongatus*, *P. typus*, and *P. senegalensis* but *P. senegalensis* is economically the most important species in the West African trawl fishery. The dominance of *P. elongatus* in the samples from the three main fish landing sites in this study indicates that the species is the most dominant sciaenid species in the inshore waters of Nigeria. Etim et al. (1994) reported that P. elongates is the most economically important fish in the Cross River estuary, Nigeria, where it constitutes 43.3% of the total catch by the artisanal fishermen.

Table 1 Catch composition of three fish species of Sciaenidae from Southern coastal waters, Nigeria

Species Scientific name	Common name	Number	Percentage
Pseudolithus elongatus	Long neck croaker	458	67.55
Pseudolithus typus	Long neck croaker	157	23.15
Pseudolithus senegalensis	Cassava croaker	153	22.56
	Total	678	

The size ranges recorded during the study, as shown in Table 1, showed that the lengths ranged from 14.90 to 31.00 cm with a mean value of 23.43±0.87 cm for *P. typus*, 13.40 to 24.70 cm with a mean value of 21.86±0.20 cm for *P. senegalensis* and 14.40 to 23.30 cm with a mean value of 19.05±0.22 cm for *P. elongatus*. The weights ranged from 35.00 to 74.00 cm with a mean value of 63.24±6.44 cm for *P. typus*, 36.12 to 69.05cm with a mean value of 51.29±3.11cm for *P. senegalensis*, and 32.20 to 46.17 cm with a 44.17±3.48 cm for *P. elongatus*. The sizes in the present study are similar

to those in other studies on croaker species. Jolaosho and Olorunniyi (2022) reported that the dominant lengths for *P. elongatus* ranged from 10.761 to 25.5 cm in the Makoko River, Nigeria. Salarpouri et al. (2022) reported a total length range of 18.0 to 47.5cm, with a mean 28.7±5.9cm for *Atrobucca nibe* in the Oman Sea. In this study, the size structure indicated that the juvenile to adult life history stages were prominent in all three species; this may be due to the selectivity of fishing gear deployed by the fishers in the study area. Hossain et al. (2010) observed that the difference in size structure might be attributed to the variation of environmental factors, mostly water temperature and food availability.

The results on length-weight relations (LWRs) of all species are given in Table 1. The formula of LWRs was estimated to be $BW = 0.0133TL^{2.38}$ for *P. typus,* $BW = 0.0537TL^{2.86}$ for *P. senegalensis, and* $BW = 0.00391TL^{3.00}$ for *P. elongatus*. Estimations revealed that length and weight for all species were highly correlated, with the coefficient of determination (r^2) ranging from 0.82 to 0.98 ($P < 0.05$) indicating a high degree of positive correlation between the two attributes (length and weight). This may be due to the conducive environmental parameters of the ecosystem for the growth of the fish. Estimates of the parameter b (2.38, 2.86, and 3.00) obtained from linear regressions of the relationship between log weight and total length demonstrate the patterns of growth of the three species, with *P. typus* and *P. senegalensis* exhibiting negative allometry and *P. elongatus* exhibiting an isometric growth pattern. The croaker species estimated b values ranged from 2.38 to 3.00 and were within the usual range (2.50 to 3.50) of b values for fishes (Froese, 2006). Environmental variables, gonad development stages, sex, stomach fullness, functional health state, season, population, and variation among species all influence the parameters of L-W interactions in fish (Nieto-Navarro et al., 2010). Growth is a fundamental characteristic of all living organisms, and growth patterns and growth rates are highly species-specific (Olopade et al., 2015). In this study, *P. senegalensis* and *P. typus* presented negative allometric growth, suggesting that size increases more than weight in both species. This finding is similar to the findings of Pathak (1975), who obtained a 'b' value of 2.392 for P. *typus*. Nunoo et al. (2014) also reported a negative allometric growth pattern in *P. typus* near shore waters in Benin. In this study, only *P. elongatus* showed an isometric growth pattern. Le Cren (1951) noted that obedience to the cube law (isometric growth) is rare among the vast majority of fish species.

Table 2 Length-weight relationship parameters of three fish species of Sciaenidae from Southern coastal waters, Nigeria

Species		**Total Length**		**Weight**					
	N	**Mean**	**Range**	**Mean**	**Range**	**a**	**b**	**r^2**	**Growth pattern**
P. typus	157	23.43±0.87	14.90 - 31.00	63.24±6.44	35.00 - 74.00	0..0133	2.38	0.82	Negative allometry
P. senegalensis	153	21.86±0.20	13.40 - 24.70	51.29±3.11	36.12 - 69.05	0.0357	2.86	0.93	Negative allometry
P. elongtatus	179	19.05±0.22	14.40 - 23.30	44.17±3.48	32.20 - 46.17	0.00391	3.00	0.98	Isometric
Total	1073								

The mean monthly variations of the condition factor in the three Sciaenid species are presented in Table 3. Except for the months of February, June, and July, all other months showed significant differences ($p< 0.05$) in the values of the condition factor for the three species. King (1996) reported that variations in K in fish may be indicative of food abundance, adaptation to the environment, gonad development, sample size, habitat quality, growth increment, water temperature and salinity, fishing activities, individual metabolism, age, and maturity. The variation of Fulton's condition factors among fish may occur due to the variation of productivity and their physiological conditions. A condition factor that is equal to or greater than 1.0 would indicate that the species is relatively "fat" or "plump," indicating good health condition and well-being for the fish. The results revealed that the condition factors recorded ranged from 0.64±0.04 to 1.93±0.03 for *P. typus*, 0.74±0.04 to 1.85±0.05 for *P. senegalensis* and 0.73±0.03 to1.61±0.01 for *P. elongtatus.* In the present study, the three species followed the same pattern, with condition factors higher in the dry season, mostly between September and February, than in the rainy season. This can be explained by the fact that species condition factor values less than one are considered low, while those greater than one are considered high (Mir et al. 2012). Variations in the condition factor in different habitats might be attributed to food availability, the ecology of a water body, different levels of sexual maturity, and the physiological status of fish, along with other unknown factors (Alam et al., 2014). The CF can increase or decrease during the reproductive cycle of fish, depending on the spawning stage (Lam and Dinh, 2021). Besides, this sudden change in value also indicates a difference in the feeding habits of some fish species (Phan et al., 2021). The condition factor often decreases at the beginning of the reproduction process due to a

high metabolic rate, then becomes normal and increases afterwards. During that period, the fish does not feed and utilizes the accumulated visceral fat during spawning (Lizama and Ambrosio, 2002). The condition factor of fish species is known to fluctuate, decrease during times of low temperatures and/or low availability of food, increase towards the spawning season, have a sharp decline after spawning, and then increase again after spawning (Froese, 2006).

Table 3 Monthly mean of condition factors of three fish species of Sciaenidae from Southern coastal waters, Nigeria

Month	*P. typus*	*P. senegalensis*	*P. elongtatus*
Jan	0.71±0.01 [b]	0.62±0.02 [a]	0.61±0.01 [a]
Feb	0.75±0.05	0.75±0.01	0.75±0.03
March	0.71±0.01 [b]	0.84±0.04 [a]	0.82±0.02 [a]
April	0.54±0.04 [b]	0.74±0.04 [a]	0.73±0.03 [a]
May	0.57±0.04 [b]	0.72±0.02 [a]	0.71±0.01 [a]
June	0.51±0.01	0.51±0.51	0.54±0.04
July	0.41±0.01	0.43±0.54	0.44±0.01
August	0.62±0.02 [a]	0.61±0.01 [a]	0.75±0.05 [b]
Sept	0.61±0.01 [b]	0.73±0.03 [a]	0.71±0.01 [a]
Oct	0.74±0.04 [b]	0.93±0.03 [a]	1.01±0.01 [a]
Nov	0.62±0.02 [c]	0.91±0.01 [a]	0.83±0.03 [b]
Dec	0.93±0.03 [b]	1.14±0.04 [a]	1.12±0.02 [a]

Means with different superscripts along same row are significantly different ($p<0.05$

Table 4 Monthly mean of hepatosomatic index (HSI) of three fish species of Sciaenidae from Southern coastal waters, Nigeria

Month	*P. typus*	*P. senegalensis*	*P. elongtatus*
Jan	1.45±0.05 [b]	1.85±0.05 [a]	1.61±0.01 [b]
Feb	1.31±0.01 [b]	1.72±0.02 [a]	1.33±0.03 [b]
March	0.64±0.04 [b]	1.01±0.01 [a]	0.94±0.04 [a]
April	0.85±0.05 [b]	0.74±0.04 [b]	1.12±0.02 [a]
May	0.66±0.02	0.65±0.05	0.62±0.05
June	0.91±0.04 [ab]	0.92±0.02 [a]	0.73±0.03 [b]
July	0.82±0.02	0.80±0.05	0.084±0.01
August	1.04±0.04 [a]	0.83±0.03 [b]	0.73±0.03 [b]
Sept	1.53±0.03 [a]	1.21±0.01 [b]	1.05±0.05 [c]
Oct	1.65±0.05 [a]	1.41±0.01 [b]	1.23±0.03 [c]
Nov	1.73±0.03 [a]	1.11±0.01 [b]	1.04±0.04 [b]
Dec	1.93±0.03 [a]	1.71±0.01 [b]	1.51±0.01 [c]

Means with different superscripts along same row are significantly different ($p<0.05$)

Table 4 shows the monthly variations in the HSI values recorded during the study for the three Sciaenid species and their significant differences. The results showed that the months of May and June did not have significant differences ($P>0.05$) in the values of HIS. The HSI values recorded for *P. typus* ranged from 0.64±0.04 to 1.93±0.03, 0.74±0.04 to 1.85±0.05 for *P. senegalensis,* and the HSI values for *P. elongtatus* ranged 0.73±0.03 to1.61±0.01. The monthly HIS values recorded in this study for the three species were relatively low from March to July. This could be attributed to the fact

that most spawning takes place during the rainy season. According to Rajaguru (1992), in female *Cynoglossus arel*, the lowest gastro and hepatosomatic indices were recorded only during the peak spawning period, whereas in male *C. arel,* a peak of empty stomachs occurred during the same period, which was the spawning period, and the lowest gastro and hepatosomatic indices were recorded during the spawning period.

4. Conclusion

The health status of three of the most abundant and valuable Sciaenidae stocks in the coastal waters of the Niger Delta of Nigeria was assessed following mass fish kills using health indices of fish such as weight, length, condition factor, and hepatosomatic index that are central to the exploitation and conservation of the stock of Sciaenidae in particular, which is very important for the local fishery. Results revealed that *P. typus* and *P. senegalensis* had better growth in length than in weight, therefore having a negative allometry, and only *P. elongtatus* had isometric growth. The monthly condition factors of the studied Sciaenidae stocks are close to the recommended range, indicating a good fish population with reflections of healthy status. HSI values in the three species followed a similar pattern, reflecting similar conditions in coastal ecosystems and supporting fish productivity, indicating the suitability of habitat for the three species.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest

Statement of ethical approval

No specific ethical approval was necessary for this study.

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