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Length at first capture (L_{C50}) of *Sardinella aurita* and *Sardinella maderensis* landed from purse seines at the Tema fishing Harbour, Ghana

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Abstract
This study was conducted at the Tema fishing harbor to assess length at first capture (L_{c50}) of *Sardinella maderensis* and *S. aurita* landed by purse seines to confirm growth overfishing. Hundred samples for each species were purchased randomly from November 2015 to January 2016. $L_{c50,}$ length frequency distribution, length-weight relationship, condition factor and selection factor were estimated. L_{c50} for *S. maderensis* and *S. aurita* was 15.00 cm and 13.00 cm respectively and the mean length, 15.1 ± 2.8 cm and 13.1 ± 2.3 cm respectively, which are lower than the minimum allowable landing sizes suggesting breach of the fisheries regulation in Ghana. The selection factor was 1.83 (*S. maderensis*) and 1.63 (*S. aurita*) with 8.3 cm mesh size. Length-weight relationship showed allometric growth for *S. aurita* and isometric growth for *S. maderensis.* Results validates growth overfishing of the two clupeids landed at the Tema fishing harbour.

Keywords: length-weight, sardinella, growth overfishing, length at first capture, Tema harbour

1. Introduction

The fisheries sector plays a major role in the national economy and food security for Ghana with marine capture fisheries accounting for about 420,000 tons of fish per year [1]. Fish consumption in Ghana is estimated to be 23kg per year, much greater than the global per-capita average of 19 kg [1]. The Sardinella fishery (*Sardinella aurita and Sardinella maderensis*) is important in Ghana because it is a relatively cheap food of animal protein as well as constituting the economic backbone of many fishers; fish processors and traders in coastal areas in Ghana whose livelihoods depend mostly on the Sardinella. For instance, in years of good Sardinella fishery, the species could constitute as much as 40% of total domestic marine fish production. However, in recent years from 2010 – 2014, the abundance and distribution of the sardines within Ghana's coast have recorded large variations in landings and near collapse [2].

The observed heavy decline in landed catch especially pelagic from 277,000mt in 1996 to 92000 mt in 2011 in Ghana is due to factors such as increasing number of fishermen and fishing nets deployed coupled with increased geographical reach by fishing vessels, weak governance and open- access fishery [3]. Consequently, declining landed catch for sardines in Ghana deepens the severity of poverty and food insecurity within vulnerable fishing households whose livelihoods depend solely on Sardinella.

However, the decline in landed catches might be long lasting, depriving vulnerable coastal communities in Ghana of benefits provided by fish stocks particularly, Sardinella fishery. Selectivity of fishing gears amidst other factors are drivers fueling the consistent decline in landed catches of pelagic fish stocks within Ghana's coastal waters.

Therefore, to avert heavy declines in landed fish catches, in the form of growth or recruitment over fishing within the Sardinella fishery due to gear selectivity, there is the need to assess whether there has been a change in the mean length of landed fish stocks.

The absence of information pertaining to population dynamics, particularly, length at first capture (L_{c50}) within the Sardinella fishery hinders sustainable management. Thus, information obtained from this study will provide management strategies such as mesh size regulation for sustainable Sardinella fishery to meet the needs of both present and future generations.

This study was conducted to assess the length at first capture (L_{c50}) for *Sardinella aurita* and *Sardinella maderensis* to ascertain possible growth overfishing.

2. Materials and methods

2.1 Study Area

The study focused on Tema canoe beach, a section of the Tema fishing harbour, located on the geographical coordinates 5.6333° N, 0.0167° W (Figure 1). There are over 400 artisanal fishing vessels with 318 canoes operating with purse seine fishing gears and 182 canoes operating with drift gill net [4]. Fishing and its related activities form the primary livelihoods of most inhabitants around the Tema fishing harbor with few engaged in alternate livelihoods such as petty trading.

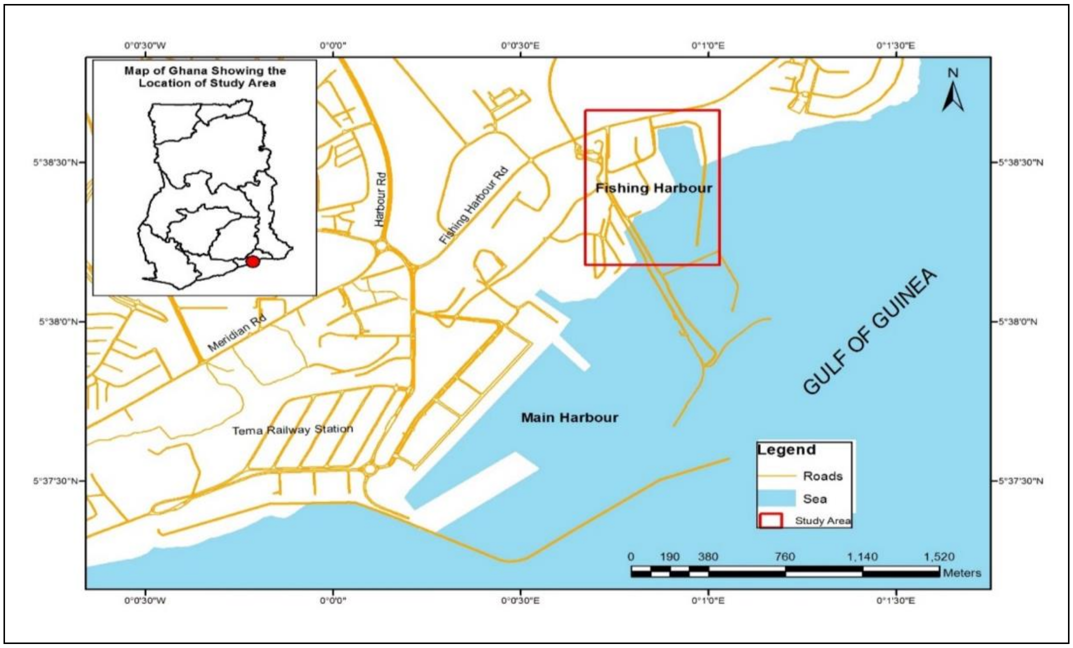

Fig 1: Map of Ghana showing the location of the Fishing Harbour.

2.2 Data Collection
A minimum of hundred samples for each fish species were purchased randomly from landings of purse seiners at the Tema canoe beach monthly from the month of November 2015 to January 2016. Purchased fish samples were preserved on ice in ice chest and transported to the laboratory at the Department of Marine and Fisheries Sciences, University of Ghana. In the laboratory, fish samples were identified using identification keys by [5]. The standard length was measured in cm using a fish measuring board to the nearest 0.1 cm. The weight of each individual fish specimen was recorded in grams using an electronic balance to the nearest 0.01g.

2.3 Analysis of Length frequency distribution
The pooled monthly length frequency data was grouped at 1 cm interval to construct a histogram for both species.

2.4 Length weight relationship
The length-weight relationship of each fish species was determined using the equation $W= aL^b$ and in the linear form:

$$\text{Log}\, W = \text{Log}\, a + b\, \text{Log}\, SL$$

Where W is the weight of fish in grams (g); SL is the standard length of fish (cm); a is a scaling constant and b is the growth coefficient [6].

2.5 Condition factor
The condition factor or coefficient of Condition factor (K) was estimated by the relationship:

$$K = 100 \times \frac{W}{L^3}$$ [7]

where, K = condition factor,
L = standard length (cm),
W = weight of fish (g).

2.6 Estimation of length at first capture (Lc_{50})
The probability of capture was estimated by plotting the cumulative probability of capture with mid-length. Length at first capture (L_{c50}) was taken at 50% of the resultant cumulative curve [8].

2.7 Data Analysis
Sample Z-Test was done to examine the statistical difference between the length classes for both species. The z-test was applied because sample size for measured fish lengths (standard lengths) were greater than 30. The significance of the growth type (b) from isometric growth (b = 3.00) was done using XSLAT statistical tool. The alpha value for statistical difference was p -value = 0.05.

3. Results
3.1 Length Frequency Distribution
Figure 2 shows a unimodal frequency distribution of *S. maderensis*. The maximum length, mean length and modal length were estimated at 22.9 cm, 15.1± 2.8 cm and 13.5 cm respectively. The range for *S. maderensis* was 9.3 cm – 22.9 cm. The length frequency distribution of *S. aurita* is shown in Figure 3. From this figure, the maximum length, mean length and modal length were recorded as 19.5 cm, 13.1 ± 2.3 cm and 14 cm respectively. The range for *S. aurita* was 8.8 cm - 19.5 cm. Sample z test indicated significant difference between the measured lengths (standard lengths) for *S. maderensis* and *S. aurita* (df =1, p-value (0.0001) < 0.05).

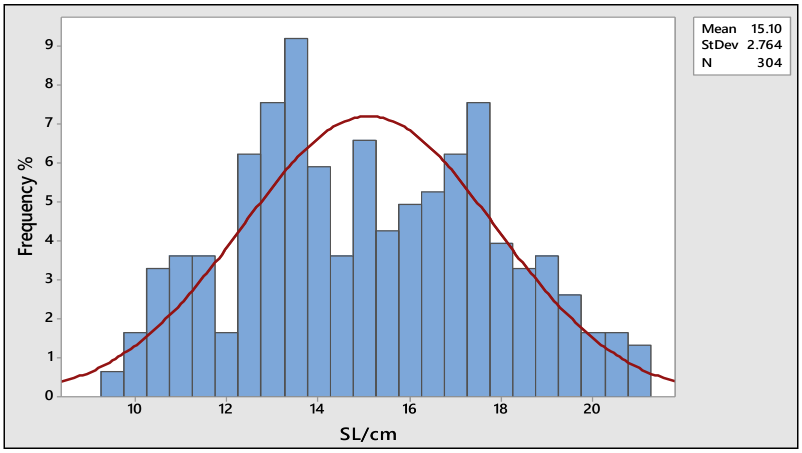

Fig 2: Length frequency distribution of *S. maderensis* landed at the Tema Fishing Harbour

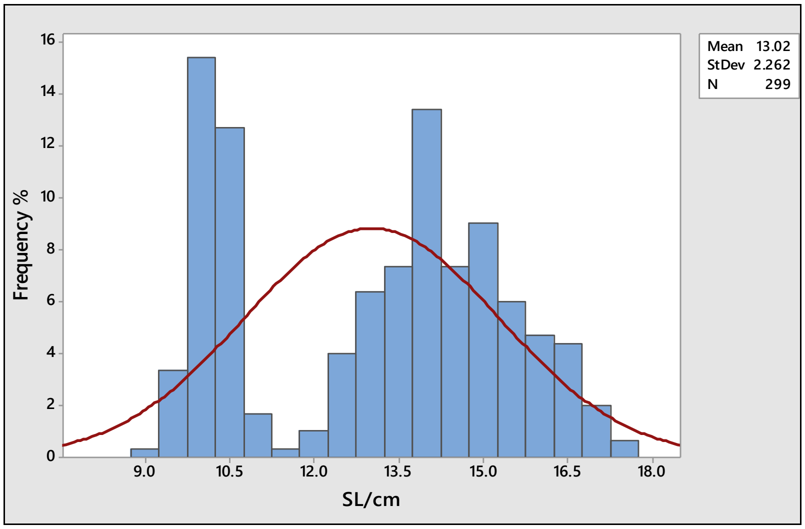

Fig 3: Length frequency distribution of *S. aurita* landed at the Tema Fishing Harbour.

3.2 Length weight relationship

The log transformed length weight relationship of *S. maderensis* showed a log transformation equation of Log W = 3.0074 LogSL-1.8376 (Figure 4). The calculated slope (b) was 3.0 at significance level of p -value = 0.0. A strong correlation (R^2 = 0.9) between the weight and length was obtained (Figure 4). Figure 5 shows the log transformed length weight relationship for *S. aurita* with a log transformation equation of Log W =2.4038 Log SL-1.2522. For this species, the slope (b) was 2.3 at significance level of p-value = 0.00. The correlation between the weight and the length was found to be relatively strong (R^2=0.7). The condition factor (K) was estimated at 1.25 and 1.5 for *S. maderensis* and *S. aurita* respectively (Table 1).

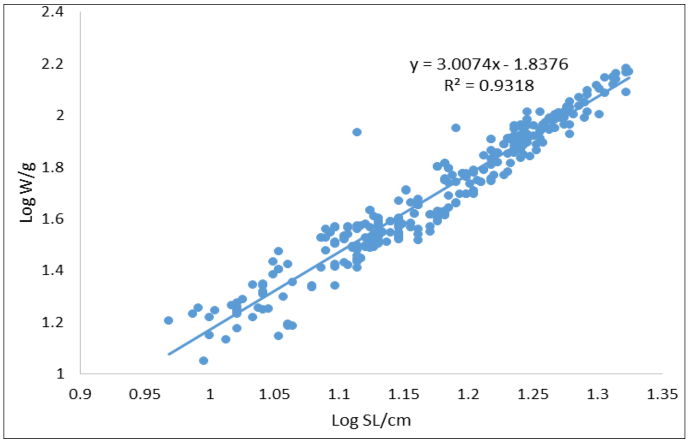

Fig 4: Log transformed length weight relationship of *S. maderensis.*

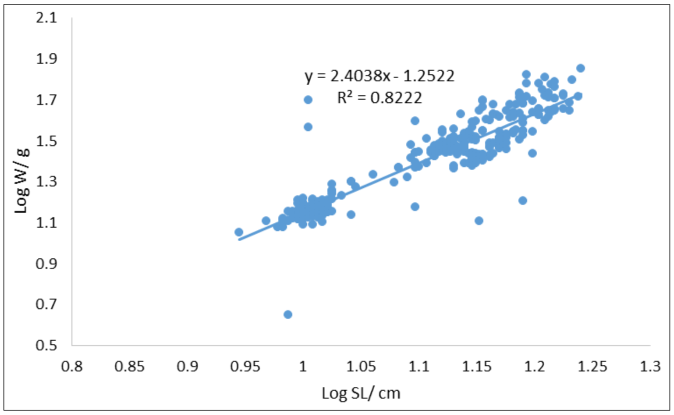

Fig 5: Log transformed length weight relationship of *S. aurita.*

Table 1: Comparison of estimated stock parameters for *S. maderensis* and *S. aurita* encountered with purse seine from November 2015 to January 2016.

Parameters	*S. maderensis*	*S. aurita*
Maximum length (cm)	20.5	17.3
Mean length (cm)	15.1 ± 2.7	13.1 ± 2.3
Length range (cm)	9.3-22.9	8.3-19.5
Selection factor (SF)	1.81	1.63
Length at first capture (L_{c50})	15.0	13.5
Mesh size (cm) of purse seine	8.3	8.3
Slope (b) of L-W relationship	3.0	2.3

3.3 Length at first capture

Figure 6 and 7 shows the length at first capture (L_{c50}) for the assessed fish species. From Figure 6 the length at first capture was estimated at L_{c50} =15.0 cm for *S. maderensis*. Figure 7 shows the length at first capture (L_{c50}) of *S. aurita*. The calculated length at first capture for *S. aurita* was L_{c50} =13.5 cm which is higher than that of Amponsah [9] for both *S. aurita* L_{c50} =5.99 and *S. maderensis* L_{c50}=5.30.

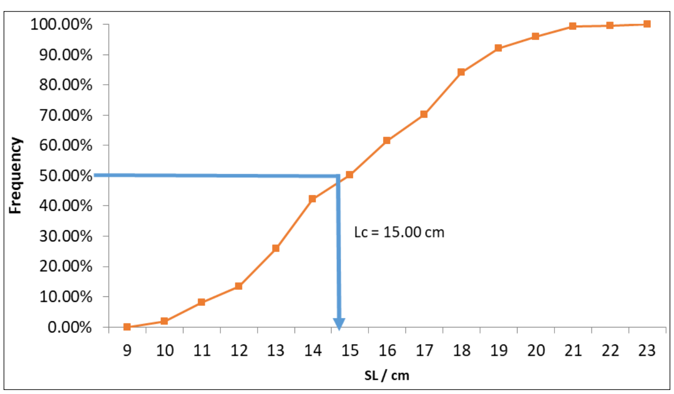

Fig 6: Length at first capture (L_{c50}) of *S. maderensis* landed at the Tema Fishing Harbour.

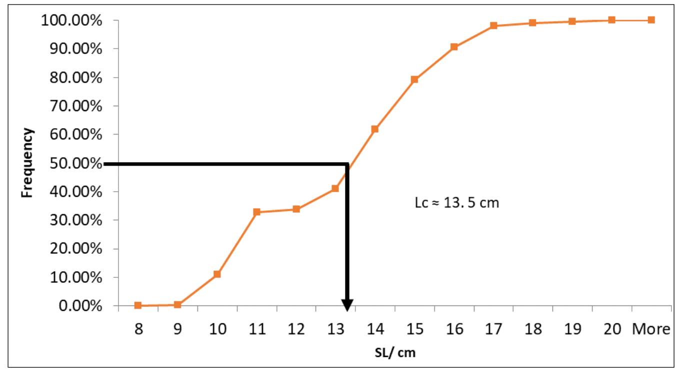

Fig 7: Length at first capture (L_{c50}) of *S. aurita* landed at the Tema Fishing Harbour.

3.4 Mean monthly condition factor

The mean monthly condition factor/ (K) for both *S. maderensis* and *S. aurita* are presented in Figure 8. Mean monthly condition factor for *S. maderensis* was lower in January 2016 (1.39 ± 0.02) and higher in November 2015 (1.65 ± 0.02) while that for *S. aurita* was also lower (1.03 ± 0.02) in January 2016 as compared to 1.41 ± 0.01 estimated for November 2015. However, the mean monthly condition factors for both species were higher than 1.00 indicating that the assessed species were in good physiological condition [10].

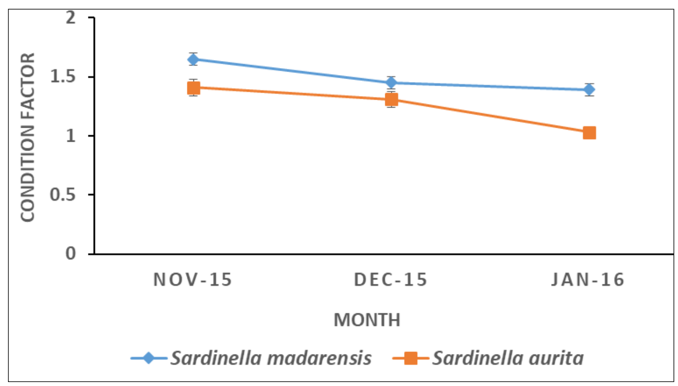

Fig 8: Condition factor for *S. maderensis and S. aurita* from November 2015 to January 2016.

3.5 Selection factor (SF)

The Selection Factor (SF) was estimated using the relation: Lc_{50}= S.F x Mesh size [11].

The estimated selection factor was 1.81 for *S. maderensis* and 1.63 for *S. aurita* (Table 1). The mesh size which was the main input for calculating Selection Factor (SF) was 8.3 cm both for *S. maderensis* and *S. aurita* (Table 1).

4. Discussion

Length-weight relationship can be used to determine fish

Weight from length, condition index and ontogenic allometric changes [12]. Estimates of length-weight relationships are necessary for stock assessment and is also useful for fishery conservation and management [12].

The length weight relationship for *S. aurita* and *S. maderensis* had the growth type b value to be 2.3 and 3.0 respectively indicating that *S. aurita* exhibit a negative allometric growth. The negative allometric growth shows that the length grows faster than the weight indicating a thin rather than a fat fish. On the contrary, *S. maderensis* had a slope to be 3.0, implying an isometric type of growth where the length grows proportional to the cube of length. Length-weight relationship in fishes is affected by several factors such as sex, diet, gonad maturity, health, stomach fullness and on techniques of preservation [13].

The mean length estimated for both *S. maderensis* and *S. aurita* were relatively lower than estimated values documented in other studies indicating heavy fishing pressure [14,15]. This observation confirms the heavy exploitation on the Sardinella fishery within Ghana's coastal waters. However, the significant difference in mean length, observed in the present study suggest a relatively heavier fishing pressure on *S. aurita* than *S. maderensis* possibly as a result of consumer preferences.

The observed mean Condition factor (K) of *S. maderensis* and *S. aurita* were higher than one indicating that the species were in good physiological conditions [10]. However, the decreasing pattern of mean monthly Condition factor (K) for both assessed fish species could be assigned to environmental factors such as rainfall. The Condition factor (K) of *S. maderensis* ranged from 1.65 to 1.39 while *S. aurita* ranged from 1.41 to 1.03. The increase in Condition factor (K) in *S. maderensis* could be that it was well fed. Condition factor (K) expresses the relative degree of wellbeing or robustness of fish. It reflects the degree of nourishment and state of sexual maturity in fish. Condition factor (K) is based on the hypothesis that fish in better condition are heavier. A high Condition factor (K) would indicate a well-fed fish, while a low Condition factor (K) may indicate a poorly fed fish of the same length.

The estimated Selection Factor (SF) for *S. aurita* and *S. maderensis* was (1.63) and (1.83) respectively with the same mesh size of 8.3 cm for both species. The lower Selection Factor (SF) for *S. aurita* was an indication that they were bulkier while the relatively higher Selection Factor (SF) for *S. maderensis* showed that they were slender [11].

The length at first capture (L_{c50}) for both *S. maderensis* (L_{c50} = 15.00 cm) and *S. aurita* (L_{c50} = 13.00 cm) were relatively higher than the length at first capture recorded by Amponsah [9] for both *S. aurita* (L_{c50} = 5.99 cm) and *S. maderensis* (L_{c50} = 5.30 cm). This variation could be due to plethora of factors such as time and duration of sampling, fish landing site sampled, quantity of samples obtained as well as the type and mesh size of fishing gear within the sampling fish landing site. However, in comparison with minimum landing sizes of fishes in Ghana's fisheries Act 625 (1992) (*S. aurita* and *S. maderensis* 8cm), recorded estimates from the present study were relatively lower, strengthening the assertion that growth overfishing exists within the coastal fishing operation in Ghana. This is exemplified by the constant increase in number of fishing vessels in Ghana's coastal waters over time from 8176 canoes in 1937 to 13000 canoes in 2013 [4].

According to Lawson and Kwei [16] and Koranteng [14], the significant changes in artisanal fisheries in Ghana included the following:

1. introduction of outboard engines as a means of propelling the canoes,
2. change from the use of natural to synthetic netting materials and
3. Introduction of the purse seine net.

This is because purse seiners use motors, which was introduced by the Government's Fisheries Department as alternative means of propelling the canoes [17]. By using motors, the fishers could engage the migrating shoals much longer and much further away from their home landing points where they would return to daily.

Further, regardless of the mesh size of the purse seine net, which was similar for both species, the relatively lower selection factor in *S. aurita* may have accounted for the lower L_{c50} with the higher Selection factor (SF) of *S. maderensis* accounting for the higher L_{c50} of *S. maderensis* in the study. However, an increase in mesh size would increase the length at which Sardines especially, *S. aurita* would become vulnerable to fishing gear. This management intervention would result in the avoidance of future occurrence of overfishing as more sardines will have the opportunity to mature to marketable size and spawn at last once before harvested by fishing gears.

5. Conclusion

The length weight relationship for *Sardinella aurita* and *Sardinella maderensis* indicated that *S. aurita* exhibited a negative allometric growth while *S. maderensis* exhibited an isometric growth. The condition factor (K) of the two fish species were higher than 1.0 showing that they were in good physiological conditions. The estimated length at first capture (L_{c50}) and minimum length for *S. aurita* and *S. maderensis* were lower than the minimum lengths outlined in Ghana's Fisheries Act 625 (2010), implying management implications of the presence of growth overfishing for the two stocks.

6. References

1. MOFA. Available at mofa_facts_and_figures.pdf, Ministry of food and agriculture, Accra, Ghana, 2010.
2. FAO. The State of World Fisheries and Aquaculture; Rome. 2014; (223).
3. SFMP. USAID/Sustainable Fisheries Management Project, 2015.
4. Akyempon S, Bannerman B, Amador K, Nkrumah B. Ghana Canoe Frame Survey. Accra: Fisheries Scientific Survey Division, Ministry of Fisheries and Aquaculture Development, 2013.
5. Fischer WG. Bianchi and Scott WB. FAO species identification sheets for fishing purposes: Eastern Central Atlantic; fishing areas 34, 47 (in part). (eds.): Canada Funds-in-Trust. Ottawa, Department of Fisheries and Oceans Canada, by arrangement with the Food and Agricultural Organisation of the United Nations. 1981; 1-7.

6. Ricker WE. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 1975; 191:382.
7. Le Cren ED. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). The Journal of Animal Ecology. 1951; 1:201-19.
8. Enin UI. First estimates of growth, mortality and recruitment parameters of Macrobrachium macrobrachion Herklots, 1851 in the Cross River estuary, Nigeria. Dana. 1995; 11(1):29-38.
9. Amponsah SKK. Assessment of the Security of Coastal Fishing Operations in Ghana from the Perspectives of Safety, Poverty and Catches. Accra: University of Ghana, 2015.
10. Pauly D. Some simple methods for the assessment of tropical fish stocks. Food & Agriculture Org, 1983.
11. Pauly D. Fish population dynamics in tropical waters: a manual for use with programmable calculations. ICLARM Stud. Rev. 1984; (8).
12. Teixeira F, de Mello Vidal N, Gonzalez-Bergonzoni I, Iglesias C. Length–weight relationships of eight fish species from the lower section of the Uruguay River Verlag, Blackwell, 2006.
13. Tesch FW. Age and growth. Methods for assessment of fish production in fresh waters, 1971.
14. Koranteng KA. The Ghanaian fishery for sardinellas. Dynamics and Use of Sardinella Resources from Upwelling off Ghana and Ivory Coast. 1995:290-9.
15. King M. Fisheries biology, assessment and management. John Wiley & Sons, 2013, 16.
16. Lawson RM. African entrepreneurship and economic growth: A case study of the fishing industry of Ghana. Ghana University Press, 1974.
17. Kwei EA. Recent developments in the canoe fisheries in Ghana. Journal of Science. 1961; 1(1&2):29-35.