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Tidal influence on Fish Faunal Distribution and Species Diversity in Kakum Estuary, Ghana

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ABSTRACT

Estuarine and coastal areas are complex and dynamic aquatic environments. In such an area, where river water mixes with seawater, a large number of physical and chemical processes take place, which may influence water quality thereby affecting the distribution and diversity of the biota. The study was conducted in the transition period of dry and wet conditions from February to May 2018. The influence of low and high tides on the hydrographic parameters such as salinity, dissolved oxygen, and water temperature in the three sampling stations was analyzed in relation to fish faunal distribution and species diversity of the estuary. The common fish species in the estuary were juveniles of *Sarotherodon melanotheron* and *Mugil cephalus*, *Liza falcipinnis* and the crab *Callinectes amnicola*. These species were encountered during both low and high tides in all sampling stations, which indicates their adaptation to a broader range of hydrographic conditions. The majority of species encountered were juveniles. Although most of the fish species were marine in origin, some including *Tilapia zillii*, *Hemichromis fasciatus and Apolochelichthys spilauchen* were freshwater in origin whilst, *S. melanotheron* is a resident fish species in the estuary. Length-frequency distribution and length-weight relationships of *S. melanotheron*, *T. zillii*, *L. falcipinnis*, *Mugil cephalus*, and *Eucinosthomus melanopterus* which were the five most dominant fish species during the period of study in Kakum estuary were analyzed. The modal sizes of the dominant fish species were mainly juveniles in the length-frequency distribution. The length-weight relationships of *S. melanotheron*, *L. falcipinnis* and *M. cephalus* showed allometric growth, whereas that of *T. zillii* and *E. melanopterus* showed isometric growth. The study, therefore, identified that Kakum estuary is a transitional zone for both marine and freshwater fish species using the estuarine ecosystem as nursery grounds. The presence of marine and freshwater-origin species, and resident species in the estuary further suggest that estuaries are highly dynamic, and slight changes in their environment can cause a great deal of harm to its fish biota.

Keywords: Fish species occurrence, Habitat distribution, Hydrographic parameters, Species diversity, Length-weight relationships.

1. INTRODUCTION

The growth and survival of fish species in the estuarine environment is influenced by abundance and great diversity of food resources, protection against predation and other favourable environmental conditions that prevail in brackish waters (Paterson and Whitfield, 2000). These conditions favour the presence of large populations of fish species in the shallow aquatic

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environments (Roza and Zimmerman, 2000; Vidy, 2000). The fish populations are dominated by juveniles of marine species and contain few resident species or occasional freshwater fish species visitors. The populations show a wide temporal variation in their species composition due to environmental dynamics (tidal influence) and migratory nature of most of the fish species (Roza and Zimmerman, 2000).

Several studies on fish community in estuarine environment had shown its importance for several reasons. According to Ryan and Ntiamoah-Badu (2000), the coastal wetlands (mostly lagoons and estuaries) are among the most biologically productive but least understood ecosystems in most parts of the world, and they tend to be most diverse aquatic habitats (Gordon et al., 1995). They serve as breeding and feeding grounds for diverse fish species and other organisms such as mammals, birds and reptiles (Ryan and Ntiamoah-Badu, 2000). Again, the value of estuaries as sources of fish and other ecological services had been well-documented (McLusky, 1989; Blaber, 2000; Dahanayaka and Aratne, 2006; Woke and Wokoma, 2007; Plavan et al., 2011). The ecological function of estuaries as nurseries for diverse marine and freshwater fish species as well as migratory routes for both catadromous and anadromous fish species has also been highlighted (Fincham, 1984; Blaber, 2000; Plavan et al., 2011).

In Ghana, these habitats are among the most valuable ecosystems since they are closely tied to salt marshes, mangrove swamps and tidal flats which constitute significant features of Ghana's coastline providing critical habitats for many fish and wildlife resources that support the local economy (Aheto et al., 2014). Therefore, the aim of this study was to investigate the fish species composition, distribution and diversity in relation to the low and high tides in the Kakum estuary in the phase of recent dwindling of fish stocks in Ghanaian waters.

2. MATERIALS AND METHODS

2.1. Study Area

Kakum estuary is located between $5^0 5'50''$N, $1^0 19'20''$W and $5^0 6'5''$N, $1^0 19'0''$W (Fig 1) at Cape Coast in the Central Region of Ghana. The estuary receives freshwater sources from two rivers, Kakum and Sweet rivers, which empty into the Gulf of Guinea at Iture. The vegetation type is coastal savannah with grassland and few mangrove trees around the brackish water. According to Sackey et al. (1993), the estuary is endowed with five different species of mangroves: *Rhizophora mangle, R. racemosa, R. harrisonii* (red mangroves); *Laguncularia racemose* (white mangroves) and *Avicennia germinans* (black mangrove). The fringing communities in the estuary are mostly juvenile fish species and occasionally very large organisms which migrate either from the sea or the riverine sources into the estuarine habitat. The study was conducted from February to May, 2018. This period is a transition from dry conditions (when the marine influence is greater in the estuary) to wet conditions (when the riverine influence dominates). A daily tidal chart table was used to determine the different periods in tides. Both high tides and low tides happens during the same day within a space of 6hrs successively. The study identified three ecological zones in the wetland with respect to tidal ranges. These were: the head, where the freshwater from the Kakum river enters the estuary (Station 1); the middle, where greater dilution of saline and freshwater occur (Station 2); and the mouth, where the marine water enters the estuary (Station 3).

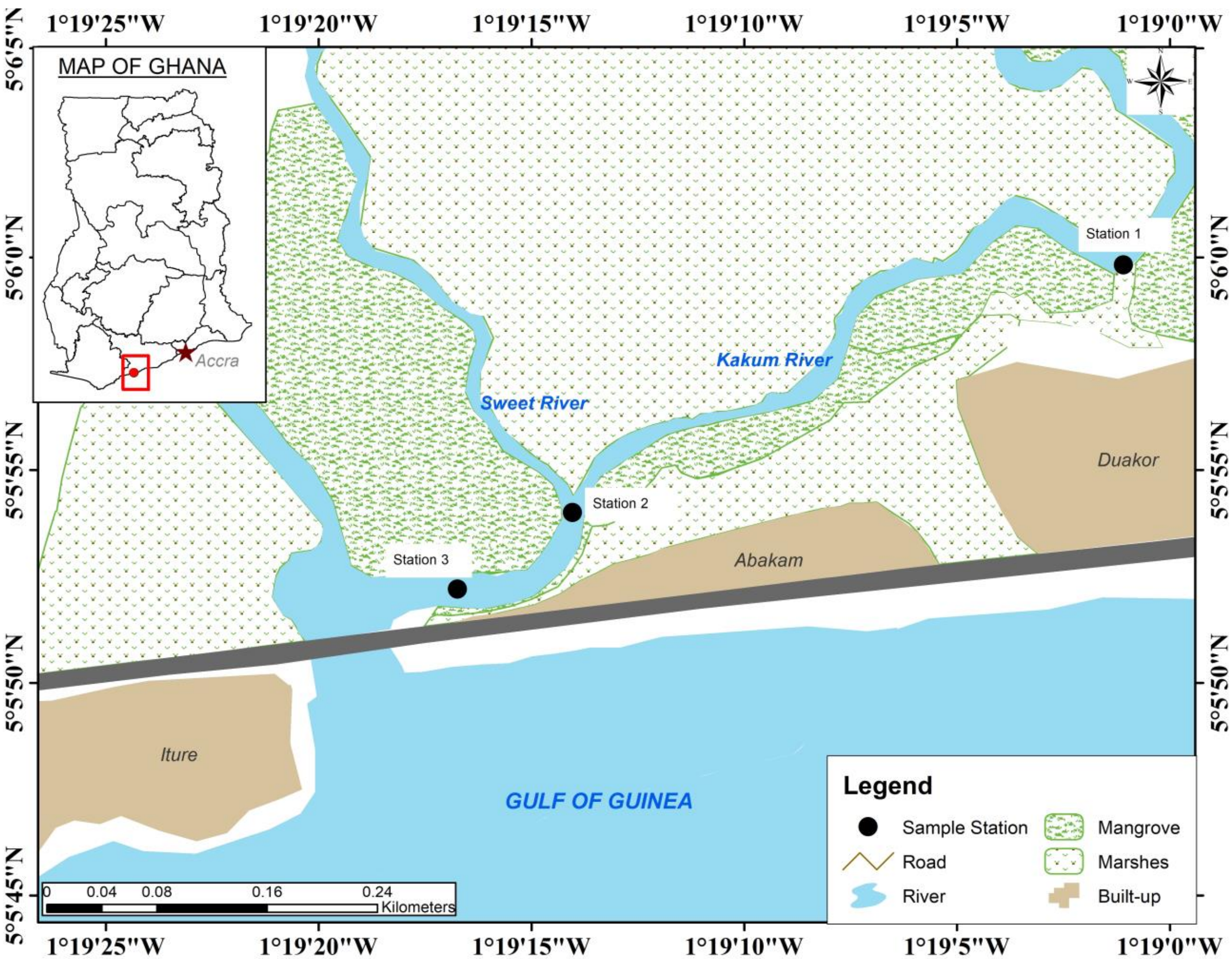

Figure 1. Map of Kakum estuary showing study areas (Station 1, Station 2, and Station 3).

2.2. Physico-chemical Parameters

The physico-chemical parameters were measured from three locations across the length of the estuary, starting from the mouth, through to the middle and to the head of the estuary. Sampling was conducted monthly from February to May during the second week of each month. Salinity, dissolved oxygen (DO) and temperature in the estuary were measured *in-situ* using refractometer and DO meter (Ecosense DO 200A) respectively. The temperature readings were taking from the Ecosense DO 200A. These physico-chemical parameters were recorded at low tide and high tide for six consecutive days in a space of 6hrs and 12hrs within each day depending on time of tidal occurrence. Three replicate recordings were taken per station during each tide, amounting to nine replicates in the estuary per tide for a day, and fifty-four replicates per tide for a month. The readings of the parameters preceded the fish sampling. Monthly means and standard deviations were computed based on the fifty-four replicates.

2.3. Fish Sampling

Sampling was done using pole-seine net (7 m long and 1.5 m deep) with stretched mesh size of 5 mm, and in addition a cast net of 20mm was used at specific locations. These fishing gears were employed for fish sampling due to the nature of substrate of the estuary and also to ensure the capture of all fish sizes. The seine net was deployed only at the middle (station 2) which was a rocky area and that the cast net was not the appropriate gear to be used in this area. According to Fisheries Act 625, seine net can be deployed in shallow water if only its based-on research purposes. Sampling was done every two weeks in each month during low and high tides. Three replicate recordings were taken at each zone during each tidal period and samples were kept on ice in sampling bottles and transported to laboratory and preserved in 10% formalin. A total of 1551 individual organism were sampled, which constituted 846 during low tides and 705 during high tides. Identification manuals were used to identify the fishes to the species level (Schneider, 1990; Paugy et al., 2003). The number of fishes belonging to each species caught from the sampling stations at low and high tides were also recorded. The morphometries of fin and shellfishes such as: total length (TL) of finfish, carapace length (CL) of crabs and body length (BL) of shrimp specimens were measured to the nearest 0.1 cm using fish measuring board. The body weights (BW) of the finfishes and shellfishes were measured to the nearest 0.01 g using an electronic balance OHAUS (Model: R71MD15).

2.4. Ecological Indices

Fish species composition, richness, diversity and evenness in the estuary were determined using the following indices.

The richness was determined using Margalef index (*d*):

$d = (s – 1)/ In\ N$ (Margalef,1958) ------------------------(1)

where *s* is the number of species in the sample, and *N* is the number of individuals in the sample.

The Shannon-Wiener species diversity index (*H′*) was used:

$H' = -\sum_{i}^{s} P_i(lnP_i)$ (Krebs, 1999) ------------------------(2)

Where, *s*: No. of species and P_i: proportion of individuals belonging to species in the station.

The evenness (*J′*) of diversity was calculated from Pielou's index:

$J' = H'/H_{max}$ (Pielou, 1966) ------------------------- (3)

where $H_{max} = ln\ s$.

3. RESULTS

3.1. Physico-chemical Parameters

Figure 2 shows the variations in salinity, dissolved oxygen and temperature in the mouth, middle and head stations of Kakum estuary during the period of study.

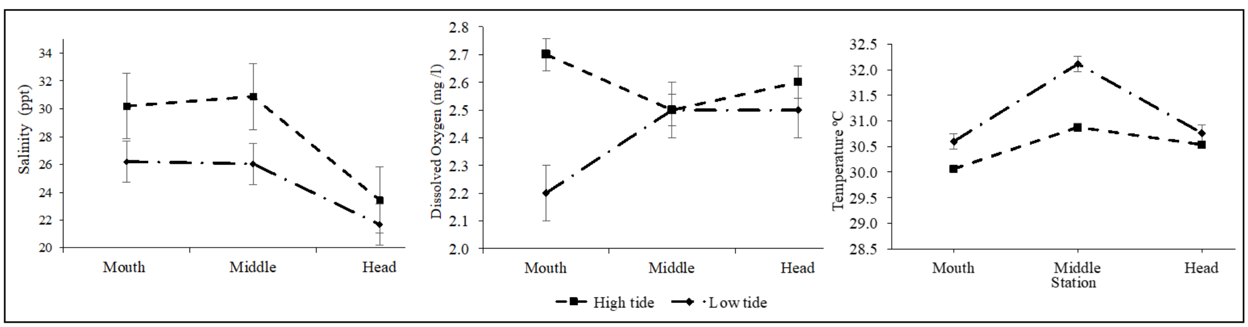

Figure 2. Physico-chemical parameters variations at low and high tides in Kakum estuary.

The mean minimum salinity recorded during high tides was 23.3‰ at the head station and the mean maximum was 30.8‰ at the middle; whereas at low tides the mean minimum occurred at the head station with a value of 21.8‰, and the mean maximum salinity recorded was 26.0 ‰ at the mouth. Concentration of dissolved oxygen generally varies spatially and temporally across the sampling stations of the estuary. Mean dissolved oxygen concentration during low tide ranged from 2.2 to 2.5 mg/l; whereas at high tides it varied from 2.5 to 2.7 mg/l throughout the study period. Slight temperature variations were observed with respect to space as one move along the estuary. The mean minimum temperature recorded during high tide was 30.0°C and the mean maximum was 30.8°C; whilst at low tide, 30.6ºC was recorded as the mean minimum and 32.1°C was recorded as the mean maximum temperature.

3.2. Occurrence of Fish Species

The occurrence of fish species recorded in the three sampling stations at low and high tides during the study period are shown in table 1. A total of 33 species (fin- and shellfishes) belonging to 18 families were sampled across the entire estuary. Six finfish species namely: *Liza falcipinnis*, *Mugil cephalus*, *Mugil curema* (Mugilidae), *Citharichthys stampflii* (Bothidae), *Lutjanus goreensis* (Lutjanidae), *Eucinosthomus melanopterus* (Gerreidae), and one shellfish species, swimming crab *Callinectes amnicola* (Portunidae) occurred both at low and high tides in all the stations.

Fishes that occur only at low tides include *Molene mertensi* (Bothidae) and *Sesarma angolenses* (Grapsidae); and fishes encountered only at high tides include: *Sardinella maderensis*, *Sardinella aurita* (Clupeidae) and *Psettia sebea* (Monodactylidae) (Table 1).

3.3. Species Richness, Diversity and Evenness

Species richness, diversity and evenness of Kakum estuary at low and high tides were determined (Table 1). The middle station recorded the highest species richness both at low and high tides, where 23 species belonging to 15 families were encountered. The mouth and head stations at low tides recorded 16 species each belonging to 9 and 11 families respectively; whereas at high tides 21 species belonging to 11 families were recorded at the mouth station, and 19 species belonging to 12 families were encountered at the head station. Using Shannon-Wiener diversity index, low tides were estimated to have the highest species diversity (H' = 2.6), whilst at high tides the diversity index was (H' = 2.4). The species evenness for low and high tides were 0.778 and 0.707 respectively.

3.4. Composition of Fish Species at Low Tides

At low tides, 846 individual fish specimens comprising 28 species were recorded (Fig 3). *S. melanotheron* with a composition of 23.74 % was the dominant fish species encountered at low tides; *L. falcipinnis* (10.52 %), *M. cephalus* (7.71 %), *Gobius* sp. (7.09 %) and *E. melanopterus* (6.97 %). The *T. zillii*, *A. monroviae* and *C. glaycos* each constituted 5.75 %. Other species recorded at low tides with a composition of less than 0.13% were: *H. fasciatus*. *P. jubelini*, *M. mertensi*, and *E. encrasicolus*.

Table 1. Occurrence (numbers recorded) and Diversity of Fish Species in the Kakum Estuary at Low and High Tides.

Families	***Species***	***LOW TIDES***			***HIGH TIDES***		
		STATIONS					
		Mouth	***Middle***	***Head***	***Mouth***	***Middle***	***Head***
Acanthuridae	*Acanthurus monroviea*	37	10	-	27	1	-
Ariidae	*Arius gigas*	-	-	5	-	1	8
Bothidae	*Molene mertensi*	1	-	-	-	-	-
	Citharichthys stampflii	17	23	9	13	14	5
Carangidae	*Campogramma glaycos*	13	31	-	1	19	17
Cichlidae	*Hemichromis fasciatus*	-	1	-	2	-	-
	Tilapia zilli	-	22	31	7	12	35
	Sarotherodon melanotheron	-	3	210	7	19	49
Clupeidae	*Ethmalosa fimbriata*	-	5	-	-	2	-
	Sardinella maderensis	-	-	-	-	10	-
	Sardinella aurita	-	-	-	-	1	-
Elopidae	*Elops lacerta*		11	1	-	16	1
Engraudlididae	*Eugraulis encrasiocolus*	-	1	-	-	-	1
Gerreidea	*Eucinosthomus melanoptherus*	25	15	14	12	7	25
Grapsidae	*Sesarma angolenses*	-	-	1	-	-	-
Gobiidae	*Gobius*	22	26	5	11	8	-
	Gobioides	-	8	-	-	-	1
	Periothalmus sp.	-	-	-	1	1	-
Haemulidea	*Pomadasys jubelini*	-	2	1	1	-	-
	Pomadasys peroteti	1	-	-	-	1	-
	Plectorynchus macrolepis	3	4	1	4	-	1
Lutjanidae	*Lutjanus goreensis*	12	24	2	9	10	1
	Lutjanus fulgens	4	4	-	1	5	-
Monodactylidae	*Psettia sebea*	-	-	-	-	-	1
Mugilidae	*Liza falcipinnis*	33	11	53	41	17	61
	Liza grandisquamis	-	3	7	21	3	10
	Liza dumerilli	4	-	7	4	-	22
	Mugil cephalus	16	21	19	37	22	51
	Mugil curema	19	4	5	3	11	4
Penaeidae	*Peneaus notialis*	-	3	1	1	7	-
Poecilidae	*Apolochelichthys spilauchen*	-	3	-	-	5	-
Portunidae	*Callinectes amnicola*	18	10	1	3	7	5
	Callinectes marginatus	3	-	-	1	1	-
Overall number of individuals sampled			**846**			**705**	
Total number of families sampled		9	15	11	11	15	12
Total number of species sampled		16	23	16	21	23	19
Shannon-Weiner species richness (H’)			2.592			2.429	
Margalef’s index (d)			4.1539			4.5744	
Pielou’s species evenness			0.778			0.707	

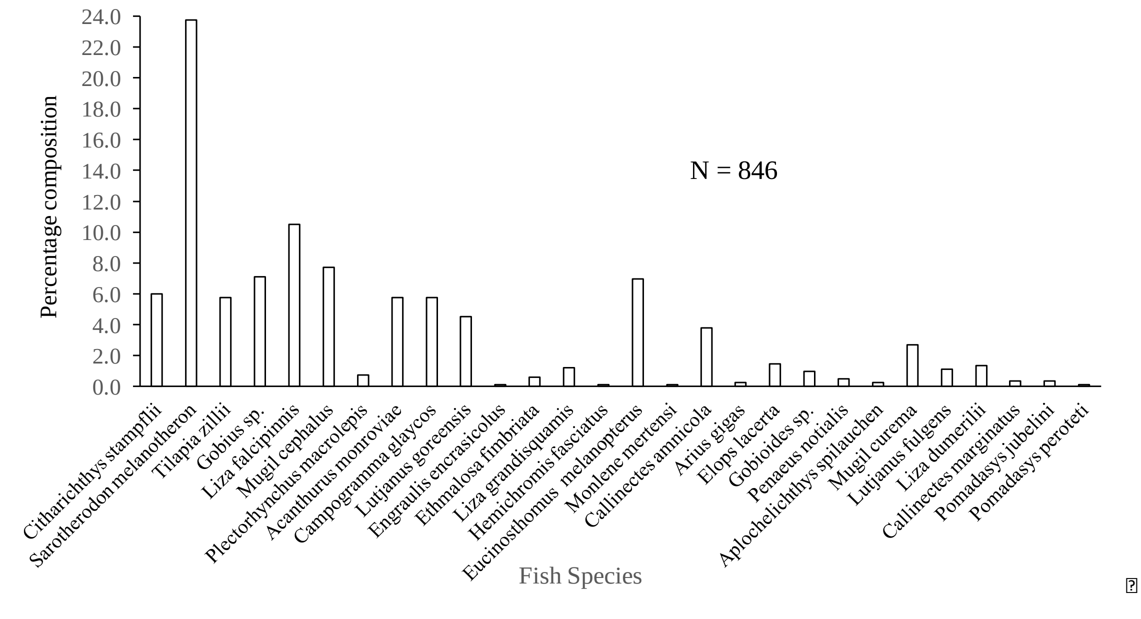

Figure 3. Percentage composition of fish species at low tide in the Kakum estuary from February – May, 2018.

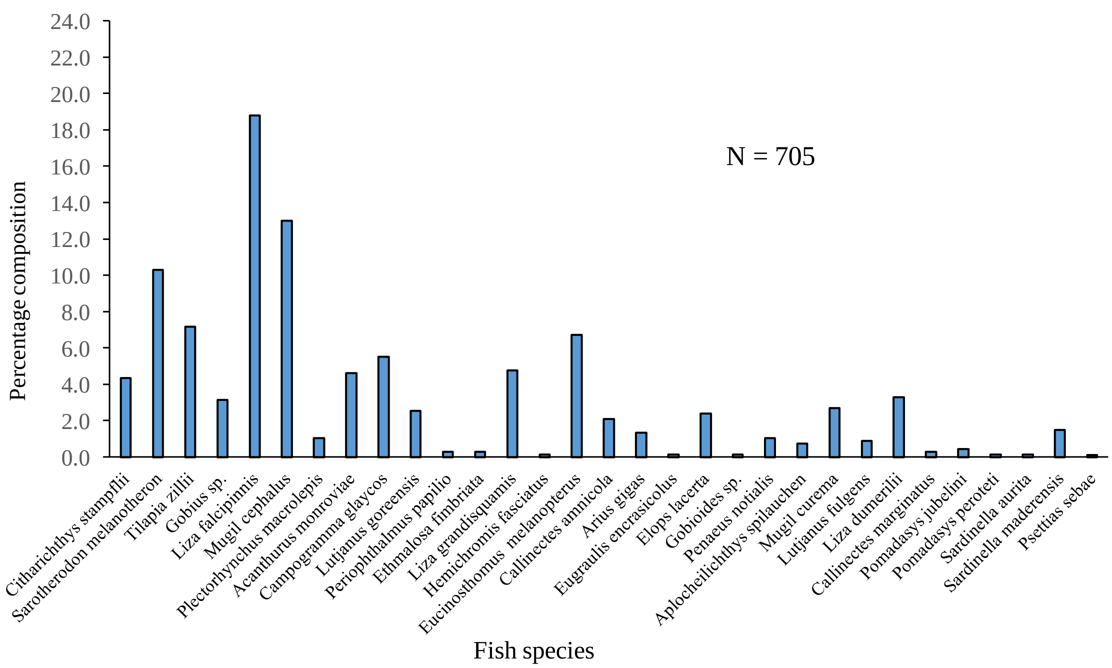

Figure 4. Percentage composition of fish species at high tide in the Kakum estuary from February – May, 2018.

3.5. Composition of Fish Species at High Tides

At high tides, 705 individual fish specimens comprising 31 species were encountered (Fig 4). *L. falcipinnis* with a composition of 18.8% was the dominant fish species recorded at high tides. *M.*

cephalus (13.0 %) and *S. melanotheron* (10.0 %) were encountered. *T. zillii* and *E. melanopterus* each constituted 7%. *Periophthalmus* sp., *E. fimbriata, H. fasciatus, E. encrasicolus, Goboides* sp., *A. spilauchen, L. fulgens, P. jubelini, P. peroteti, S. aurita, S. maderensis* and *C. marginatus* had the lowest composition of less than 1.0% at high tides.

3.6. Length and Weight Analyses of Dominant Fish Species

Figures 5 and 6 illustrate the length-frequency distribution and length-weight relationships of *S. melanotheron, T. zillii, L. falcipinnis, M. cephalus,* and *E. melanopterus* that were obtained during the period of study in Kakum estuary.

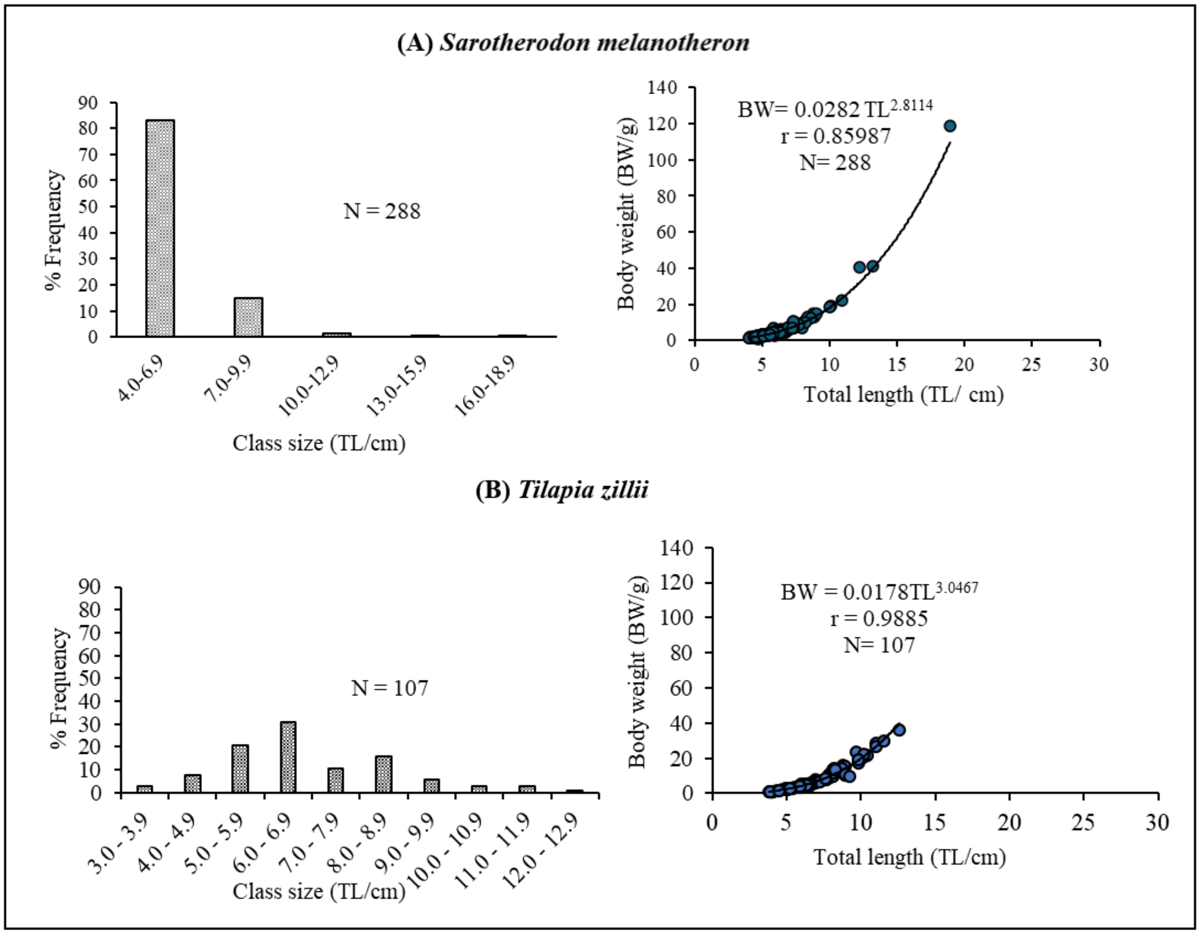

Figure 5. Length-frequency distribution and length-weight relationships of dominant fish species (A: Sarotherodon melanotheron, and B: Tilapia zillii) in the Kakum estuary between February-May, 2018.

The size range of the *S. melanotheron* was between 4.0 to 18.9 cm TL with a modal class of 4.0 – 6.9 cm; *Tilapia zillii*, size range (3.8 - 12.6 cm TL) and modal class (6.0 – 6.9 cm); *Liza falcipinnis* recorded a size range of 4.6 - 20.5 cm TL with a modal class of 8.6 – 10.5 cm; *Mugil* *cephalus*, size range (5.0 - 24.6 cm TL) and modal class (8.0 – 10.9 cm); and *Eucinosthomus melanopterus*, size range (4.0 - 10.8 cm TL) with modal class (7.0 – 7.9 cm).

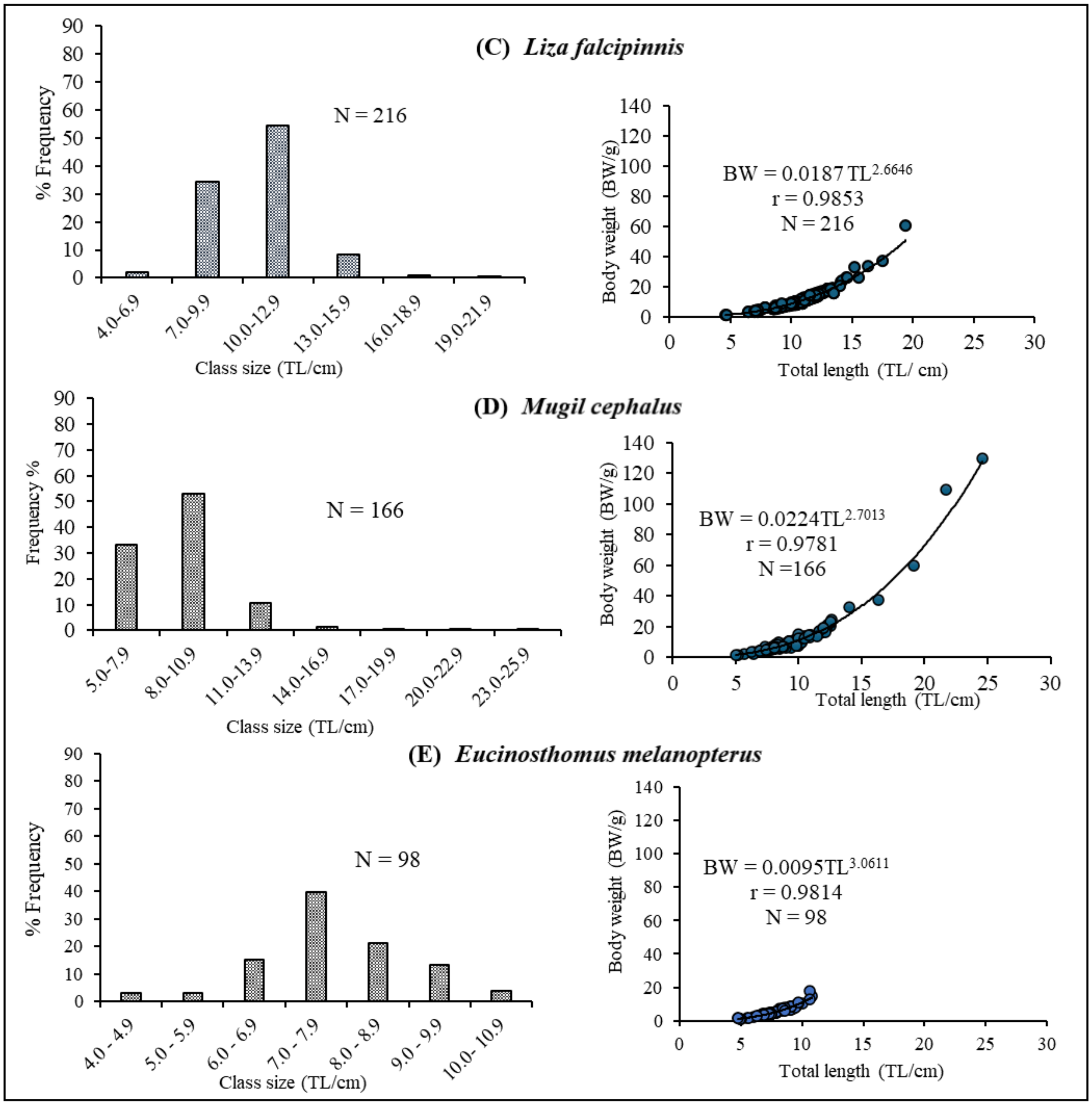

Figure 6. Length-frequency distribution and length-weight relationships of dominant fish species (C: Liza falcipinnis, D: Mugil cephalus, and E: Eucinosthomus melanopterus) in the Kakum estuary between February and May, 2018.

The length-weight relationship for *S. melanotheron* was represented by the equation BW= 0.0282 $TL^{2.8114}$ where BW and TL represent body weight and total length of the fish species respectively. The coefficient of correlation r = 0.86 showed a strong correlation between the fish length and weight. Using students' t- test, the gradient (*b* = 2.8114) was not significantly different from 3 hence the growth description was allometric (Fig 5). *Tilapia zillii* had a length-weight relationship as BW = 0.0178 $TL^{3.0467}$, with r = 0.99 and *b* = 3.0467 which was not significantly different from 3 hence growth was isometric.

In figure 6, *Liza falcipinnis* had length-weight relationship as BW = 0.0187 $TL^{2.6646}$, with r = 0.99 and *b* = 2.6646 which was significantly different from 3 hence growth was allometric. *Mugil cephalus* had length-weight relationship as BW = 0.0224 $TL^{2.7013}$, with r = 0.98 and *b* = 2.7013 was significantly different from 3 hence growth was allometric. *Eucinosthomus melanopterus* had length-weight relationship as BW = 0.0095 $TL^{3.0611}$, with r = 0.98 and *b* = 3.0611 was not significantly different from 3 hence growth was isometric.

Table 2. Descriptive statistics and estimated parameters of length-weight relationship (LWRs) for the 5 most dominant species in Kakum estuary from February – May 2018 based on the equation log (W) = log a + b log(L).

Species	***N***	***a***	***b***	***SE(b)***	***r^2***	***p***	***t-test significant***	***Growth behavior***
Saratherodon melanopterus	288	0.0282	2.8114	4.05021	0.9552	0.0000	-0.4657	allomteric
Liza falcipinnis	226	0.0187	2.6646	2.35689	0.9708	0.0000	-0.1423	allometric
Tilapia zillii	107	0.0178	3.0467	0.05342	0.9773	0.0000	0.8742	isometric
Mugil cephalus	166	0.0224	2.7013	5.76818	0.9567	0.0000	-0.0518	allometric
Eucinoptomus melanopterus	98	0.0095	3.0611	0.05851	0.9632	0.0000	1.0443	isometric

Note: N: number of sampled individuals; *a*: intercept; *b*: slope of the equation of the LWRs; *SE(b)*: standard error; r^2: coefficient of determination; *p*: significance of regression with *p* significant at <0.05; SE: t-test (significance was conducted to verify if *b* is significantly different from the consensus *b*=3; the growth was deduced based on *b).*

Table 2 summarizes the descriptive statistics and estimated parameters of the length-weight relationships of the 5 most dominant species in Kakum estuary. The length-weight of each species exhibited a highly positive correlation (*r* = 0.86, 0.99, 0.99, 0.98, 0.98 for *S. melanotheron, L. falcipinnis, T. zilli, M. cephalus* and *E. melanopterus* respectively. The values of intercept (*a*) regression coefficient (*b*), coefficient of determination (r^2) are presented in table 2.

Table 3. t-test: Two- Sample Assuming Unequal Variances of species diversity, richness and evenness of fish composition at low and high tides in the Kakum estuary.

	Variable 1	***Variable 2***
Mean	25.63636364	21.36363636
Variance	1719.676136	894.9261364
Observations	33	33
Hypothesized Mean Difference	0	
df	58	
t Stat	0.480019992	
P(T<=t) two-tail	0.633018579	
t Critical two-tail	2.001717484	

Table 3 indicates a *p*-value of 0.63 for which $p > 0.05$, hence there was no significant difference between the species diversity, richness and evenness of fish composition at low and high tides in the estuary.

Table 4. Regression analyses between the various hydrographic factors at low tides and high tides of the two most abundant fish species (MS-mean square, F-f–statistics, p-probability statistics, df-degree of freedom).

	Low Tide				***High Tide***			
	S. melanotheron				***L. falcipinnis***			
Source of variation	df	MS	F	*p*	df	MS	F	*p*
Salinity	9	605.42	0.103	0.755	13	85.27	1.87	0.196
Temperature	9	545.98	0.985	0.349	13	95.78	0.34	0.565
Dissolved oxygen	9	557.53	0.799	0.397	13	87.40	1.53	0.239

Relating hydrographic factors and the numbers of *S. melanotheron* and *L. falcipinnis* at low and high tides respectively throughout the sampling period *p*-values could be inferred to be not significant ($p>0.05$) (Table 4).

4. DISCUSSION

A diversity of factors including habitat physiographic attributes and microhabitat diversity influence the structure, distribution, diversity and composition of fish communities (Aggrey-Fynn et al., 2011). It was reported that various marine finfish and shellfish utilize the Kakum estuary as nursery ground (Blay, 1997; Okyere et al., 2012; Aheto et al., 2014). This study emphasized on the fish composition and diversity in Kakum estuary during the transition period between the dry and wet season.

Considering the temperature of the estuary, it swiftly changes spatially when moving from the mouth to the head stations of the estuary as well as temporally with respect to tides (Fig 2). Mean temperatures were higher at low tide than high tide during the sampling period. During high tides more water tends to flow from the sea into the estuary which increase the volume of water and cause a decrease in the water temperature. Meanwhile during low tides, it is the opposite that occurs, sea water recedes and water from the Kakum river enters the estuary which was relatively low levels during the sampling periods (dry season to onset of rainy season). Perhaps with the onset of rains, temperatures recorded at low tides might have been influenced by the river inflows into the estuary. There was also a reduction in temperature towards the head station due to the presence of vegetation which shielded the water from receiving direct and maximum light penetration, decreasing the temperature of the water, similar to the findings of Akpan et al. (2002). This study observed spatio-temporal changes in salinity in the Kakum estuary during the period of sampling. During high tides there was a high influx of water from the sea which might have contributed to the high salinity at the mouth of the estuary because of their proximity as compared to the head, whereas during low tides, more freshwater flowed from the Kakum river into the estuary thereby decreasing the salinity. The salinity at the middle zone was slightly stabled at low tides and high tides. The observations in this study were not far from the report from Dzakpasu and Yankson (2015) in the same estuarine environment. From this study, DO was relatively high during high tides which might have resulted from mixing due to tidal forcing. Meanwhile during low tides, it was the reverse for DO concentration probably due to less inflow of freshwater from the Kakum river into the estuary. The lowest DO in estuary was recorded in the middle, the same zone where the highest temperature was recorded, suggesting influence of temperature on DO concentration. Again, the high number of fish species observed during low tides might have also been a factor contributing to the reduction of the DO concentration since they tend to utilize more oxygen in the water. Observations from Dzakpasu and Yankson (2015) indicate that at the peak of dry season in the Kakum estuary, no significant difference of DO was recorded during low and high tides, but at the peak of wet season DO at high tide was higher than at low tide.

It is well known that hydrographic and other environmental conditions play critical roles in the selection of habitats by fish species (Cardona, 2006; Nip and Wong, 2010). It was observed in this study that, fish species recorded in the Kakum estuary originated from the marine, brackish water and freshwater. Out of the 33 fish species encountered, five were most dominant which includes: *S. melanotheron, T. zillii, L. falcipinnis, M. cephalus* and *E. melanopterus* constituting a composition of 56.4% of the entire fish community. Except *M. cephalus* and *E. melanopterus* the rest of the dominant fish species present had also been reported by Okyere et al. (2012) and Levy et al. (2015). *S. melanotheron* was recorded to have the highest composition (23.7%) at low tides and *L. falcipinnis* also being the highest at high tides with a composition of 18.8%. This observation is confirmed by Little et al. (1988) and Aheto et al. (2014) that occurrence and composition of fish species in brackishwater habitat in the tropics is largely influenced by salinity. Again Wright (1986) and Blay (1997) reported that salinity is a key factor influencing the occurrence and composition of fish species in brackishwater habitats in the tropics and subtropics because of fish species differences in salinity tolerance. Nevertheless, salinity in the estuary during the period of sampling could not be linked to the occurrence of fish species in various stations, for which were similar to the findings of Okyere *et al.* (2010). However, the increase in salinity might have caused a declination in the number of fish species in various stations during high tides. The *L. falcipinnis* was found in almost all the stations during various tides whereas, *S. melanotheron* was also found in all the three stations at high tides; whereas Okyere et al. (2010) reported that they are found in the middle reaches at low tides. Besides these commonly encountered fishes, juveniles of marine fin- and shellfishes including the swimming crab *Callinectes amnicola* (Portunidae), *Elops lacerta* (Elopidae) and *Psettias sebea* (Monodactylidae) have been reported in the Kakum estuary (Blay, 1997). This suggests that the wetland is highly utilized as feeding grounds by juvenile marine fishes, while freshwater species use it as breeding, nursery and feeding grounds (Okyere, 2010).

The species encountered in Kakum estuary were 32 finfish and two shellfish species belonging to 15 families; whereas 28 species belonging to 14 families were reported by Blay (1997). Species diversity and evenness estimated during low tides were 2.592 and 0.778 respectively, whilst that at high tides were 2.429 and 0.707 respectively. The species richness estimated at low and high tides were 4.1539 and 4.5744 respectively. The Student's t-test for two-sample mean indicates a p-value of 0.63 for which $p>0.05$, hence there was no significant difference between the species diversity, richness and evenness of fish composition at low and high tides in the estuary. This might have been due to the relatively short period of sampling. Levy et al. (2015) reported that the pronounced tidal exchange between the station and the sea might have presented the most heterogeneous hydrographic condition in Kakum wetland influencing the species diversity. The difference in species diversity and richness between this study and previous similar studies (Aheto et al., 2014; Levy et al., 2015) might be attributed to the different study periods and station selection for sampling.

Biologically, fish size is generally more relevant than age, mainly because several ecological and physiological factors are more size-dependent than age-dependent (Santos et al., 2002). Consequently, variability in size has important implication for diverse aspect of fisheries science and dynamics (Erzini, 1994). From this study *S. melanotheron* which was the most abundant species in the estuary had majority of its individuals to be 4.0-6.9 cm TL. The *S. melanotheron* is the mainstay of the fishery of many West African coastal lagoons as reported by Blay (1998). Again, Okyere (2010) also reported that the blackchin tilapia was the second most abundant fish in the Kakum wetland and they were represented by a large number of juveniles mostly 2.0 - 2.9 cm TL which also confirms the findings of this study. It is likely that the largest adults of *S. melanotheron* (18.9 cm TL) caught had come into the estuary to spawn and/or feed. There was a positive correlation between the length and weight of all the abundant fish species recorded in this study. The abundant fish species, *S. melanotheron, L. falcipinnis* and *M. cephalus* showed allometric growth, whereas *T. zillii* and *E. melanopterus* showed isometric growth in the length-weight relationships (Figs 5 and 6). However, Petrakis and Stregiou (1995) cautions that the use of these length-weight relationships should be rigorously limited to the size range applied in the estimation of the linear regression parameters, and in this study most of the fish specimens encountered were juveniles. Therefore, Safaran (1992) cautions that it is particularly dangerous to extrapolate L-W data interpretation to juvenile fish.

From the results of the regression analyses (Table 4), there was no significant effect between the various hydrographic factors and the abundance of *S. melanotheron* at low tide, and *L. falcipinnis* at high tide. However, site selectivity by juvenile fishes (particularly the grey mullets) within mangrove swamps in the Mediterranean estuaries were found to be highly influenced by prevailing habitat salinity conditions (Cardona, 2006). The observed correlation between fish abundance and salinity variations from this study was consistent with that of Nip and Wong (2010). However, a similar work conducted in the tropical region of Australia (Laegdsgaard and Johnson, 2001) did not find salinity to have any significant influence on types and abundance of juvenile fishes utilizing mangrove habitats as nursery.

5. CONCLUSION

In conclusion, this study identified that Kakum estuary is a transitional zone for both marine and freshwater fish species using the estuarine ecosystem as nursery grounds. The common species that were encountered during low and high tides in all sampling stations indicate their adaptation to variations in the hydrographic conditions in the estuary. The presence of marine and freshwater-origin species, and resident species in the Kakum estuary further confirms that estuaries are highly dynamic and slight changes in its environment can cause a great deal of harm to its fish biota.

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7. CONFLICT OF INTERESTS

No conflict of interest.

8. REFERENCE

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