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Dankwa HR

CSIR-Water Research Institute,
P. O. Box AH 38, Achimota,
Ghana.

Quarcoopome T

CSIR-Water Research Institute,
P. O. Box AH 38, Achimota,
Ghana.

Owiredu SA

CSIR-Water Research Institute,
P. O. Box AH 38, Achimota,
Ghana.

Amedorme E

CSIR-Water Research Institute,
P. O. Box AH 38, Achimota,
Ghana

Correspondence

Quarcoopome T

CSIR-Water Research Institute,
P. O. Box AH 38, Achimota,
Ghana.

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State of fish and fisheries of Fosu Lagoon, Ghana

Dankwa HR, Quarcoopome T, Owiredu SA, Amedorme E

Abstract

Fish and fisheries of Fosu Lagoon were surveyed when the lagoon was closed to the sea to assess its present status. Fish samples were obtained from hired local fishers using different fishing gears in each of three sections of the lagoon. A total of 6,197 fish specimen comprising four species and four families sampled were as follows: *Sarotherodon melanotheron* (Cichlidae), *Heterobranchus bidorsalis* (Clariidae), *Pellonula leonensis* (Clupeidae) and *Liza falcipinnis* (Mugilidae). *S. melanotheron* constituted 99.5% and 92.3% of the total number and weight respectively of fish caught. The total length of *S. melanotheron* from all gears combined ranged from 4.1 cm to 14.0 cm while the weight ranged from 0.8 g to 47.3 g with a mean weight of 6.5 g indicating stunted growth. Catch rates of 0.94274 kg man h⁻¹, 6.300 kg man h⁻¹ and 0.255 kg man h⁻¹ were estimated for cast net, drag net and gill net respectively with annual catch of 199 tones for the lagoon.

Keywords: Fosu Lagoon, fish, fisheries, *Sarotherodon melanotheron*

1. Introduction

Most of the coastal lagoons of Ghana historically supported artisanal fisheries that constituted a major source of livelihood and dietary protein resources for riparian and other communities. More than 90 of these lagoons are found along the 550 km long coastline of Ghana [1]. Lagoons in Ghana are primarily shallow water habitats ranging in size from a few hectares to over 30 000 hectares with associated marsh vegetation. In addition to providing fish habitats, the lagoons are important as staging, feeding and roosting areas for water birds. Some of the lagoons, for example Fosu Lagoon play a very important role in the celebration of annual festivals and the daily religious life of the people. Most of these lagoons are, however under serious threat from human-induced interference and global climatic changes. Fosu Lagoon is a major source of livelihood for inhabitants of the Cape Coast Metropolis. Its location puts a lot of stress on the lagoon ecosystem since it serves as a recipient of both liquid and solid waste from various activities dotted along the lagoon. Additionally, the lagoon is threatened by climate change resulting in wide fluctuations in water level sometimes to near desiccation during the dry season. These factors have led to physiological or morphological changes, decreased species diversity and alteration in the fish community structure and composition which ultimately impact negatively on the fisheries of the lagoon. There is, therefore, the need for the adoption of effective fisheries management and conservation measures to ensure sustainable utilization of the fish and fisheries resources of the lagoon. As a first step, the fish and fisheries of the lagoon must be assessed to determine its state so as to provide the requisite information for effective fisheries management, conservation and restoration.

Objectives of the study were to determine the current status of the fish and fisheries of the Fosu Lagoon, including estimates of annual catch and fish biodiversity assessment.

2. Materials and methods

2.1 Study area

The Fosu Lagoon is located in Cape Coast, the regional capital of Central Region of Ghana and lies between latitude 5° 06' N - 5° 07' N and longitude 1° 15' W – 1° 16' W (Fig. 1). It is a 'closed' lagoon separated from the sea (Gulf of Guinea) by a sand bar and occasionally breached by heavy rains or manually by sand winning activities or as part of rituals during the 'Fetu' Festival in the region.

The lagoon originally had a surface area of about 0.61 km² (61 ha) with an average depth of 1.5 m thus it is considered as a shallow lagoon. It is surrounded by many sites that act as point

sources for discharge of pollutants. These include domestic waste discharges from a highly polluted area, a metropolis transport garage on the northern side of the lagoon, and an industrial waste discharge from mechanical workshops on the north-eastern side.

Drains from an educational institution and a nearby hospital, household dumping and sewages characterize the environs of the lagoon. The human activities in the study area are immense and have caused massive sedimentation especially in the more populated northern sector where one can walk many meters on waterweeds as the lagoon has been transformed into waste and marsh land.

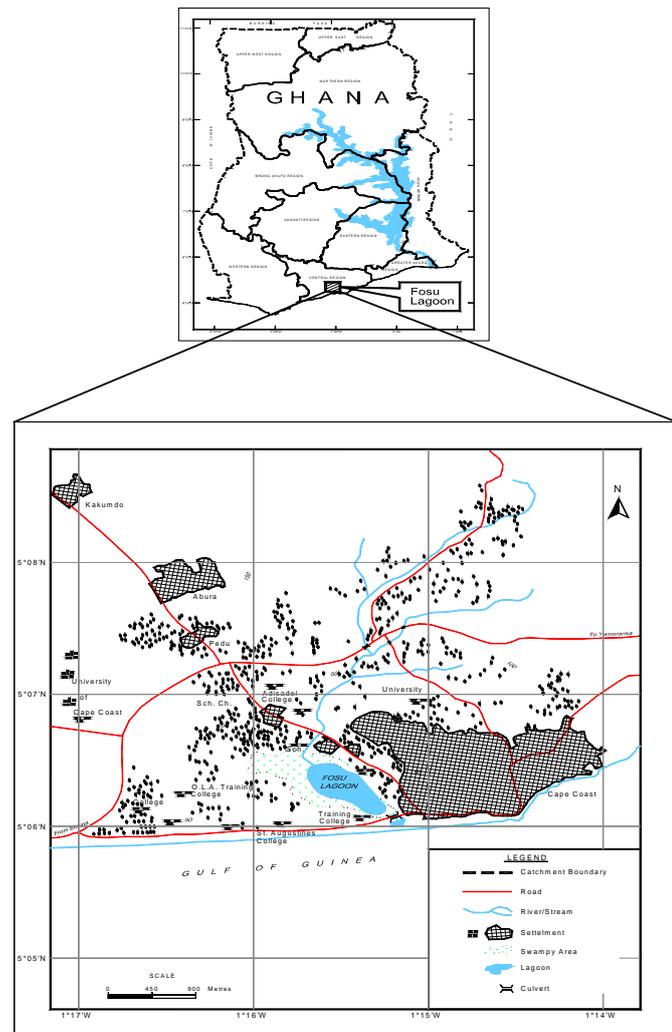


Fig 1: The Map of Ghana showing Fosu Lagoon

2.2 Sampling

The lagoon was divided into 3 sections namely northern, middle and southern to ensure that samples are taken from all sections of the lagoon. Fishing was done for 5 days using cast net, gill net and 2-man drag net at various sites within each section by hired local fishers. Two of the fisherman used cast net with mesh size of 12.7 mm ($1/2$ inch) measuring 34 m from the top to the base and 6.5 m across the base i.e. the diameter at the base. One fisherman did the casting from a canoe and the other waded through the water and hand-picked the catch from under the net – their normal way of casting. Casting was done in each case for 4 hours during the day. The third fisher who used monofilament gill net measuring 91.4 x 5.5 m (100 x 6 yds)

with 12.7 mm mesh size set the net from 6 pm and retrieved it at 6 am the following day. Samples were taken from operators of a 2-man drag net who fished both during the day and in the night at the various sections of the lagoon for specified periods. The catch from each gear was identified to species level, and for each individual weight as well as standard length and total length was measured to the nearest 0.1 g and 0.1 cm or 1.0 mm respectively. Catches of other local fishers were inspected daily to find out the type of species they were catching. In some cases their catches were weighed and the time used for fishing was noted and these were used to complement experimental catches in the estimation of catch rates.

2.3 Data analysis

From the species identified, length and weight measurements as well as the total number of individual fishes of each species caught the following parameters were estimated:

- Species composition – to determine the fish community structure.
- Relative abundance – to determine the importance of each species in the community.
- Size distribution of major species – to determine the number of fishes that make up each length group which in turn determines the size structure of the species in the lagoon.
- Condition factor using the formula $K = W \times 100 L^{-3}$ (Tesch FW) [2] to determine the physiological well-being of the fish or how well the lagoon is suited for the growth of fish populations.
- Length at first maturity - to determine the length at which 50% of the fish population mature. The cumulative percentage of mature individuals in various length groups was plotted to determine the mean length at first sexual maturity, L_{50} . Females and males with gonads at stages III and IV were considered as mature.
- Fish biodiversity - to determine how diverse the fish species are and how individual fishes are distributed among the species.

According to (Dahlberg MD, 1970, *et al.*) [3] fish biodiversity was determined using three diversity parameters namely Shannon-Wiener diversity index, species richness and species evenness.

The Shannon-Wiener diversity index (H') which measures changes in species number and species evenness or equitability is given by $H' = - \sum P_i \log P_i$ [4] where P_i is the proportion of individuals in the i^{th} species. Species richness (D) which measures how species rich the fish community is, was computed as $D = (S-1) / \log N$ [5] where S is the number of species in the sample and N the total number of individuals.

Pielou's measure of evenness (J) was computed to measure how evenly distributed the individual fishes are among the species using the formula $J = H' / \log S$ [6] where H' is the diversity index and S is the number of species.

- Annual catch

The annual catch from the lagoon was estimated from the number of fishers, their average daily catch and the number of fishing days in a year taking into consideration the ban on fishing during the year in connection with the annual 'Fetu Afahye' Festival. Fishing effort was calculated as the man-hours used in fishing. Knowing the catch per annum and the total surface area of the lagoon, the yield per hectare per year ($\text{ha}^{-1}\text{yr}^{-1}$) was computed.

3. Results

3.1 Fish species caught

A total of 6,197 individuals weighing 38.86 kg comprising four species and four families were sampled from the lagoon during the study period. The four species (families in brackets) are as follows: *Sarotherodon melanotheron* (Cichlidae), *Heterobranchus bidorsalis* (Clariidae), *Pellonula leonensis* (Clupeidae) and *Liza falcipinnis* (Mugilidae). *Clarias gariepinus* (Clariidae) was observed in a fishers' catch during inspection though it was not sampled.

3.2 Species composition

By far, *S. melanotheron* was the dominant species in the lagoon constituting 99.5% and 92.3% of the total number and weight respectively recorded during the study (Fig. 2 & 3). The other species *H. bidorsalis*, *P. leonensis* and *L. falcipinnis* constituted 6.7%, 0.24% and 0.73% by weight and 0.24%, 0.18% and 0.06% by number respectively of the catch.

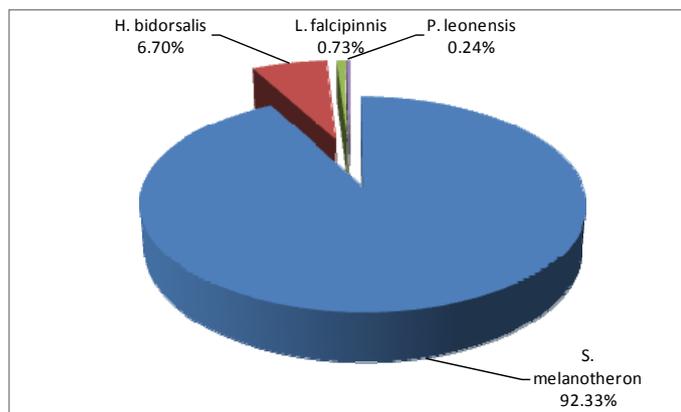


Fig 2: Percentage Composition in terms of Weight of fish caught from Fosu Lagoon

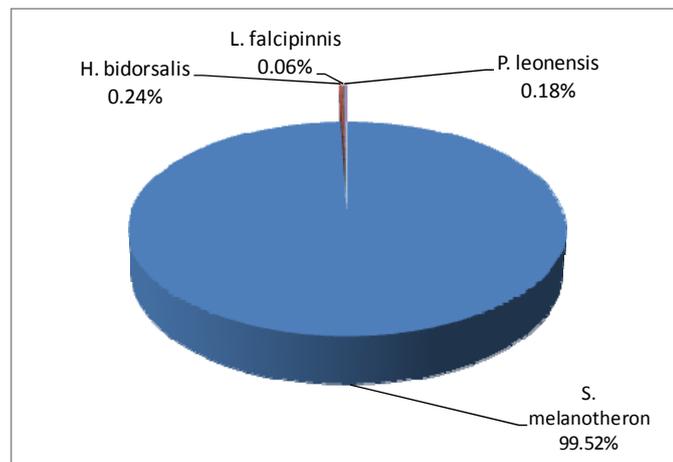


Fig 3: Percentage Composition in terms of Number of Fish caught from Fosu Lagoon

3.3 Fish size distribution

Combining catches from all the gears and methods the total length of *S. melanotheron* sampled ranged from 4.1 cm to 14.0 cm with a modal class of 7.0 - 7.9 cm while the weight ranged from 0.8 g to 47.3 g with a mean weight of 6.5 g. The size range caught by the different gears used is presented in Table 1. With the exception of gill net where the modal length of fish caught was 8.0 - 8.9 cm, the modal length of fish from each of the other gears was 7.0 - 7.9 cm.

Table 1: Size distribution of *Sarotherodon melanotheron* from various Fishing Gears used in Fosu Lagoon

Type of fishing gear	Length range (TL cm)	Modal length (cm)
All fishing gears combined	4.1 – 14.0	7.0 - 7.9
Cast net with hand picking	5.0 – 14.0	7.0 - 7.9
Cast net without hand picking	5.0 – 10.0	7.0 - 7.9
Gill net	6.0 – 12.0	8.0 - 8.9
Drag net	4.1 – 12.0	7.0 - 7.9

3.4 Length-weight relationship

The length-weight relationship of *S. melanotheron* from Fosu Lagoon is represented by the equation $W = 0.025 TL^{2.78}$ ($r^2 = 0.928$) where W is the weight of fish in grams and TL total length in cm (Fig. 4).

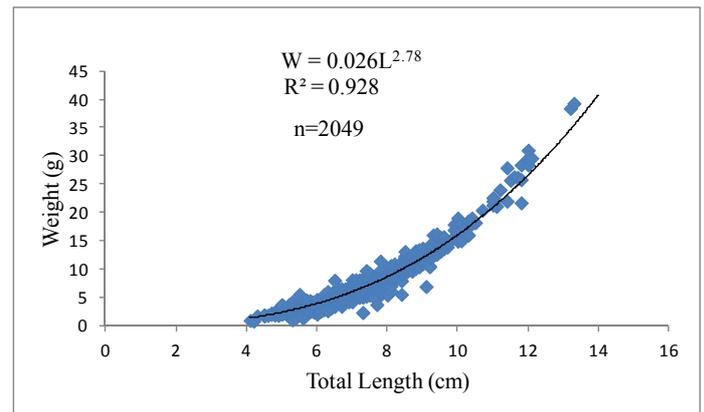


Fig 4: Length-weight relationship of *Sarotherodon melanotheron* from Fosu Lagoon

3.5 Condition factor

Mean condition factor for all sexes combined was 3.9 standard length. The same value was obtained for males and females separately.

3.6 Length at first maturity

The mean length at first sexual maturity, L_{50} , for both males and females was 6.0 cm (Fig. 5).

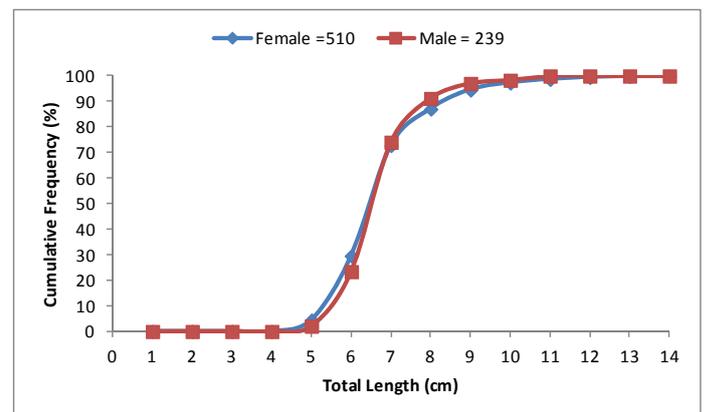


Fig 5: Length at first maturity for *Sarotherodon melanotheron* from Fosu Lagoon

3.7 Fish biodiversity

The Shannon-Wiener diversity index, H' , which combines both species richness and evenness was calculated to be 0.02. Those for species richness (D) and evenness (J) were 0.93 and 0.03 respectively.

3.8 Catch rates and annual total catch

Catch rates of 0.94274 kg man-h⁻¹, 6.300 kg man-h⁻¹ and 0.255 kg man-h⁻¹ were calculated for cast net, drag net and gill net respectively. From interviews conducted, about 140 fishers were estimated to be working on the lagoon. Assuming that on

the average 100 fishers operated a day and fished for 286 days in a year considering the ban on fishing during the Fetu Afahye (Festival) then the catch rates and quantity of fish taken by the different gears and the total annual catch in a year is presented in Table 2.

Table 2: Catch Rates, Daily Catch and Total Catch from various Gears Deployed in Sampling from Fosu Lagoon

	Cast Net	Drag Net	Gill Net
Numbers of fishers (N)	50	40 (paired)	10
Total man-hours (Number of fishermen x Number of fishing hours)	Afternoon: 30 fishers x 3 hours = 90 man-hours Morning: 20 fishers x 4 hours = 80 man-hours	20 fishers x 4 hours = 80 man-hours	10 fishers x 12 hours = 120 man-hours
CPUE (kg man-hr ⁻¹)	0.94 kgman-hr ⁻¹	6.3 kg man-hr ⁻¹	0.26 kg man-hr ⁻¹
Catch day ⁻¹ (kg)	0.94 kg x 90 = 84.6 kg 0.94 kg x 80 = 75.2 kg = 159.8 kg	6.3 kg x 80 = 504 kg	0.26kg x 120 = 31.2 kg
Total catch yr ⁻¹ gear ⁻¹	159.8 kg x 286 = 45,702.8 kg	504g x 286 = 144,144 kg	31.2kg x 286 = 8,923.2
Total annual catch for all gears	198,770 kg or 199 tonnes		
Catch ha ⁻¹ yr ⁻¹	199 tonnes/61 ha = 3.2 tonnes ha ⁻¹ yr ⁻¹		

Thus the annual catch from the lagoon is estimated to be 199 tonnes or 3.2 tonnes ha⁻¹ yr⁻¹.

3.9 The Fisheries

The number of fishers was estimated taking into consideration the shift system of fishing during the day and night as well as fishing alternatively in the lagoon and the sea at different water levels. Fishers operating in the lagoon were mostly from the Cape Coast municipality and operated on free access basis, thus no permission was needed for entry into the fishery. From interviews conducted about 140 fishers operated in the lagoon from four landing sites namely Children's Park near the beach, Friends Garden near the Stadium, Aquarium No.1 ('Ebuw Ano') and Aquarium No. 2. Most of the fishers operated in the night and on shift basis giving a wrong impression since very little was seen during the day time. The main fishing gears used in the lagoon was cast nets, monofilament gill nets or set nets and 2-man drag nets. Tuesdays are taboo days for the lagoon and fishers are not supposed to fish on this day. Fish were sold at the various landing sites to women who came at dawn to wait for particular fishers they did business with. Fish were measured for sale with a special container.

4. Discussion

4.1 Fish species caught

In a previous study by (Blay Jr. J, *et al.* 1993) [7] five species were recorded. Out of the five *Porogobius schlegelii* and Decapods were not observed in the current study whiles *P. leonensis* was not found in the previous study. No shell fishes were found in fishers' catch and none was found in or around the lagoon. The size of *L. falcipinnis* suggests that it could be a remnant of what was brought into the lagoon the last time it was opened. *P. leonensis* is a freshwater species whose distribution extends into coastal waters (8). According to fishers interviewed, in the past a variety of species were caught in the lagoon. These included ten pounder/lady fish *Elops lacerta* ('ahenembandzi'), rock sole/flounder ('futufutu'), golden lagoon snapper *Lutjanus goreensis* ('esoe'), grey mullets, shrimps and crabs. These species are no more found in the lagoon and their absence, according to the fishers could be attributed to a severe drought that occurred in the late 1990s that nearly caused the lagoon to dry up. Whenever there is a splash of sea water over the sand bar during spring high tides

into the lagoon it brings along with it larvae or zoea of crustaceans which then develop and remain in the lagoon. The breaching of the sand bar for festivities also brings in marine species even though they may be short-lived due to the high fishing pressure and their inability to reproduce and replenish themselves in the lagoon.

4.2 Fish species composition

S. melanotheron is the mainstay of the fisheries of the lagoon. A similar conclusion was also made by (Blay Jr. J, *et al.* 1993) [7]. The dominance of *S. melanotheron* in Ghanaian lagoons forming over 90% of catch is reported by various authors (9, 10, 11, 12 & 13). Their dominance in lagoons could be due to their resilience and their prolific reproductive habits which enable them to withstand stressful conditions compared to other species.

4.3 Fish size distribution

The maximum total length of 14.0 cm recorded in the current study is smaller than the 15.9 cm reported by (Blay Jr. J, *et al.* 1993) [7] for the same lagoon and far smaller compared to what has been recorded for the same species in other locations in Ghana. The maximum reported size from the West African sub region according to (Dankwa HR, *et al.* 2004) [13] is 25.0 cm TL in lagoons in La Côte d'Ivoire while (Fagade SO, 1974) [14] reported a maximum length of 27.0 cm TL in the Lagos Lagoon, Nigeria. In Ghana according to Blay (*pers. com.*) specimens measuring nearly 27.0 cm TL were found in fish landings from the Weija Reservoir. The modal length in the current study from all gears combined was 7.0 - 7.9 cm TL which was bigger than the 6.0 - 6.9 cm TL reported in the previous study by (Blay Jr. J, *et al.* 1993) [7]. (Koranteng KA, *et al.* 1997) [12] reported modal class of 7.0 - 7.4 cm SL (9.0 - 9.4 cm TL) from the Sakumo Lagoon. The difference between the two studies in the Fosu Lagoon is probably due to the differences in duration of study or increased fishing pressure. With the exception of gill net from which a modal length of 8.0 - 8.9 cm was recorded, the modal length from the other gears separately was 7.0 - 7.9 cm. A higher percentage (about 37 %) of fish sizes below 7.0 cm was caught in drag net compared to below 5 % in each of the other gears. This means that catches from drag net composed of much higher proportion of smaller sized fishes than those from the other

gears. The use of drag net should therefore be discouraged. On the whole, the size of *S. melanotheron* in the Fosu Lagoon is a clear indication that the species is being overexploited.

4.4 Length-weight relationship

The exponent 2.78 indicates that the growth pattern of *S. melanotheron* is negatively allometric meaning that increases in length and weight of the species are not equal during growth resulting in fishes becoming slender with increase in length.

4.5 Condition factor

Condition factor of a fish species is a measure of the physiological 'well-being' or 'fatness' of the fish and gives an indication of how suitable the aquatic environment is for their growth. The condition factor of 3.9 SL obtained in this study is typical of Cichlids and indicates that the aquatic environment or the water quality of the lagoon was favourable for the growth of *S. melanotheron*. The small sizes of *S. melanotheron* can, therefore, be attributed to high fishing pressure to a large extent.

4.6 Size at first maturity

Both sexes matured at a very small size of 6.0 cm. A similar observation was made by (Blay Jr. J, *et al.* 1993) [7] who concluded that it corresponds to a maturity age of approximately 4.8 months which is close to the maturity age of 3 months reported for stunted tilapia populations [15]. Thus, the current findings corroborate the report by (Blay Jr. J, *et al.* 1993) [7] that the tilapia population in the Fosu Lagoon can be described as stunted. Intense fishing, as observed in the lagoon, exerts selective pressure leading to fish becoming reproductively mature at progressively smaller sizes and explains why *S. melanotheron* in the Fosu Lagoon mature at such a small size. Similar smaller sizes at first maturity have been reported from the Keta and Songor Lagoons which are also under intense fishing pressure [13].

4.7 Fish biodiversity

Diversity indices summarize the numerical associations of organisms and allow populations to be compared and are generally more reliable indicators of environmental health or stress than individual indicator species [16]. Species richness measures the number of species in a community so that the more species the richer the community. Species evenness measures the distribution of individuals among species in a community so that greater evenness indicates greater ecological stability. The low values of diversity parameters estimated for the Fosu Lagoon is a true reflection of the situation in the lagoon – where there were just five species with distribution of individuals skewed towards only one species indicating that the lagoon fish community is ecologically imbalanced.

4.8 Catch rates and total annual catch

In an earlier study by (Blay Jr. J, *et al.* 1993) [7] an estimate of 452-664 kg ha⁻¹ translating into 28 - 41 tonnes per annum was made for Fosu Lagoon. This was considered higher than those reported for other tropical lagoons. It must however, be noted that the study by (Blay Jr. J, *et al.* 1993) [7] spanned a little over one year and therefore included periods when the Lagoon was opened and closed to the sea. It is also worth noting that during the time the study was done the use of drag net had not been introduced into the lagoon. Catch rates of drag net, as indicated in the current study, far exceed that of cast net which

was the major fishing gear in use during the earlier study. (Koranteng KA, *et al.* 1997) [12] estimated the total annual catch from the Sakumo Lagoon to be 114 tonnes per year or 327 kg ha⁻¹ while (Vanden Bossche, J-P *et al.* 1990) [17] estimated the potential fish yield of the same lagoon to be 120 tonnes per year. This translates into a yield of 2.2 tonnes ha⁻¹yr⁻¹ which is quite comparable to the current estimate for the Fosu Lagoon. The average total annual catch from the Muni Lagoon was estimated by (Koranteng KA, *et al.* 2000) [10] as 75 tonnes. Catch rates of 0.8792 kg man-h⁻¹ for fishing by cast nets and 1.3385 kg man-h⁻¹ for drag net operators were estimated for the Sakumo Lagoon [12]. The corresponding estimates for the current study are 0.94 kg man-h⁻¹ and 6.30 kg man-h⁻¹ respectively which are quite comparable.

4.9 The Fisheries

4.9.1 Fishers

The shift system and the absence of fishers association as well as the free access nature of the fisheries made it difficult to estimate the number of fishers operating in the lagoon. Respondents indicated that the number of fishers swells up during low water periods and when catches from the sea were low to as high as 500 people. During high water periods, as was the case during the study period, most people especially the elderly were not able to do fishing.

4.9.2 Fishing gears

The 2-man drag net and cast net were the common gears deployed in the lagoon. The standard size of gill net was 91.4 m x 5.5 m (100 yards x 6 yards) while that of cast net was 34 m long and 6.6 m base diameter. The mesh size (stretched) of both nets was 12.7 mm (½ inch). The 2-man drag net measured 15.8 m x 12.3 m with a mesh size of 5.0 mm. Gill nets were not only set overnight but also used as drive-in-gear where an area along the edge of the lagoon was cordoned off with the net and fishes are driven into it by disturbing the water with either the hands or sticks. This method of fishing, which was not popular, was practiced at night around the Stadium area. In the early days bigger mesh sizes (38.0 mm, 51.0 mm and 41.0 mm) were used and bigger fishes were caught than being caught now. The 2-man drag net is supposed to have been introduced quite recently – about 2010 but it is gradually becoming the gear of choice because of its high catch rate. It was reported that occasionally mosquito nets were also used to target mainly *P. leonensis*.

4.9.3 Marketing and utilization of fish

A container full of fish weighed 6.0 kg and was sold for GH¢ 10.00 (i.e. approx. US\$ 2.5) at the lagoon side. Thus, 1 kg of fish was sold for GH¢ 1.70. Fish were either dressed at the shore or taken home and processed after which they were fried. Some of the women engaged a gang of women to degut and de-scale the fish at the shore. Fried fish was taken to other big towns like Accra, Takoradi, Mankessim, Kasoa and as far as Ho in the Volta Region for sale. Fried black-chin tilapia from lagoons is a delicacy that goes with 'kenkey' - a local dish made of maize. The daily earnings of a cast net fisher who normally landed about 3 - 4 containers a day, fishing in the morning and in the evening, was estimated to be GH¢ 30 - 40, that for gill net operators was estimated to be 2 containers i.e., GH¢ 20 and for drag net operators who land about 10 containers a day was estimated to be GH¢ 100 for 2 fishers. Higher catches are made when the sand bar is breached since marine fishes are then able to come into the lagoon. Higher

catches of fairly bigger fishes are also made when water level in the lagoon is high.

4.9.4 Taboo days

The taboo fishing days was not being adhered to and fishing was done throughout the whole week until a ban is placed on fishing in the lagoon from 1st August to 1st September as part of the annual celebration of the 'Fetu Afahye' festival. Thus, there are approximately 286 fishing days in a year^[7] assuming that the ban on fishing on Tuesdays is respected.

5. Conclusions

A large number of people depend on Fosu Lagoon fisheries for their livelihood, especially fishing, fish processing, marketing and basket weaving. *S. melanotheron* was the mainstay of the lagoon fisheries as it was the dominant species in catches forming 99.5% and 92.3% by number and weight respectively. The low biodiversity parameters indicated that the fish community in the lagoon was ecologically imbalanced. The condition factor of *S. melanotheron* which was a measure of the physiological 'well-being' or fatness of fish showed that the aquatic environment or water quality of the Lagoon was favourable for their growth since they were not emaciated. Catches from dragnet consisted of high proportion of smaller-sized fishes in addition to the fact that their catch rates was higher than the other gears and could therefore be harmful to the fisheries. The lagoon fisheries were under intense fishing pressure as manifested by the small sizes of fish that were landed by fishers and also the small size at which the fish matured. The estimated annual catch from the lagoon which is 199 tonnes is quite high and unsustainable for the fisheries.

5.1 Recommendations

The following are some proposed management interventions in consultation with fishers for the improvement of lagoon fisheries: Enforce non-fishing days to ease fishing pressure and give fish some respite; Consider regulating the use of 2-man drag net in view of the fact that the mesh sizes of the nets are too small and virtually scoop all sizes of fish, and have a very high catch rate which is not sustainable for the fisheries; Control the spread of aquatic vegetation which is gradually reducing the size of the lagoon and likely to adversely affect fish yields from the lagoon; Re-open old bridges since the new bridge now in place, unlike the two old ones, had its bottom above that of the lagoon so does not allow easy flow of sediment from the lagoon into the sea whenever the sand bar is breached leading to siltation of the lagoon; All drains that empty into the lagoon should be fitted with straining devices at the point of entry into the lagoon to prevent the influx of debris, especially plastic materials, into the lagoon; An association of fishers should be formed and the executive empowered by the Cape Coast Municipal Authority, the District Assembly and the Traditional Authority to manage the lagoon resources by enforcing existing regulations, enacting new ones and sanctioning deviants.

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