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Comparative Study of Different Gill Net Mesh Sizes in the Exploitation of Bonga fish *(Ethmalosa fimbriata)* and Sardines *(Sardinella eba)* in Brass Coastal Waters, Bayelsa State, Nigeria

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ABSTRACT: A comparative study of different gill net sizes in the exploitation of bonga *(Ethmalosa fimbriata)* and sardines *(Sardinella eba)* were conducted for 3 months between January and March 1998 in Brass River. The area is located between Latitude 4^o 2" and 4 ^{o} 6 " and longitude 6 ^{o} 2 " and 6^o 5" stretching from Akassa at the River mouth to Doukungbene near the upper edge of Clarendou. Three Mesh size of gill nets (35mm, 60mm and 70mm) were used for Bonga and Sardine fishing. The result obtained indicated that larger size classes of fish were obtained with the increase in mesh sizes of nets. In addition, marked variation in mean values (t test > $t_{0.05}$) and distribution (w > $P_{0.05}$) of the size classes were observed (for *Ethmalosa fimbriata* and *Sardinella eba*) irrespective of the mesh sizes. Also the Principal component analysis (PCA) showed high selection for larger fish sizes (in the component weighting) in the catch, which were favoured by the bigger mesh sizes (70mm). @JASEM

Fishing is the main occupation of the people of Niger Delta especially in the wetland area of the region. The local inhabitant depend largely on fish resources for their main protein need, and it serves as a major income earner.

Fishing is often undertaken in small artisanal scale and most widely used fishing gear in coastal and brackish waters are gill net (FAO 1991 & Balogun (1986). Gill net constituted over 60% of the total gear deployed in the region. In Lagos lagoon, gill net constituted the dominant gear deployed in the water body (Udolisa and Solarin 1978 & 1979, Fagade and Olaniyan 1972). In the East of the Niger -particularly in Bonny estuary, gill net constituted over 50% of the gear deployed by fishermen (Chindah and Osuamkpe 1994 and IPS 1989 & 1990).

As the human population increases the demand for fish protein increases even in exponential manner with the concomitant increase in the exploitation of fish in the natural habitat.(Tobor 1974). The desirous need to meet the demand of the teeming population leads to over exploitation of the natural fish stock in the wild which often leads to inappropriate and unfriendly fishing technique which exacerbates the declining fish yield. Despite the negative impact of this scenario in management and sustainable development of fish resources in the region, data on gear application is largely non-existent.

However, studies on fish have been mostly on fisheries ecology, biology and distribution (Fagade & Olaniyan (1972), RPI (1985), Powell & Onwuteaka (1985), Wright (1986) Chindah & Osuamkpe (1994,) but little is known on the gear used for harvesting the fish in its natural environment and as it affects fish population.

Since gear development is species targeted and Bonga fisheries is an important fisheries in the Niger delta region and gill net is the most popular gear used in the region for harvest in Bonga (Fagade & Olaniyan 1972 and NDES 2001). There is therefore the need to understand the impact of different gear (gill net mesh sizes) on the Bonga fishery. To bridge this gap, attempt is made to examine the effectiveness of different gill net mesh sizes in Brass water for exploiting fish species of commercial importance with a view to identifying adequate and sustainable local mesh sizes for exploiting these fishes.

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STUDY AREA DESCRIPTION

Brass River is located between Latitude 4º 2" and 4 º 6 "N and longitude 6 º 2 " and 6º 5"E (Fig .1) in Brass local Government area of Bayelsa state. The study area stretches from Akassa at the River mouth to Doukungbene near the upper edge of Clarendou Island.The river is strongly influenced by seawater but fresh water flushing from the Niger floods is principally experienced during the wet season.

The River is characterized by strong wave actions with swift current flow especially at mid flood and ebb tides (about 15m/S). The tidal amplitude is about 2.1 metres high. The detailed hydrology of the system is contained in NEDECO (1961).

The intertidal flat consists of moderately sorted sand to silty-clay with patches of hard "Chikoko" sediment types within the elavated intertidal banks (Hart and Chindah 1998).

Fig.1. Niger Delta and Brass River showing Stud

The vegetation is predominantly mangrove dominated by species such as *Rhizophora racemosa, R. mangle, Avicennia africana, Laguncularia racemosa, Achrostichum aurerum* and *Paspalum varginaturm (*Wilcox 1980*).*

METHODS

The study was carried out for a 3-month period (January to March 1998 (3 months). The survey relied on fish catch from local fishermen operating within the Brass River. Ten (10) local fishermen were engaged for the fishing on each day. Each of the fishermen were deployed with the 3 chosen mesh sizes (35mm, 60mm and 70mm) of gill net for 5 hours. Each gill net (multifilament) had a total area of 37.5m^2 (i.e. length = 25m and depth = 1.5m). Hauling was done manually by recovering the net and entangled fish into the boat. The netted fish were carefully removed from the net and placed in different ice chests according to the mesh size. On landing, the fishes from each ice chest were identified using the works of Tobor *et al* (1979) and Schnelder (1990) for identification the species. The length, weight of the fishes were measured and recorded. The sample data were sorted into size classes based on fish length and biomass. The numbers in each size class were recorded. The size class classifications based on fish length adopted for Ethmalosa fimbriata are:

Size class A = < 12mm of total fish length

Size class B = 12.1 - 18.0mm of total fish length

Size class C = 18.1 - 24.0mm of total fish length

Size class D = 24.1 - 30.0mm of total fish length

Size class E = > 30.1mm of total fish length

The size class classifications based on fish length adopted for Sardinella eba are

Size class A = < 9mm of total fish length

Size class B = 9.1 - 13.0mm of total fish length

Size class C = 13.1 - 17.0mm of total fish length

Size class D = 17.1 - 21.0mm of total fish length

Size class E = > 21.1mm of total fish length

In addition, Biomass classifications for Ethmalosa fimbriata are

A = < 60g of fish weight

B = 60.1 - 103.0g of fish weight

C = 103.1 - 146.0g of fish weight

D = 146.1 - 189.0g of fish weight

E = > 189.1 of fish weight

Similarly, Biomass classifications for Sardinella eba are

A = < 50g of fish weight

B = 50.1 - 60.0g of fish weight

C = 70.1 - 80.0g of fish weight

D = 90.1 - 100.0g of fish weight

E = > 100.1 of fish weight

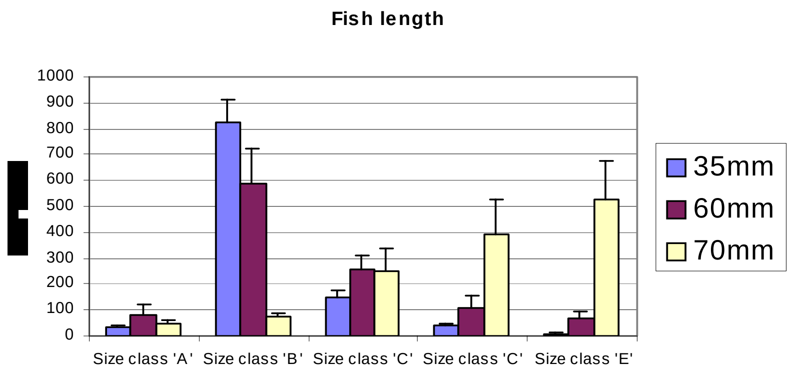
All data were subjected to statistical analyses (for (student t - test, distribution, and Principal Component Analysis-PCA) using JMP IN statistical package version 3.2.1. of SAS Institute incorporated.

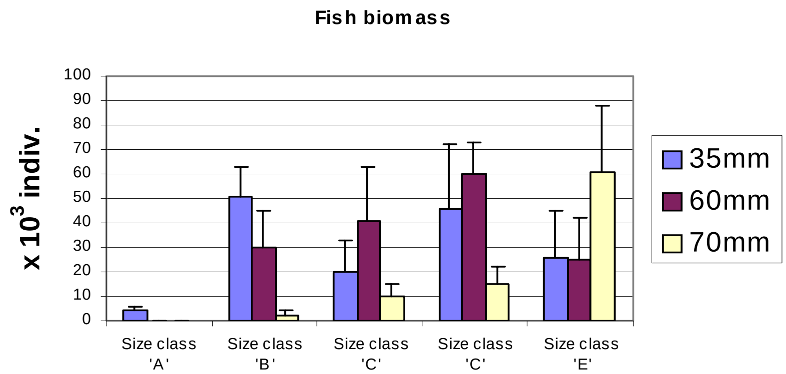
RESULTS

The number of fish (*Ethmalosa fimbriata*) occurring in each size class from the different gill net meshes sizes for fish length and biomass is presented in Figure 2.

The highest number of fish obtained were in size class (B), followed by the size class -'C' (156 ± 35 x 10^3 indiv.), size class - 'D', (64 ± 15 x 10^3 indiv), first size class - 'A', (32± 6 x 10^3 indiv), and the least value was in the "E" size class(20 ± 4 x 10^3 indiv). The coefficient of variation between the size classes was high (93.9%) and showed slight positive skewness (0.58)and kurtosis of -0.43 (Table 1).

The comparison of mean within the gill net mesh sizes using student t-test (t -test=145 > $0.89_{0.5}$) showed significance variation between the size classes caught (Table 1). Similarly, the distribution statistics of Sharpiro- Wilk test showed marked significant difference between the size classes caught with the 35mm gill net (w = 0.68, > P = $0.08_{0.5}$)





The biomass pattern of the 35mm gill net mesh size showed size class in the decreasing biomass pattern of ‘A’ biomass (872 ± 387.5 x 10^3 indiv) > ‘B’ size class (150 ± 387.5 x 10^3 indiv) > ‘D’ size class (40 ± 8 x 10^3 indiv) > ‘E’ size class (34 ± 4 x 10^3 indiv) > ‘C’ size class (10 ± 387.5 x 10^3 indiv) respectively. The coefficient of variation was the high (163.7). The values were positively skewed (2.1) with kurtosis of 4.49. The biomass classes showed no significant variation at 5% level (t = 0.88 > T = $0.37_{0.5}$. However, the distribution according to Sharpiro-Wilk distribution test indicated significance W =0.67 > P = 0.006 $_{0.5}$ (Table 1).

The 60mm mesh size gill net had a total mean catch of 208.8± 229.7 indiv. the dominant size class caught was the ‘C’ size class(588 ± 58 x 10^3 indiv) followed by ‘B’ size class (242 ± 44 x 10^3 indiv), ‘D’ size class (149 ± 35 x 10^3), ‘E’ size class (49 ± 10 x 10^3 indiv) and the least being the ‘A’ size class (16 ±2 x 10^3 indiv). The coefficient of variation amongst the size classes (CV = 153.76%) was higher than that of 35mm gill net. The skewness and kurtosis were 1.48 and 2.19 respectively. The comparism of means showed significant variation between the size classes (t - test = 0.94, t = $0.92_{0.5}$. The distribution statistics (of Sharpiro-Wilk) showed significant difference (w = 0.86, P = 0.23 $_{0.5}$ between the size classes caught with the 60mm gill net (Table 1).

Table 1: The Summary of fish length and biomass statistics for *Ethmalosa fimbriata* and *Sardinella eba* with critical values for t –test and distribution test in parenthesis ( )

Category/ species		Skewness	kurtosis	CV	student t - test	Shapiro -Wilk distribution test
Ethmalosa fimbriata						
Fish length statistics	35mm	0.58	-0.43	93.9	0.89(1.45)	0.68(0.08)
	60mm	1.48	2.19	110	0.94 (0.92)	0.86(0.23)
	70mm	0.59	-0.43	94	0.96 (0.88)	0.91(0.45)

Fig. 2: The number of individual within the biomass and length range categories for *Ethmalosa* fimbriata

Fish Biomass statistics	35mm	2.1	4.49	164	0.88(.367)	0.67 (0.06)
	60mm	1.48	2.01	110	0.94 (0.24)	0.86(0.23)
	70mm	0.99	-1.12	143.5	0.97 (0.56)	0.89 (0.33)
Sardinella eba						
Fish length statistics	35mm	-0.12	-0.98	64.6	3.46 (0.98)	.98(0.90)
	60mm	-0.23	0.76	70.6	3.16 (0.98)	0.99 (0.95)
	70mm	1.59	2.53	117	1.91 (0.94)	0.84 (0.17)
Fish Biomass statistics	35mm	0.61	-3.29	137	1.63 (0.91)	0.70 (0.01)
	60mm	0.71	-2.76	138	1.61 (0.91)	0.74 (0.3)
	70mm	0.99	-1.12	143	1.56 (0.90)	0.77 (0.5)

Similarly, the biomass catch showed pattern different from the 35mm gill net mesh size, such that the sequence was in the decreasing magnitude of 'B' size class biomass (588 ± 120 x 10^3) > 'A" (258 ± 37.5 x 10^3 indiv) > 'E' size class (111± 45 10^3 indiv) > 'D' size class (78± 18 x 10^3 indiv) > 'C' size class (9 ± 5 x 10^3 indiv) respectively. The coefficient of variation was 110% with skewness and kurtosis of 1.48 and 2.19 respectively. The test was significant at 0.5 level (t =0.94 > t stat = $0.24_{0.5}$. The distribution using Sharpiro- Wilk test showed high significant variation in the size class biomass catch (w =0.861 > P =0.23 $_{0.5}$).

The 70mm mesh gill net had a total mean catch of 219.4 ± 206.2 x 10^3 indiv) The dominant size class caught was the 'D' size class (519 ± 59 x 10^3 indiv) followed by 'C' size class (283 ± 34 x 10^3 indiv), 'E' size class (245 ± 38 x 10^3 indiv), 'B' size class (31± 3 x 10^3 indiv) and the least being the 'A' size class (19 ± 4 x 10^3 indiv). The catch coefficient of variation amongst the size classes was CV = 93.9. The skewness (0.59) and kurtosis of –0.43. The mean comparison of the size classes exhibited distinctive variation following the significant difference observed (t - test = 0.98, > t = $0.88_{0.5}$ The distribution statistics of Shapiro-Wilk test showed significant difference (w =0.91 > P = $0.45_{0.5}$ between the size classes caught with the 60mm gill net.

The biomass pattern catch showed pattern different from the other gill net mesh sizes thus having a sequence in decreasing order of magnitude of fifth (528 ± 151 x 10^3) > fourth (195 ± 31 x 10^3) > third (71 ± 2 x 10^3) > first (50 ± 17 x 10^2) respectively. The coefficient of variation was 143.5% with skewness and kurtosis of 0.99 and –1.12 respectively. The test was significant at 0.5 level (t = 0.97> t = $0.56_{0.5}$). The distribution using Sharpiro-Wilk test showed significant variation of the different size biomass classes (w = 0.89 > P = 0.33 $_{0.5}$)

The principal component analysis (PCA) on the size class (based 0n length frequency) for the 3 categories of gill net mesh sizes deployed resulted in 3 linear combination of variables (component) with components I and II with eigen values greater than 1 (Table 2). The percentage component variations explained were 51.03%, 34.50% and 14.49% for components I, II, and III respectively.

In this ordination, component (i) had multiple contributors (size class E, and D). The major contributor to component (ii) is from Size class B and C. Component III has size class A as the its major loading factor (Fig. 3).

Similarly, the PCA based on biomass had eigen values for the components I and II greater than 1 and the percentage variation explained of 57.53%, 30.86% and 11.61% respectively (Table 2 and Fig.4). The main component loading for biomass was similar to that based on fish length with component *i* having multiple loading of size classes E, and D. Component ii loaded size class B and C and component iii had size class A as its only factor loading (Table 3 and Fig 4).

Table 2: Result of principal component analysis of variation in all measured fish (*Ethmalosa fimbriata*) length size classes for the different gill net mesh sizes.

	Component		
	i	**ii**	**iii**
Eigen value	1.47	1.14	0.39
Percentage variation	48.99	38.07	12.94

explained			
Cumulative value	48.99	87.06	100
	Loading		
	Size class E	Size class B	Size class A
	Size class D	Size class C	

Table 3. Result of principal component analysis of variation in all measured fish (*Ethmalosa fimbriata*) biomass size classes for the different gill mesh sizes.

	Component		
	i	ii	iii
Eigen value	1.52	1.03	0.43
Percentage variation explained	51.02	34.47	14.49
Cumulative value	51.03	85.50	100
	Loading		
Positive	Size class E	Size class B	Size class A
Negative	Size class D	Size class C	

Sardinella eba

The highest number of fish caught with the 35mm mesh size of gill net was the 'B' size class (51 ± 12 x 10^3), followed by the 'D" size class (46 ± 26 x 10^3), fifth size class, (26 ± 19 x 10^3), 'C' size class, (20 ± 13 x 10^3) and the 'A' size class (4 ± 3 x 10^3) in that decreasing order of importance (Fig 5). The coefficient of variation between the size classes was 64.6% with slight negative skewness (-0.12) and kurtosis (-0.98). The comparison of size class means showed marked variation (t - test = 3.46 > t = $0.98_{0.5}$). Biomass had skewness and kurtosis of 0.61 and -3.29 respectively. The biomass means showed significant variation between the size classes (t - test = 1.63 > t = $0.91_{0.05}$)as was observed for the fish (Table 1).

The distribution statistics of Shapiro –Wilk test showed significant difference between the seize classes caught with the 35mm gill net (W = 0.98 > P = $0.90_{0.5}$) Table 1.

The 60mm mesh size gill net has a total mean catch of 31.2 ± 22 x 10^3. The dominant size class caught was the 'D' size class (60 ± 13 x 10^3) followed by 'C' size class (41 ± 22 x 10^3), 'B' size class (30 ± 15 x 10^3), 'E' size class (25 ± 17 x 10^3) and the least being the 'A' size class (0) Fig. 5. The catch coefficient of variation amongst the size classes (CV = 70.6) was higher than that of 35mm gill net with the skewness of -0.23 and kurtosis of 0.76. The mean showed distinct variation (t - test 3.16 > t = $0.98_{0.05}$) between the size classes. The distribution statistics of Sharpiro -Wilk tes, showed significant difference (W = 0.99 > P = $0.95_{0.5)}$ between the size classes caught with the 60mm gill net. The biomass recorded positive skewness (0.71) with kurtosis of -2. 76. The mean comparison (t - test = 1.61 > t $0.91_{0.05}$) and distribution statistics demonstrated significant variation between the size classes.

The 70mm mesh size gill net had a total mean catch of 20.6 ± 24.6 x 10^3. The dominant size caught was the 'E' size class (61 ± 27 x 10^3) followed by 'D' size (10 ± 7 x 10^3), 'C' size class (10 ± 7 x 10^3), 'B' size class (8 ± 7 x 10^3) and the least being the 'A' size class (0). The catch coefficient of variation amongst the size classes (CV = 117.4) was higher than those of 35mm and 60mm gill nets with positive skewness (1.59) and kurtosis of 2.53. The size classes had marked variation (t - test = 1.91 > t = $0.94_{0.05}$. The distribution statistics of Sharpiro – Wilk test showed significant difference (W = (0.84) > (0.169) $_{(0.5)}$ between the size classes caught with the 60mm gill net.

The ordination plot for the 3 gill net mesh sizes from the data set on *Sardinella eba* had variances of 57.53%, 30.86% and 11.60% which accounted for each axis based on eigen values of 1,73, 0.93, and 0.35 was for components I, II, and III respectively (Table 4). The first component loaded size class 'E', while size classes 'D', 'C', 'B' and 'A' were loaded in component ii respectively (Fig 6). The same loading pattern was observed for the biomass catch (Table 5 and Fig 7).

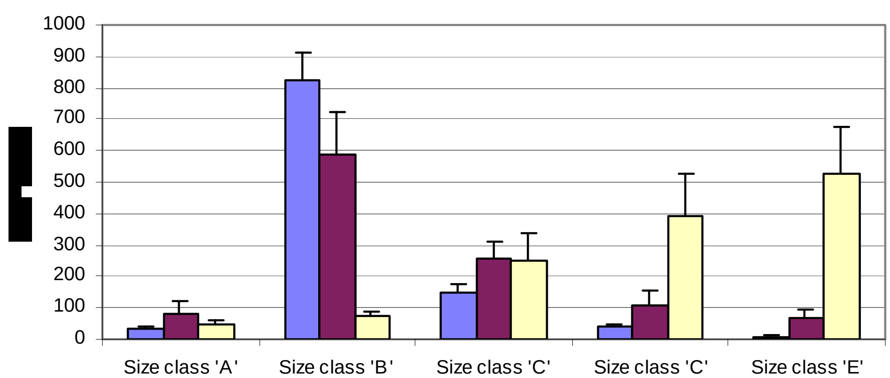
Table 4. Result of principal component analysis of variation in all measured fish (*Sardinella eba*) length size classes for the different gill mesh sizes.

	Component		
	I	**II**	**III**
Eigen value	1.73	0.93	0.35
Percentage variation explained	57.53	30.86	11.61
Cumulative value	57.53	88.39	100
	Loading		
	Size class E	Size class D	
		Size class C	
		Size class B	
		Size class A	

Table 5 Result of principal component analysis of variation in all measured fish (*Sardinella eba*) biomass size classes for the different gill mesh sizes.

	Component		
	I	**II**	**III**
Eigen value	1.93	0.53	0.21
Percentage variation explained	68.89	30.80	0.81
Cumulative value	67.39	78.53	100
	Loading		
	Size class E	Size class D	
		Size class C	
		Size class B	
		Size class A	

Fish lenght



Fish biomass

DISCUSSION

The numerous fish works dealing with the Niger Delta region adequately documented the range of species, distribution and their ecology (Ita 1978, Marcus 1982, Nwadiaro 1985, FAO 1991, Essen 1995, King 1996a and 1996b). Recent data have resulted in significant new range of information especially as it concerns their biology (food and feeding habits), and population (abundance) (RPI 1985, IPS, 1989 &1990, Chindah and Osuamkpe 1994).

The current and more significant trend is on how human intervention ranging from the application of hostile and unfriendly fishing gears, and other industrial related activities have threatened endemic fish species resulting in species loss and decline in fish population in the wild. These papers describing the general fish distribution in the region document concern on declining yield and steady poor fish catch per unit effort and species loss (RPI 1985, IPS 1990, FAO 1991 and Moses 1986).

The result of this study indicated that there are 3 major mesh sizes of gill net used by the local fishermen in Brass River. These 3 mesh size gill nets showed great variation in their size class catch distribution. Similarly, the catches per unit effort differ with mesh sizes, which showed significant variation between the size classes. This implies that each gill net mesh size had its (distinct) dominant fish size class (both in fish length and biomass), which skewed more positively as the gill net mesh size increases. This strongly suggests the importance of gill net size to the quality of fish harvested from the wild (Chindah and Osuamkpe 1994 and Balogun 1986). In order words, the proportion of table size and quality of fish are more with the larger mesh sizes for the bonga fish species especially (*Ethmalosa fimbriata and Sardinella eba*).

Similarly, a close look at the principal component loading with the size class 5 and 4 having the highest component weighting apparently implies that the more favoured gill net yielded highest fish size and biomass per unit effort. This suggest that the 70mm mesh size gill net provided opportunity for smaller fish among the species to avoid and escape capture, thus demonstrating effectiveness and table size fish catch efficiency. That said, the most appropriate gill net mesh size in Brass River is the 70mm mesh size net, which captured adequately the matured and table size fish.
The ecological implication of this finding is that the smaller size gill net sets deployed in Brass River are less sensitive to smaller fishes (and non selective) principally to new recruit that will replace the older fish generation. The trend must be adequately examined in order to arrest the declining fish catch and threat to Bonga fisheries.

The conclusion, is that for sustainable development larger gill net mesh sizes be encouraged by appropriate governmental agency through legislation and education on the need to utilize and deploy proper gear and possibly providing the recommended net sizes as capacity building to the local artisanal fishermen.

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