NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 52 Number 3, December 2021 Pg. 132-141
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng

ECONOMIC APPRAISAL OF ARTISANAL FISHERY RESOURCES IN OGUN STATE, NIGERIA

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Abstract
Fisheries resources are common asset accessible for exploitation by any one that has the means to do so. Considering the opportunities this freedom offers, there is tendency for overexploitation of the resources than is desirable. This study estimates the Maximum Sustainable Yield (MSY); Open Access Yield (OAY); and Maximum Economic Yield (MEY) of the artisanal fisheries resources of the four biotopes (Marine, Estuarine, Lacustrine and Riverine) in Ogun State. The two widely used surplus model thus Schaefer's and Fox models were used. Marine and Estuarine biotopes were exploited above the Maximum Sustainable Yield. The levels of exploitation in Riverine and Lacustrine biotopes were still within the acceptable range. The result of the estimated Open Access Yield revealed that the level of exploitation in Riverine and Lacustrine are within the acceptable range. Marine and estuarine were over exploited respectively by 63.8% and 28.07%. The current level of exploitation was such that actual catch was 227% and 156% above Maximum Economic Yield for Marine and Estuarine biotopes respectively. Riverine and Lacustrine biotopes were also overexploited from Maximum Economic Yield point of view. The level of current catch was about 84,04% and 74.81% above the estimated MEY for Riverine and Lacustrine biotopes. The study concluded that the four biotopes in Ogun State were overexploited. The level of exploitation was above its Maximum Economic Yield. Diversification of livelihoods was recommended for the artisanal fishers that exploited marine and estuarine biotopes.

Keywords: Sustainable Yields, Biotopes, Exploitation, Maximum Sustainable Yield, Open Access Yield, Maximum Economic Yield

Introduction
FAO reports (2008) revealed that over half of the captured fish stocks were designated as fully explored, producing at, or close to their maximum sustainable yield. Another 25 percent of fish stocks were overexploited, depleted, or recovering from depletion and yield less than their maximum sustainable yield (SOFIA 2006). The remaining 25 percent of the capture fish stocks are underexploited or moderately exploited. Further analyses revealed that majority of the underexploited stocks are low-value species, or species for which harvesting may be uneconomical. The exploitation of fishery resources had cost the world economy about US$50billion with respect to depreciation in asset deployed in exploiting captured fishery resources (World Bank 2008). Fisheries resources are common asset accessible for exploitation by any one that has the means to do so. Considering the opportunities this freedom offers, there is tendency for overexploitation of the resources than is desirable. Every fisher would endeavour to maximise his catch since any restraint by him would simply make more of the fishery resources available for other fishers. In the absence of any control, the fisheries resources, which multiply according to natural cycles, will be depleted to a level that can no longer support economic exploitation. This could result in decline in catches and in the short run threaten the livelihood of the fishermen. In the long run, the eventual collapse of a fishery resource is possible and consequently a vulnerable livelihood for the fishers and crew members who depend on this resources for food and income. According to Inoni & Oyaide (2007), stated that the capacity of artisanal fisheries plays an important role in food supplier,

employment provider and income earner in the Nigerian economy depends on the adoption of appropriate management strategies that will ensure their sustainability in the face of intense fishing pressure. Although, artisanal fishery in the area has contributed immensely to the socio-economic conditions of the entire populace due to economic influx of people in search of fish and fish products from the adjoining communities, empirical studies on the status of the artisanal fisher folks in the study area such as those of Akanni (2010) and Olaoye *et al.* (2012) are few; this work seek to improve the economic value of artisanal fish farming in the study area. The objective of this study is to:

Estimate of Maximum Sustainable Yield (MSY)
Estimate of Open Access Yield
Estimate of Maximum Economic Yield (MEY)

Estimation of Yields

The study of fisheries exploitation use economic analysis on the interface between human society and the biological resources. This resulted into the development of what is known as bio-economic models – analysing the interaction between human harvesting pressures and biological resources regeneration (Clark, 1973). Padilla and Charles (1994) defined bio-economic model as a quantitative model characterized by the integration of natural and human sides of the fisheries equation, linking the biological and economic elements. One of the popular bio-economic models is surplus production model. This model consider stock as one big unit of biomass without entering into any details on growth and mortality parameters or the effect of the mesh size on the age of fish capture. Surplus production models were introduced by Graham (1935), but they are often referred to as "Schaefer's' models". The objective of the application of "Surplus Production Models" is to determine the maximum level of effort that produces the maximum yield that can be sustained without affecting the long-term productivity of the stock. In practice, the Schaefer's model recommends the use a long series of annual catch and effort data and assumes equilibrium conditions. Schaefer's demonstrated that by using only catch and effort data, it was possible to approximate the equilibrium yield curve and the point of maximum sustainable yield of a fishery (Schaefer's, 1954). Surplus production models were used to estimate maximum sustainable yield (MSY) open access yield (OAY), maximum economic yield (MEY). Moses (1986) modified Schaefer's model to suit artisanal fisheries estimation by using number of fishermen and canoes as effort instead of trawlers employed in the industrial sector. Fox (1970) uses an asymmetric curve in place of Schaefer's symmetrical one. In this model, catch per unit effort decreases in a curve with increasing fishing effort rather than the straight line assumed under the Schaefer's model. The curve may be converted to a straight line by using natural logarithms:

$$\mathrm{Ln}\,(Y/f) = c + df$$

Where f is the fishing effort, c is the intercept and d is the catch-ability coefficient.

Fox model can also be written as:

$$Y(i)/f(i) = \exp © + d*f)$$

Fox (1970) state that:

$$Ymsy = -(1/d)*\exp(1-c)$$

and,

$$fmsy = -1/d$$

Methodology

Ogun State is a maritime coastal state with 15km seashore in Ogun Waterside Local Government Area. There are no coastal rivers in Ogun State but its major rivers which empty into the Lagoons include: Yewa, Ogun, Ona, Owa, Yemoji, Osun Sasa and Sunmoje. The Lagoons (Lekki and Yewa) and Creeks (Omu and Makun) covers about 760km2 and the state is also endowed with 15major reserviour/beels/weirpools. For the purpose of this study, the resources from rivers are captured as Riverine biotope; reserviour/beel/weirpools are Lacustrine. The Lagoons are referred to as Estuarine Biotope and seashore (Oceans) as Marine biotope.

Method of Data Collection

The secondary data was used for this study are from the Fishery Unit of Ogun State Agricultural Development Programme (OGADEP). The data are catch (metric tons) and effort data (number of fishers and canoes) of artisanal fishers exploiting the resources for the period of ten years (1999 to 2018) The data were analyzed using surplus function. Schaefer's and Fox model were used. The graphical method of the two models were also employed in appraising artisanal fisheries resources exploitation in Ogun state.

Data Analysis

Schaefer's and Fox Models

The sustainable yields for artisanal fisheries resources in Ogun State, Nigeria were estimated using Schaefer's model. The model is suitable for analyzing industrial and artisanal fisheries resources. Moses (1986) used the modification of Schaefer's model to estimate the Maximum Sustainable Yield (MSY) of artisanal fisheries resources in Cross River state which is similar to what O'Rouke (1971) used for Industrial fishery.

$$C = b0 + b1f1 + b2f2 + e \quad .... 1$$

Where:

f = number of fishers x number of canoe (man-canoe)
C = annual catch by artisanal fishers (metric tonnes)
e = error term, and
b0, b1, and b2 are parameters to be estimated

From equation (1) the maximum value of Cmax is:

$$dC/df = -b1 + 2b2f = 0 \text{ -------- } 2$$

The maximum effort fmax is:

$$f = -b1/2b2 \text{ --------- } 3$$

Maximum Sustainable Yield (MSY) for Schaefer's model is therefore given by substituting for maximum effort in equation 1.

$$C = b0 + b1 \{-b1/2b2\} + b2 \{-b1/2b2\}2 \text{ ----------- } 4$$

These parameters were estimated from graphical representation of the model (Fig 1-4). The estimate of Maximum Sustainable value for Fox model was calculated using the maximum effort fmax:

$$C = d0 + d1 Ln (f) \text{ -------- } 5$$
$$fmax = 1/d \text{ ------- } 6$$

Where:
f = number of fishers x number of canoes (man-canoe)
C = annual catch by artisanal fishers (metric tonnes)
e = error term, and
d0 and d1 are parameters to be estimated

Maximum Sustainable Yield (MSY) for Fox model is therefore given by substituting for maximum effort in equation 5. Open Access Yield is at the point when profits are totally dissipated and no economic rent is obtained from the resources. It implies that total income is equal to total cost. Price element was introduced to both models to estimate OAY.
$dC/df = Pf/Pc$

Where:
Pf = unit price of effort (N)
Pc = Unit price of catch (N)
The Open Access Effort was obtained by multiplying equation (4) by average price of the catch and divided by the value of fishing effort as obtained in equation (5). Rearrange and solve for f in equation (6). Open Access Yield is obtained by substituting for foay in equation (4). Maximum Economic Yield is obtained at a lower total fishing effort since positive economic rent is only obtained at effort lower than foay this is the point that Marginal Revenue equals Marginal cost.
$dTR(f)/df = dTC(f)/df$

Results and Discussion

State of the Artisanal Fishery Resources in Ogun State

This study estimated the Maximum Sustainable Yield (MSY); Open Access Yield (OAY); and Maximum Economic Yield (MEY) of the artisanal fisheries resources of the four biotopes in Ogun State. The two widely used surplus model thus Schaefer's and Fox models were used for this study to compare the outcomes. The implication of the estimated yields and effort in relation to the current level of catch and effort deployed to this resource are discussed.

Estimate of Maximum Sustainable Yield (MSY)

The result of Schaefer's and Fox model revealed that Marine and Estuarine biotopes were exploited above the Maximum Sustainable Yield (MSY). The level of exploitation in marine biotope was about 83.728 and 74.438 metric tonnes above the MSY from Schaefer's and Fox models estimate respectively. This was about 20% above the sustainable catch in table 1 above. Similarly, Schaefer's and Fox models showed that estuarine biotope was exploited above MSY by 27.875 and 19.807 metric tonnes per month respectively. The level of effort deployed to harvest these resources followed similar trend. Schaefer's model indicated that the effort was about 22% above the carrying capacity of the resources while the Fox model pegged the figure at 6.7% above the Maximum Sustainable Yield Effort (Table 1). Considering the contribution of these two biotopes to capture fishery in Ogun state, the observed overexploitation was traced to high influx of effort in the form of plank canoes and outboard engines into these biotopes. For instance, OGADEP (2009) reported that marine and estuarine biotopes accounted for 35.1% and 26.46% of total fish production in Ogun state for the year 2008. This implied that about two-third (61.56%) of the total fish production in Ogun were sourced from these biotopes. The level of exploitation of Riverine and Lacustrine biotopes was still within the acceptable level from Maximum Sustainable Yield point of view. The estimated Maximum Sustainable Yield for Riverine and Lacustrine biotopes were 241.836 and 253.421 respectively from Schaefer's model. The Fox model on the other estimated Maximum Sustainable Yield of 249.138 and 266.523 metric tonnes for Riverine and Lacustrine respectively (Table 1). The relatively under exploitation of the riverine biotopes had been attributed to the sparse nature of the resources which make it inaccessible or relatively difficult to access by nearby fishing communities unlike marine and Estuarine biotopes. (Jamiyu 2003). Apart from this, majority of riverine biotopes are seasonal in nature as the rivers get dried up during the dry season when the resources are required most to supplement income from arable farming. (Fregene, 2002)

Estimation of Open Access Yield (OAY)

Maximum Sustainable Yield is a technical optimum as the cost of effort is ignored. It assumes that exploitation of the resources continues irrespective of its contribution to the welfare of the society. This is not a true position in a rational economic setting. Open Access Yield refers to the catch level where total revenues are equal to total cost of effort. This implies that the unit cost of effort equals the unit price of catch. At this point, profits are totally dissipated and no economic rent is obtained. The result of the estimated Open Access Yield for the four biotopes in Ogun State revealed that the level of exploitation in Riverine and Lacustrine were within the acceptable range. This implied that the resources were able to pay for all the costs of effort deployed to its exploitation. This had beneficial welfare effects on the society. Riverine and Lacustrine biotopes were capable of supplying 6.48% and 12.59% respectively above the estimated catch of Schaefer's model. Fox model projected extra 8.41% and 15.58% of catch respectively for Riverine and Lacustrine biotopes (Table 2).

Result of Open Access Yield revealed that Marine and

Estuarine were exploited respectively by 63.8% and 28.07% above the estimated OAY from Schaefer's model. Fox model result depict that the resources of these two biotopes were exploited by 60.3% and 21.81% above the OAY. This implies that the resources could not account for the total cost incurred on effort for its exploitation (Table 2).

Open Access Yield represent a situation whereby all the pooled resources deployed in fishing provides a breakeven point catch. . This situation likely explained why poverty is prevalent in fishing communities as the total revenue realized is less that cost incurred on effort in line with underline principles of Open Access yield.

Estimation of Maximum Economic Yield (MEY)

Maximum Economic Yield (MEY) depends on costs and revenues and therefore is not constant over time. It varies with the price of catch and cost of the unit effort. Effort at Maximum Economic Yield (fmey) was estimated from equation 5 and the corresponding maximum economic yield were estimated by substituting for f in equation (6) where is this equation. Comparing the Maximum Economic Yield level with the actual catch in 2008, it was observed that marine and estuarine biotopes were grossly overexploited. The level of exploitation was such that actual catch was 227% and 156% above MEY for Marine Estuarine biotopes respectively as estimated from Schaefer's model. Fox model also affirmed similar trend that the current level of exploitation was 220.6% and 143.6% respectively above MEY for marine and estuarine biotopes (Table 3). Riverine and Lacustrine biotopes were also overexploited from Maximum Economic Yield point of view. The level of catch was about 84,04% and 74.81% above the estimated MEY for Riverine and Lacustrine biotopes respectively from Schaefer's model estimate. The Fox model revealed that Riverine and Lacustrine were exploited by 83.18% and 65.07% above MEY respectively (Table 3).

Conclusion

The level of exploitation of riverine and lacustrine biotope was socially beneficial to the artisanal fishers. The resource was able to pay back the cost incurred on effort for its exploitation; as was exploited within its Open Access Yield. The four biotopes in Ogun State were economically overexploited. The resources level of exploitation was above its Maximum Economic Yield. This implies net loss to the artisanal fishers as the resources could not pay for the total investment on fishing assets. The most threatened captured fishery resources from this study are marine and estuarine biotopes. The maximum economic yield of marine and estuarine resources was exploited by 224% and 150% respectively. This trend suggests different degree of underutilization of resources employed in exploitation of artisanal fisheries resources in the four biotopes of Ogun State. It also implies that it pays to withdraw part of the effort (fishers and canoe) from these resources to achieve optimum utilization of input. It also means that introduction of more effort will be a threat to the sustainability of the resources and further increased cost per kilogram of fish caught. The situation was confirmed by World Bank that bad governance of marine fisheries had been reported to have caused loss of economic benefits estimated to be to the tune of US$50billion annually (World Bank & FAO, 2008). The implication of the trend of overexploitation of artisanal fisheries resources in the four biotopes posed a threat to livelihood of fishers who depend on these resources for food and income. It also widened the gap between fish demand and supply in the state which has been estimated to be 56.6% (OGADEP, 2009). Besides this, implied more pressure on aquaculture which accounted for 7.75% of total fish production in Ogun State (OGADEP, 2009). It is becoming increasingly difficult to depend on capture fishery to meet demand for fish and further influx of effort result in less catch. Hence, it is becoming relatively expensive to harvest fish from natural resources and there is need to migrate from capture fishery to aquaculture. There should be enlightenment and capacity building to encourage artisanal fishers to embrace cultured fisheries. As a follow up to enlightenment, artisanal fishers more importantly those exploiting marine and estuarine biotopes should diversify into other profit-making ventures. Investment in effort (plank canoe, outboard engines, fishing gears, etc) may not pay back their capital outlay in the nearest future. There is a need to carry out appraisal of artisanal fishery resources in all coastal states in Nigeria to ascertain the state of these resources which provide employment for about 1.9 million people and supply's about 88.13% of the total domestic fish production that is about 450,965 metric tons (Ibraleen, 2007; PDF, 2000). The livelihood of artisanal fishers and human security are topical issues that need attention for peace and stability of the nation.

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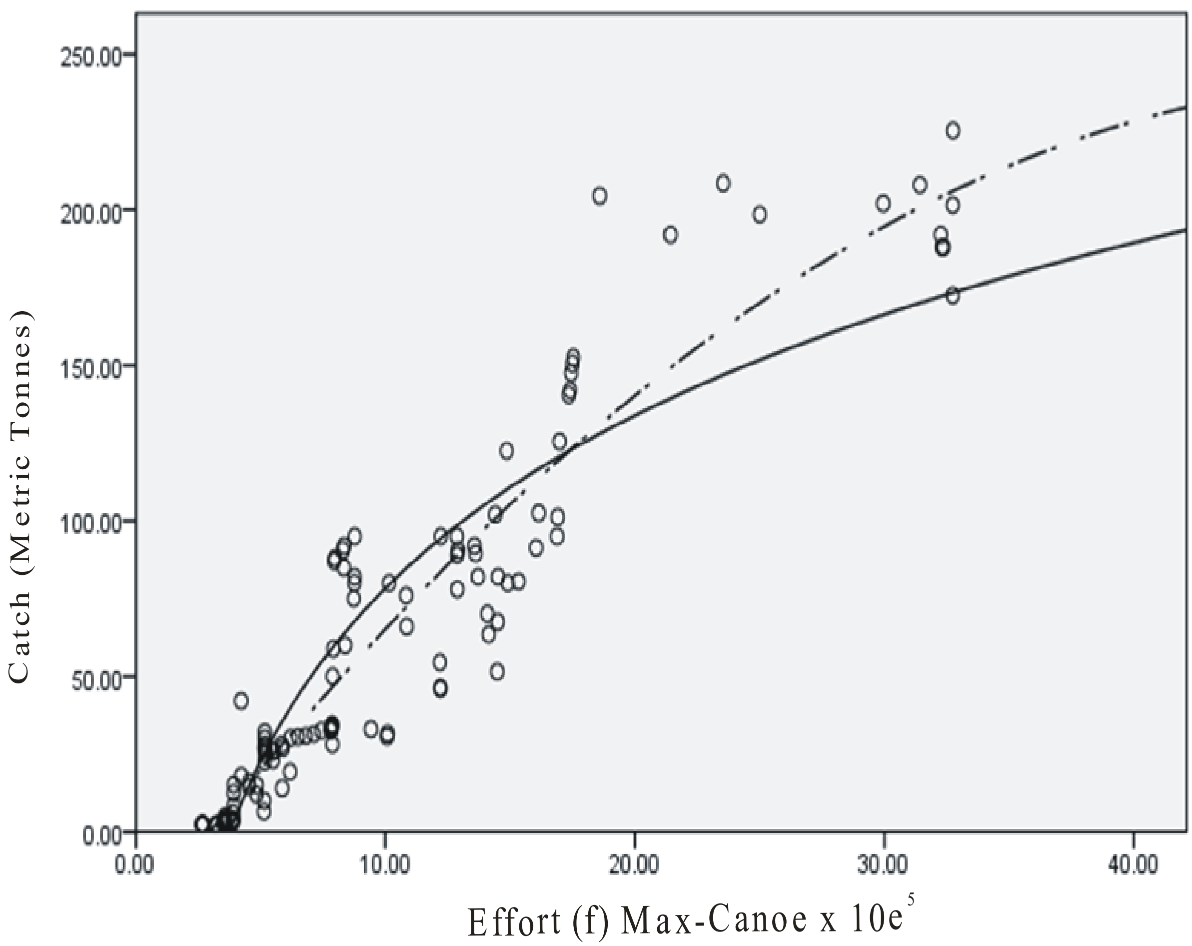
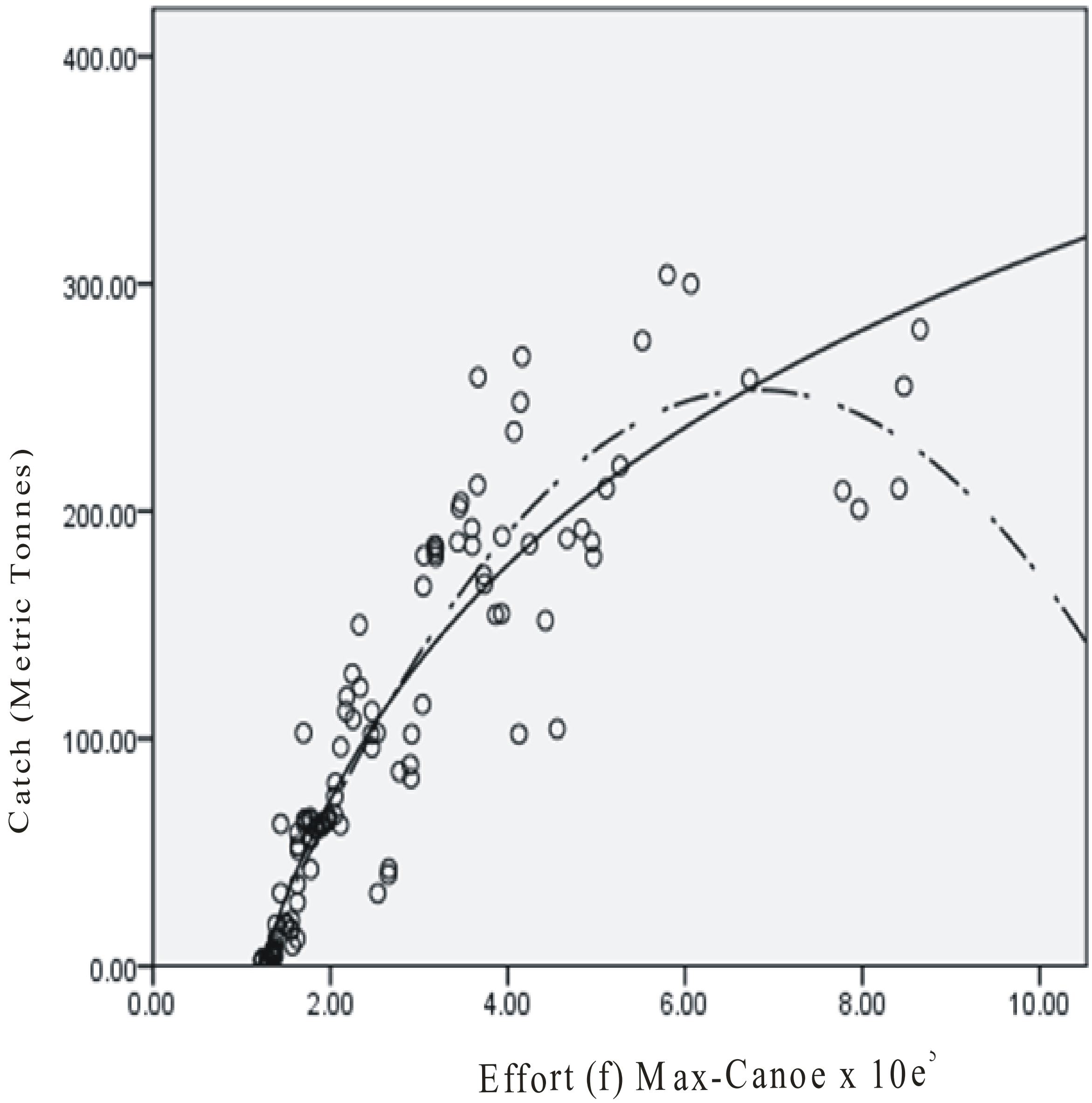


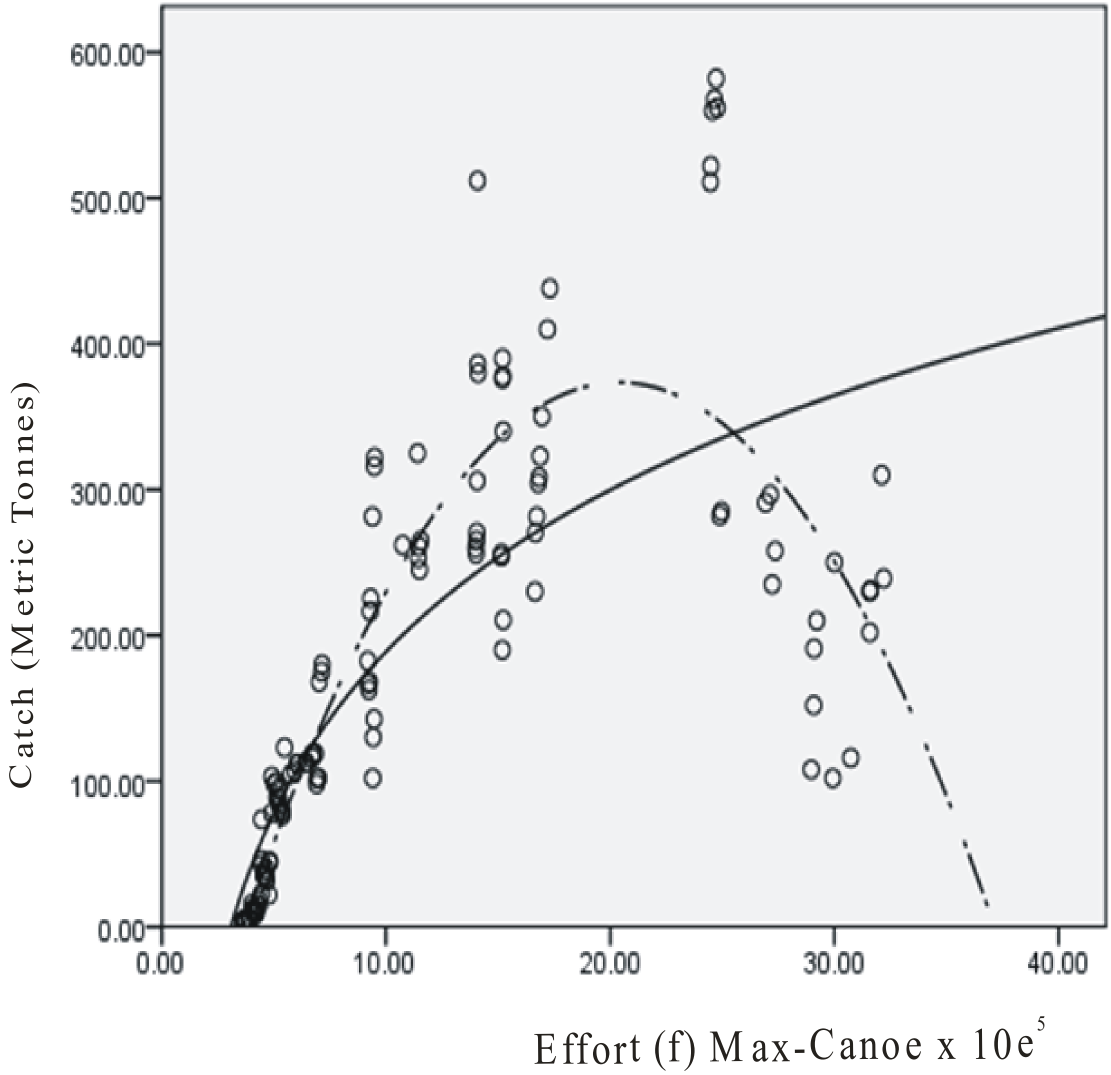
Legend:
_________Schaefe's Model
_ _ _ _ _ _ _ Fox Model

Fig. 1: Schaefer's and Fox model for Riverine Biotope



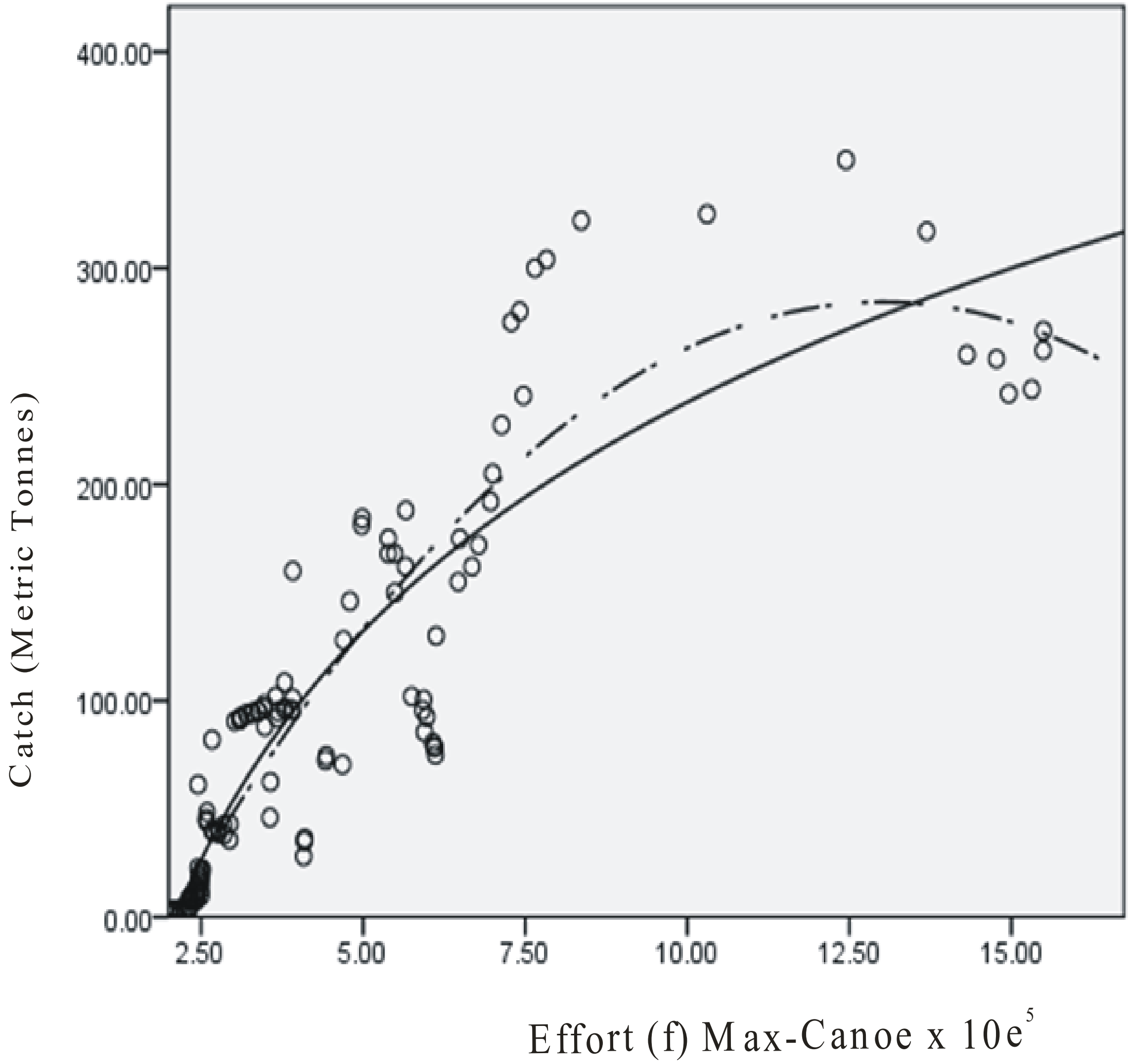
Legend:
_________Schaefe's Model
_ _ _ _ _ _ _ Fox Model

Fig. 2: Schaefer's and Fox model for Lacustrine Biotope



Legend:
__________Schaefe's Model
_ _ _ _ _ _ _ Fox Model

Fig. 3: Schaefer's and Fox model for Marine Biotope



Legend:
__________Schaefe's Model
_ _ _ _ _ _ _ Fox Model

Fig. 4: Schaefer's and Fox model for Estuarine Biotope

Table 1: **Differential of Monthly Actual Catch and Effort with Maximum (Sustainable Yield and Maximum) Effort**

Biotopes/ Model	Maximum Sustainable Yield (Metric tons)	Actual Catch (Metric tons)	Change in Catch- Metric tons (%)	Maximum Effort (Man-canoe x 10^5)	Actual Effort (Man-canoe x 10^5)	Change in Effort - Man-canoe x 10^5 (%)
Riverine						
Schaefer's	241.836	208.25	33.586 (13.89)	51.376	47.163	4.213 (8.20)
Fox	249.138	208.25	40.88 (16.41)	54.945	47.163	7.782 (8.20)
Lacustrine						
Schaefer's	253.421	221.342	32.079 (12.66)	6.819	6.335	0.484 (7.10)
Fox	266.523	221.342	45.18 (16.95)	7.281	6.335	0.946 (12,99)
Marine						
Schaefer;s	373.562	457.29	-83.728 (22.41)	20.399	24.805	-4.406 (21.60)
Fox	382.852	457.29	-74.44 (19.44)	23.288	24.805	-1.517 (6.51)
Estuarine						
Schaefer;s	284.349	312.224	-27.875 (9.8)	13.013	14.692	-1.679 (12.90)
Fox	292.422	312.224	-19.802 (6.77)	15.632	14.692	0.94 (6.01)

Source: Computed from Catch and Effort data (1999 - 2018)
( ) Figures in parenthesis are in percentages

Table 2: **Differential of Monthly Actual Catch and Effort with Open Access (Yield and Open Access Effort)**

Biotopes/ Model	Unit Price of Catch (N)	Unit Cost of Effort (N)	Actual Catch (Metric tons)	Open Access Yield (Metric tons)	% Change in Catch (Metric tons)	Actual Effort (Man-canoe x e^5)	Open Access Effort (Man-canoe x e^5)	% Change in Effort (Man-canoe x e^5)
Riverine								
Schaefer's	550,000	1,360,000	208.25	222.681	14.43 (6.48)	47.163	37.752	-9.411 (24.93)
Fox			208.25	227.365	19.12 (8.41)	47.163	41.236	-5.927 (14.37)
Lacustrine								
Schaefer's	657,000	1,300,000	221.342	253.230	31.89 (12.59)	6.335	6.657	0.322 (4.84)
Fox			221.342	262.192	40.85 (15.58)	6.335	6.828	0.493 (7.22)
Marine								
Schaefer's	657,000	14,750,000	457.29	279.182	-178.1 (63.8)	24.805	11.977	-12.828 (107.11)
Fox			457.29	285.274	-172 (60.3)	24.805	13.479	-11.326 (84.03)
Estuarine								
Schaefer's	657,000	9,552,000	312.224	243.787	-68.44 (28,07)	14.692	8.861	-5.831 (65.81)
Fox			312.224	256.327	-55.9 (21.81)	14.692	9.261	-5.431 (58.64)

Source: Computed from Catch and Effort data (1999 - 2018)

Table 3: Differential of Monthly Actual Catch and Effort with Maximum Economic (Yield and Maximum Economic Effort)

Biotopes/ Model	Unit Price of Catch (N)	Unit Cost of Effort (N)	Actual Catch (Metric tons)	Maximum Economic Yield (Metric tons)	% Change in Catch (Metric tons)	Actual Effort (Man-canoe x e^5)	Maximum Economic Effort (Man-canoe x e^5)	% Change in Effort (Man-canoe x e^5)
Riverine								
Schaefer's	528,000	1,360,000	208.25	111.341	-96.91 (84.04)	47.163	18.876	-28.287 (149.86)
Fox			208.25	113.683	-94.57 (83.18)	47.163	20.618	-26.545 (128.75)
Lacustrine								
Schaefer's	550,000	1,300,000	221.342	126.615	-94.73 (74.81)	6.335	3.329	-3.006 (90.30)
Fox			221.342	134.091	-87.25 (65.07)	6.335	3.414	-2.921 (85.56)
Marine								
Schaefer's	657,000	14,750,000	457.29	139.591	-317.7 (227.6)	24.805	5.988	-18.817 (314.25)
Fox			457.29	142,637	-314.7 (220.6)	24.805	6.739	-18.066 (268.08)
Estuarine								
Schaefer's	657,000	9,552,000	312.224	121.894	-190.3 (156.1)	14.692	4.431	-10.261 (231,57)
Fox			312.224	128.164	-184.1 (143.6	14.692	4.631	-10.061 (217.25)

Source: Computed from Catch and Effort data (1999 - 2018)