Compliance To Mesh Size Regulations In Artisanal Marine Fishery In Ghana

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Work in Progress[1]

(Comments will be appreciated)

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1. Introduction

In Ghana, fishing is the most important direct and indirect employment generating activity in the entire coastal zone of length of about 528 km. It has been estimated that the fishery sub-sector supports about 1.5million people, and fish and fish products contributed 21% (US $56 million) to the nations non-traditional export earnings in 1997(FAO, 1998). With the persistent decline in the price of cocoa and gold which are Ghana's traditional export commodities and the resultant adverse effect on foreign exchange earnings, government policy aims at increasing the production of non traditional export commodities, including fish, to meet the growing domestic demand and export.

Ghana's fish production comes from two main sources, marine and inland. Fish catch from the marine constitutes about 85% of total domestic fish production. The marine fishery sector has four fishing fleets; namely artisanal (canoes), inshore, industrial and tuna fleets (FAO, 1998). The artisanal fishery sector, which is the most important sector, dominates in terms of vessels, employment and fish landing (Koranteng, 1992; Ministry of Environment Science and Technology, 1998). According to FAO (1998), as at 1997, the artisanal fishery sector in Ghana had 8,895 vessels (canoes) out of 9,106 vessels (i.e. 98%) in the marine fishery sector. The canoes use four main gears; namely, Gillnet, Poli-Watsa, Hook and line, and Beach seine nets. As at 1997, the sector has employed 101,741 fishermen and 150,000 fish processors and traders. Of the total marine annual fish catch by the four fleets, between 70% and 80% comes from the artisanal fisheries (FAO, 1998). Between 1988 and 1992, out of the total

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marine fish landing of 327,000 tons, artisanal fishery contributed 260,000 tons (i.e. about 80%). But in terms of value added, within the same period, the sector contributed US$23,100 to the total figure of US$63,310 that accrued to the marine fishery.

The artisanal marine fish resource in Ghana is owned by the state but the resource is an open access to Ghanaians since government policy regarding artisanal fishery encourages the development of the resource to increase employment and reduce rural poverty. However, the use right of the fish resource is enshrined in fishing regulations by government (PNDC law 256 of 1991) to ensure sustainability. The government regulations (which are command and control instruments) include adherence to mesh-size regulation, which require minimum mesh size of 25mm, approximately one inch, in stretched diagonal length.

However, the mesh size regulation, among others, has not been very effective due to non-compliance. Some fishers have vehemently rejected the mesh size regulation on the basis that the minimum size of 25mm in stretched diagonal length cannot catch some targeted species, e.g. anchovy. It is noted that the fishers use mesh sizes between 10mm and 25mm and this is disastrous in artisanal fishery. As a result the sector is characterised by overexploitation and overcapitalisation (Koranteng, 1997). It is obvious that the artisanal fishery resource will run into extinction and subsequently deepen poverty and increase the rate of unemployment in fishing communities in the long run if fishers do not adhere to the mesh size regulation, among others. According to Koranteng (1992), the destructive nature of some artisanal fishing gear such as the seine net cannot be overemphasised. In view of this, this research seeks to investigate likely reasons that are responsible for non-compliance with mesh size regulation with **Komenda-Edina-Eguafo-Abrew District,** a fishing intense area, as a case study, analyse the relationship between fishing skills and effort limiting through quota systems and limits to fishing trips, and also find out whether wealthy fishermen are more likely to conserve the fish resource.

1.1 Objectives of the Study

The main objectives of this study are to investigate:

1. whether factors such as **ignorance** of fishers about the consequences of the use of mesh sizes smaller than 25mm in stretched diagonal on the fish stock and habitat, the level of **poverty**[3] of the fishers ***and/or*** **non-compliance** by other fishers, are responsible for the violation of the mesh size regulation.
2. the relationship between socio-economic characteristics such as income, level of education, marital status, number of dependants, religion and tribe; and fishing experience and ownership of fishing vessel of the rule breakers, and the possible reasons for the violation of the regulation.
3. whether heterogeneity in fishing skills, proxy by levels of technical efficiency[4], determine choice of effort limiting strategies such as uniform quota and uniform fishing trips.
4. whether wealthier fishermen are more likely to enforce the mesh size regulations than the poorer fishermen.

1.2 Significance of the study

By empirically investigating and unearthing the likely reasons for rule breaking the findings of this study will be very useful to Department of Fisheries of the Ministry of Agriculture in Ghana. Thus it will help the department to evaluate and improve the existing effort-limiting strategies in the artisanal marine fishery.

Second, as a unique study that will empirically investigate motivation for non compliance to rule of use, and the strength of fisher-heterogeneity in rule enforcement in Ghana in particular and West Africa in general, this research will serve as a useful reference material for policy makers and academicians.

2. Artisanal Marine fishery in Ghana

2.1 A Brief historical development of Fishing Gear

Until late 19th century, marine fishery in Gold Coast (now Ghana) was basically artisanal and the fishing technology was very simple and less efficient. The fishing

[3] For the purpose of this study, we shall rely on self-perception of the fishermen.
[4] The choice of this proxy is motivated by Baland and Platteau (1996, p161) commitment to the phrase '…technically more efficient...' in explaining regulation with heterogeneous resource users.

gears used were Castnets, gillnets (locally called 'Ali' net), seine nets, trapnets, and handlines. The rope used for the nets was produced from bowstring hemp and the twine for nets was made from pineapple leaves (Lawson and Kwei, 1974, and Koranteng, 1992). The industry used dugout canoes which were locally made of *Triplochiton scleroxylon*, locally known as 'wawa' (Koranteng, 1992). The targeted fish stock was in abundance and there were relatively low demand for fish due to the low population of less than three million and inadequate facilities to preserve fish. As a result, the fishers operated in very near coastal waters (Fishery Department, 1992).

From the late 19th century and early 20th century, Ghana's population increased considerably which consequently triggered the demand for fish. The sector in response to this underwent some considerable changes, notably: the introduction of improved fishing gears such as the purse seine net and synthetic netting materials, introduction of outboard motors, improvement in fish processing and storage facilities (Koranteng, 1992).

The beach seine net was introduced in the artisanal marine fishery industry at the beginning of the 20th century. Soon after this, an encircling net was introduced and developed later into a purse seine net locally called 'watsa' net with meshes of about 50-60 mm. This was further improved to have thinner twine and contain much smaller mesh sizes of 10-13 mm. The local name of this improved net is 'poli'. Fishery scientists consider this net very destructive to artisanal fish stock since it is capable of harvesting large schools of juvenile fishes. The most recent and popular gear is 'Ali-watsa' net, which is a combination of the 'ali' and 'watsa' nets. Some of the fishers also attached hooks to the gill and set nets. In addition, the change from natural to synthetic netting materials has decreased frequency and duration of mending of nets and consequently increased fishing time (Koranteng, 1992). Presently there are four main artisanal marine fishing gears. These are; Gillnet, Poli-Watsa, Hook and line, and Beach seine nets.

2.2 Gear types and Targeted species in artisanal marine fishery

Table 1 provides information on artisanal marine fishing gears and targeted fishes.

Table 1. Gears and targeted Fishes

Type of Gear	Targeted fishes
Poli/Watsa/Ali	Small and medium size pelagics: anchovy, sardinellas, mackerels and burrito
Gillnets	Large pelagics: bill fishes, tunas and shacks
Beach Seine nets	Pelagics and demersals
Hook and lines	Demersal

Source: Fishery Department, 1992

- **Gillnet** is a rectangular piece of netting fixed to a head line, which is fitted with floats, on top and with a foot-rope weighted with lead, stones or shells at the bottom. The gill net is either operated as set net, where the foot rope is heavily weighted and anchored at each end so that the net fishes at a fixed position, or as a Drift net where the foot rope is lightly weighted or not weighted so that the net drifts with the current.
- **Beach seine net** has one end fixed to the bottom and the other end moved freely to surround a given area. The net is later pulled to catch the fish.
- **Hook and line** is usually long ropes carrying several hooks. The hooks are baited with small low-priced fishes[5].

Although all the above gears are used by the artisanal marine fishers in Ghana, it is notable that the largest canoes measuring 15-20 meters mainly use ali/poli/watsa and other smaller canoes use different types of gear such as the beach seines, set nets, gillnets and hook and line (Fishery Sector Capacity Building, ??). Of about 8,895 canoes of varying sizes in 1996, about 56.2% were motorised. Although the number of canoes have been stable, fishing techniques have improved and thereby intensifying fishing efforts (Fishery Sector Capacity Building, ??).

2.3 Trends in Fish Resource harvest

Presently the artisanal marine fishery operates in about 189 fishing villages and 310 landing sites throughout Ghana. It is estimated that the sector lands about 250,000 mt

[5] See Moses(19??)

annually of which 180,000 mt constitute small pelagic species. The pelagic species consist of *sardinella aurita and s. maderensis*, and anchovy. The *sardinella*, experience seasonal fluctuations and as a result does not strictly lend itself to the concept of Maximum Sustainable Yield (MSY)(Koranteng, 1992). After a very high increase in the landing of *sardinella aurita*, the peak of 125,815 tons was reached in 1992, and the catch has been surging downwards over the years.

Table 2. Trends in Catch Per Unit Effort (CPE)

Year	1992	1993	1994	1995	1996
CPE	38.2	29.6	24.5	24.3	34.6

Source: FRUB (1997)

Table 2, shows the trend in the Catch Per Unit Effort (CPE) from 1992 to 1996. The figure declined from 1992 through 1995 even in the face of improved fishing techniques. This provides a good indication of excessive exploitation of the resource. Although the CPE increased by 42.4% from 1995 to 1996, it was still lower than the 1992 level.

3.0 Overview of Property Rights and Marine Fishery Resource Management in Ghana

3.1 A Brief Overview of Property Rights

Property right, according to Ostrom (2000), define actions that individuals can take in relation to other individuals regarding some "thing". And if an individual has a right, other individual(s) has the commensurate responsibility to respect that right. Resources that do not have ownership or control are referred to as open access. It is important to distinguish among some property regimes. Worthy of note are, common property (which is divided into unregulated common property, regulated common property or common pool), state property and private property.

Common property denotes resources that are owned by a community and rules of access to the resource are defined by the community that owns the resource (Helberg, 2001). A typical example of these resources is marine fishery stock. Common property could either be regulated, where the rules governing the resource utilization are clearly specified, or unregulated where the rules do not exist or are not enforced to limit the use of the resource (Baland and Platteau, 1996; Helberg, 2001). The

unregulated common property is also known as the common-pool (Helberg, 2001). These resources have two main characteristics; difficulty or high cost of excluding potential users, and every user subtracts from benefit to other users ((Ostrom, 1990). Marine fishery stock is good example of these resources. The two characteristics are recipes for over-exploitation of say marine fishery resources, a phenomenon known as the "tragedy of the commons". The five property rights that are very relevant for the use of common pool resources are access, withdrawal, management, exclusion, and alienation (Schlager and Ostrom, 1992, Ostrom 2000).

State Property, on the other hand are resources owned by the state, and rules of access and conservation are enforced by the state (Heltberg, 2001). It is not uncommon that due to high cost of enforcement, state property degenerates to open access or common property. In many developing countries, marine fishery stock is state property, however due to high cost of monitoring the resource becomes a common pool to fishers.

Finally, private property exits when an individual has a property right over a resource. This right, typically, includes the right to posses, use, transfer, destroy, manage and exclude other potential users of the resource (Ostrom, 2000; Heltberg, 2001).

3.2 Artisanal marine fishery stock in Ghana as a Common Pool

As noted earlier, common pool resources are characterized by difficulty of excluding non-members and the use of the resource by each member subtracts from total benefit that accrue to other members. Ostrom (2000, 1993), identified seven variables, which makes it conducive for a resource to be used as a common property, these include: (a) Accurate information about the condition of the resource and expected flow of benefits and costs is available at low cost to the participants (b) Participants share a common understanding about the potential benefits and risks associated with the continuance of the status quo as contrasted with changes in norms and rules that they could feasibly adopt (c) Participants share generalized norms of reciprocity and trust that can be used as initial social capital (d) The group using the resource is relatively stable (e) Participants plan to live and work in the same area for a long time (and in some cases, expect their offspring to live there as well) and, thus, do not heavily discount the future (f) Participants use collective-choice rules that fall between the

extremes of unanimity or control by a few (or even bare majority) and, thus, avoid high transaction or high deprivation costs (g) Participants can develop relatively accurate and low-cost monitoring and sanctioning arrangements.

According to McCulloch et al (1998), where the above critical conditions are not present and collective action needed for resource management is lacking, the motivation of beneficiaries depends on economic costs and benefits, as well as time involved in and social tensions or gratification from participation. And when government supports are lacking in a situation where there are sufficient incentives, local authorities develop local mechanisms that replaces the role of the government.

At independence in 1957, the Coastal Zone that stretches from 10m-height contour to the seaward limit of the continental shelf and the resources within the Exclusive Economic Zone of 200 nautical miles, including fishery, become the property of the state. The government however granted the use right to all Ghanaians, and consequently declaring particularly artisanal fishery resources an open access. Until early 20th century artisanal marine fishery in Ghana, with reasonable low population, was very close inshore using simple fishing technology comprising inefficient gear and dug out canoes propelled by oars and sails. Total catch was below the maximum sustainable yield; hence the artisanal resource management was not an issue. The artisanal marine fishermen lived in communities, and the chief fisherman, who usually happens to be the founder of the fishing community and/or most skillful and wealthy fisherman, together with some elders and successful fishermen, resolve fishing related conflicts, enforce social norms relating to fishing, and oversee the general welfare of other fishermen in his community. When it happens that the fishing community is within the jurisdiction of a bigger village, the village Chief ranks superior to the Chief Fisherman. However, the Chief Fisherman is usually granted the powers to resolve fishing related conflicts and punish violators of fishing norms (usually by imposing fines or excommunicate). Occasionally, referrals are made to the village Chief, who in most cases depend on the expert advise of Chief fishermen within his jurisdiction to pass judgments. Prior to the early 20th century, the fish resources were in abundance and as a result there was very little migration of artisanal marine fishermen and fishing activities were within limited confines of fishing communities. It is a norm that if any fisherman migrates to a fishing

community he reported to the chief fisherman and his elders who formally introduce him to other members of the community and henceforth oversee his general welfare. It is noteworthy that the Chief Fisherman has no powers to exclude any fisherman from fishing.

As Ghana's population grew over the years at approximate rate of about 3%, the economic performance of the nation declined persistently beginning in the early 1970s and recorded the worse performance by the dawn of the 1980s. The economy was characterized by deteriorating terms of trade, high rate of inflation of about 123%, highly overvalued currency among others. All these unfavorable indicators culminated in high unemployment rates. A significant number of the displaced labor found solace in the agriculture sector, including the artisanal marine sub-sector. The mobility naturally coincided with the introduction of new techniques in fishing such as introduction of outboard motors, which enabled the fishermen to travel further to fish, increased boat sizes from 25 feet to 40 feet, new gears, and enhancement of fish processing techniques (Walker, 2001). The rapid development of the artisanal fishery eventually led to the reduction in catch per unit of effort and subsequent decline in the profitability and increased poverty in artisanal marine fishing communities. Consequently, many artisanal fishermen embarked on the use of destructive fishing techniques, notably poison, dynamites and very small mesh sizes that capture fishes of all sizes and species. As noted by McCulloch et al (1998), population growth exerts increased competition for resources and produces a growing number of people with group membership claims. By 1984, the practice had become rampant posing a great danger to the resource sustainability. In 1984 the government through the Fisheries Department enacted a law banning the use of mesh sizes smaller than 25mm in stretched diagonal and the other destructive fishing methods. Bodies charged with the responsibility of enforcing this rules are the Ghana Navy, Department of fisheries, and the judiciary. Due to persistent limited budgets of government, far less than adequate funds were made available to the ministry to monitor and enforce these regulations effectively along the vast coastline. It has also been argued that few violators who were sent to court were made to pay very marginal fines, which is not deterring.

3.3 Co-Management: A Brief Historical Background and Recent Developments In Artisanal Marine Fishery in Ghana

An important question worth asking is why fishing communities accept these destructive fishing practices. The answer, which is not far fetched, rests on the common pool nature of the resource. With many profit maximizing fishing communities, each harvesting a common pool resource, with very low probability of detecting non-compliance by other communities, it is obvious that equilibrium harvest will be far from Pareto optimum. Conversely, it will be unrewarding for any community to comply with the rules of use. Thus, to motivate all communities to comply, there is the need for defined and secured rights to communities! The three fundamental questions regarding these rights, noted by McCulloch et al (1998), are, (a) does a community have secured ownership rights over the collectively managed resource? (b) Is there security of membership in a community to ensure that an individual will have continued use rights to the resource over time? (c) Is there an effective local institution to manage and regulate the use of the resource, to assure a community that if it abides by the rules, others will also abide? The answers to these questions are deeply rooted in the history of marine fishery co-management in Ghana.

Beginning 1850 when the Ali net was first introduced by some fishermen along the Coast of Gold Coast (Now Ghana) a good number of fishermen opposed its use based on reasonable arguments such as, long term fishery resource sustainability and unfair competition, among others (Walker, 1999). The chiefs in the fishing communities went ahead to draft byelaws prohibiting the use of these nets. This resulted in several conflicts between the two polarised interest groups. Paradoxically, all the British Colonial courts, including the Supreme Court, ruled in favour of the adoption of the destructive technology, disregarding and challenging the authority of the community leaders who drafted the byelaws. In one of the rulings on the conflict between the Colony v Local chiefs over the use of Ali nets, Walker (1999), started that the then Chief Justice, Griffith, remarked; *"…if (I) thought for a moment that the use of the Ali nets did tend to injure a fishing industry (I) would advise the defendants to apply to the government to legislate, but with the experience of practically the whole civilized world against that view, (I) did not hesitate to say that the Government should rather encourage than discourage the use of the Ali net."* Walker (1999), also noted that based on the influence of this ruling, the Colonial secretary of Agriculture in 1934 in a

memo to the Provincial Commissioner of Winnebah, a fishing village in the central region, stated that he could not agree with the chiefs who were then claiming that the introduction of the Ali nets was resulting in over-fishing and fish scarcity. The Secretary therefore ordered the withdrawal of all byelaws prohibiting the use of Ali nets claming "*the best fishing net is the net that catches the most fish*". Based on these developments, which rendered byelaws of fishing communities impotent, it was not surprising that technologies to harvest more fish enhanced rapidly and spread widely and quickly, degenerating into the use of explosives and poisons, along the entire cost of Ghana until 1984 when the mesh size law, among others was enacted. It is not difficult to infer from the above, that throughout the period Government discouraged sustainable co-management initiatives taking by local authorities in the fishing communities. This phenomenon, which portrays inadequate policies of colonial governments in sustainable fishery resources management about just a century ago might have strongly and negatively influenced the traditional knowledge and could, as a result, explain non-compliance to the mesh size regulation today.

By way of addressing these issues, there has been a strong bond of partnership developing between local fishing communities and the Fishery Department. Community Based Fisheries Management Programme (CBFM), which is under the auspices of the Fisheries Sub-sector Capacity Building Project started in 1995 as a joint venture between the Ghana government and IDA/World Bank was implemented. The CBFM was to strengthen the existing structures to improve the long-term sustainability of Ghanaian fisheries. To achieve this objective, committees were formed in each community charged with the responsibility of drafting byelaws governing fishing activities within the community and submit this to the District Assemblies for approval. This strategy, aims at instiling some trust and sense of responsibility in communities, and also creates some partnership between the higher local authority and the fishing communities. Thus fishing communities, will not feel alienated from fishing laws that hitherto were drafted and handed over to them by the Fishery Department. The Capacity Building Project also had the objectives of improving the capacity of the Department of Fisheries, address the issue of lack of an active management regime, weak institutional and legal frameworks for fisheries and a growing financial and resource crisis in the industry. The co-management strategy has achieved some remarkable results, especially regarding the use of poison and

dynamite in artisanal marine fishery. Despite these achievements artisanal marine fishermen still oppose the mesh size regulation, a puzzle that this research seeks to unravel.

4.0 Methodology

4.1 Sample selection

As stated earlier, the case study of this research is Komenda-Edina-Eguafo-Abrew District, a fishing intense District in the Central Region of Ghana. Table 3 gives summarised information on artisanal fishing within the Central Region.

The population of the study consists of all artisanal marine fishers in Komenda-Edina-Eguafo-Abrew District who operate with pursing nets, set nets and Ali nets, which are the most highly used, with mesh sizes less than 25mm in stretched diagonal. Thus purposive sampling technique will be used to select sample of 40% respondents from each net category (i.e. in each stratified sample). This will constitute 132 pursing nets, 164 set nets and 99 Ali nets. A questionnaire will be administered to the fishers. It will elicit information on the socio-economic characteristics of fishers, fishing experience, ownership of fishing vessel, reasons for the violation of mesh size regulation, fishing inputs, and fishers views about introduction of uniform quotas and uniform fishing trips[6].

[6] *A copy of the question nair is at the appendix1 of the paper.*

Table 3: Spatial distribution of Gear and Fishermen within the Central Region.

	DISTRICT						
	EFUTU-EWUTU-SENYA	GOMOA	MFANTSEMAN	ABURA-ASEBU-KWAMANKESE	CAPE COAST	KOMENDA-EDINA-EGUAFO-ABREW	**TOTAL**
PURSI-NG NET	215	121	279	61	19	330	**1025**
BEACH SEINE	21	14	65	3	56	15	**174**
LINE	57	101	10	0	0	44	**212**
LOBSTER NET	0	30	123	0	0	0	**153**
OTHER SET NETS	78	277	253	29	40	411	**1088**
ALI NET	47	24	50	185	70	248	**624**
DRIFTING NETS	0	25	60	0	0	0	**85**
NIFA NIFA	0	14	0	0	0	0	**14**
FISHERS	**6610**	**3900**	**11410**	**2940**	**2300**	**10153**	

Source: Canoe Frame survey 1995

4.2 Analytical Framework

Both Descriptive Statistics and Econometric Techniques will be used to analyze the data to be collected. In order to address the first objective, frequencies of the responses of the fishers within and across the various stratification- i.e. net category- will be presented and analyzed.

4.2.1 Sequential Logit Model

Addressing the second objective will require the estimation of a Sequential Logit Model since the three expected responses are not entirely discrete. This is because

those who break the rule because they are poor and/or conformant to rule breaking are not ignorant of the consequences of rule breaking on the fish stock. Following the presentation by Liao (1994), we define the binary choices as:

y1= 1 if the fisher is ignorant of rule breaking of fish stock in the long run.

y1= 2 if the fisher is not ignorant of rule breaking of fish stock in the long run

y2= 1 if the fisher is not ignorant but poor

y2= 2 if the fisher is not ignorant but a conformant to rule breaking

y2= 3 if the fisher is not ignorant but poor and conformant to rule breaking

These will generate the following probabilities of interest:

$$\mathbf{Pij = Pi \,.\, Pj/i} \quad \text{.....(1)}$$

Where **Pi** is the probability of outcomes of y1, **Pj/i** is the conditional probabilities for the outcomes of **y2** and **Pij** are the final probabilities. An important assumption here is that **y2= 1, 2, 3** are mutually exclusive.

To estimate **Pi**, first the total sample will be divided into two parts; fishers who are ignorant and those who are not ignorant of the consequences of the rule breaking on the fish stock. Secondly, the corresponding **Binary Logit Model** will be estimated using the **Maximum Likelihood Estimation Procedure**. Thus,

$$\mathbf{Pi = L(\sum \beta iXi) = e^{\sum \beta iXi} / (1 + e^{\sum \beta iXi})} \quad \text{.....(2)}$$

Where β is a vector of coefficient of all **Xi**, which are the socioeconomic characteristics of the respondent fishers such as income, age, sex, marital status, number of dependants, religion, tribe; and fishing experience and ownership of fishing vessel.

To estimate the conditional probability, **Pj/i**, the sub-sample of fishers who are not ignorant will be used. Thus,

$$\mathbf{Pj/i = \mathit{L}(\sum \alpha iXi) = e^{\sum \alpha iXi} / (1 + e^{\sum \alpha iXi})} \quad \text{.....(3)}$$

Where α is the vector of the same explanatory variables considered in equation 2. After estimating equations 2 and 3, the probabilities of interest (i.e. equation 1) will be estimated.

4.2.2 Frontier Production Function

In order to address the third objective it is necessary we proxy for the heterogeneity in fishing skills. Technical efficiency estimates will be considered as the proxy. To generate these estimates, stochastic frontier production function would be employed[7]. The specification of the function involves a production function, which has an error term of two components, one to account for random effects and another to account for technical inefficiency[8].

Assume the relation between fish catch and effort is given by the equation,

$$X_i = f(E_i, \beta)e^{vi}e^{ui} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where i denotes each fishing unit[9], β are the coefficients of composition of effort (i.e. **L and K), vi** is the usual white noise disturbance term, and **ui** is one sided error term (**ui ≤ 0**) that measures technical inefficiency. The **ui** is non-positive because for any level of effort actual catch cannot be greater than the potential catch. The function $f(E_i, \beta)e^{vi}$ is the potential output or the frontier. The following assumptions apply to the error terms:

- **E (uiuj)=0,** where **i≠j**
- **E (vivj)=0,** where **i≠j**
- **E (uivj)=0,** where **i≠j**
- **E(vi)=0,** and $E(vi)^2 = \sigma^2_v$
- **E(ui)≠0,** since **ui** is truncated normal**;** and $E(ui)^2 = \sigma^2_u$ **……(5)**

From equation 4, fishing unit i's inefficiency at a particular fishing season could be defined as:

$$e^{ui} = X_i / f(E_i, \beta)e^{vi} \ (\leq 1)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

Introducing natural logs, equation 6 could be restated as

$$Ui = \ln X_i - \ln f(E_i, \beta) - Vi \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(7)$$

For the purpose of this study we shall assume the functional form of the model is the translog production function because this functional form is relatively flexible since it does not impose the assumption of constant elasticities of production nor elasticities

[7] See Fan (1991)
[8] See Coelli (1994)

of substitution between inputs (Cemare 2000, Squires et al, 1998, Eggert 2000). The fish Stochastic Translog Production function, which satisfy the symmetric condition, could be stated as:

$$\mathit{Ln}\mathbf{Xi} = \beta_0 + \beta_1 \mathit{Ln}\mathbf{K} + \beta_2 \mathit{Ln}\mathbf{L} + \beta_3 \mathit{Ln}\mathbf{M} + \beta_4 \mathbf{LnT} + \beta_5 \mathbf{LnK}^2 + \beta_5 \mathbf{LnL}^2 + \beta_7 \mathbf{LnM}^2 + \beta_8 \mathbf{LnKLnL} + \beta_9 \mathbf{LnKLnM} + \beta_{10} \mathbf{LnL}\mathit{Ln}\mathbf{M} + (\mathbf{Vi} + \mathbf{Ui}) \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where β_0 through β_{10} measure elasticity of individual inputs and input combinations. **X** is the total output or catch in kilograms, **K** is registered gross weight of the fishing vessel, in tons; **L** is crew size; **A** is the age of the fishing vessel, **H** is engine horsepower; **V** is length of fishing gear and **M,** which is used here as a proxy for hours per trip[10]**,** is a composite variable representing fuel (premix) and ice block used at sea (Viswanatan et al,??). The Maximum Likelihood Estimates of the **β in e**quation 14 for each gear could be obtained using FRONTIER Version 4.1 Computer Program (Coelli, 1994)**.**

After the technical efficiency estimates are obtained, a **Binary Logit Model** will be estimated for each net, with **'yes'** and **'no'** responses to proposed uniform quota system and uniform fishing trips as the dependent variables and efficiency estimates as explanatory variables in separate models.

4.2.3 Multinomial Logit Model

A multinomial Logit Model will be used to tackle the fourth objective. The dependent variable will be the degree of commitment to rule enforcement, proxied by the choice of punishment to rule breakers; fine not exceeding 300,000.00 Cedis[11], forfeiting of the net used in fishing, bared from fishing (P.N.D.C. Law 256). The explanatory variable is income levels of fishers. The model can be stated as:

$$\mathbf{Pi} = e^{\Sigma \delta i \mathbf{Xi}} / (1 + e^{\Sigma \delta 1 \mathbf{Xi}} + e^{\Sigma \delta 2 \mathbf{Xi}} + e^{\Sigma \delta 3 \mathbf{Xi}}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where δ is the vector of intercept and coefficient of income, i = **1, 2, 3;** and the **1,2,3** represent the three choices of punishment of defaulters; i.e. fine not exceeding

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[9] The subscript t has been changed to i because we are considering cross-sectional catch. Due to different species usually present in a harvest, Xi would be computed as an index of the sum of all species, each weighted by its price.

[10] It has been argued by Cemare (2000), that the number of hours fished could be endogenuous. Therefore direct estimation of the Translog Production function may result in simulteneity bais.

[11] This is equivalent of $34.00 USA

300,000.00 Cedis, forfeiting of the net used in fishing, and bared from fishing, respectively.

5.0 Expected Findings

- Cannot be determined a priori for the first and second objectives
- For third objective, it is expected that more skilful fishermen will prefer uniform fishing trip whiles the less skilful fishermen will prefer uniform quotas, finally
- For the fourth objective, we expect that wealthier fishermen will propose harsher punishment, since theory indicates that they should be more concerned about management of the resource.

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Appendix I.

A *DRAFT* QUESTIONNAIRE

Please answer the questions below and tick where appropriate.

A. SOCIAL/DEMOGRAPHIC DATA

1. Age
a. Below 18
b. 18 – 24
c. 25 – 50
d. 51 and above

2. What is your marital status?

a. Single
b. Married
c. Separated
d. Divorced
e. Widowed

3. If married, how many wives do you have?

4. How many dependants do you have?

5. What is highest level of formal education that you have obtained?
a. No Formal Education
b. Primary
c. JSS/Middle
d. SSS/Secondary
e. Tertiary
f. Other (specify)

6. What is your religion?
a. Christianity
b. Muslim
c. Traditional Religion
d. Any other (Please Specify)……

7. What is your Tribe?
a. Ewe
b. Fante
c. Nzema
d. Ga
e. Ashanti
f. Any other (Please Specify)……

B. FISHING EXPERIENCE OF CAPTAIN

8. How long have you been fishing?
9. Have you ever received any formal training in fishing from any organisation?

a. Yes b. No

10. If Yes to question 9, Please provide the information below:

Provider	Nature	Duration	Frequency

C. FISHING INPUTS

11. Please provide information on the following.

Type Of Equipment	Size/Brand	Weight	Quantity	Year Of Purchase	Total Economic Life
Canoe					
Pursing nets					
Ali nets					
Set nets					
Outboard Motor					

12 Please provide information on the following.

Type Of Net	Mesh Size	Length
Pursing nets		
Ali nets		
Set nets		

13. What is the average number of crewmembers that you engage in each trip?

14. How many of the crewmembers are:

- Captains
- Senior members
- Junior members
- Any other (please specify)

15. What is the duration of each fishing trip?

16 Who owns the fishing vessel?

a. The captain
b. An entrepreneur who is not part of the crew
c. An entrepreneur (other than captain) who is part of the crew

d. Joint ownership by the Captain and an entrepreneur who is not part of the crew
e. A company (Specify size)…….
f. Any other (Please Specify)……..

D. FISH HARVEST

17. Please provide the required information in the Table below on MAXIMUM QUANTITY of fish harvested (per trip) within the last major season.

Type Of Fish	Max Quantity Of Harvest	Price Per Measure

18. Please provide the required information in the Table below on MINIMUM QUANTITY of fish harvested (per trip) within the last major season.

Type Of Fish	Min Quantity Of Harvest per Trip	Price Per Measure

19. Please provide the required information in the Table below on AVERAGE QUANTITY of fish harvested (per trip) within the last major season.

Type Of Fish	Max Quantity Of Harvest per Trip	Price Per Measure

E. MESH SIZE REGULATION

20. What is the department approved mesh size for your net?

21. Does your net have approved mesh size by the Department of Fishery?
Yes ……. No……..
22. Do you believe that if fishermen use nets of mesh sizes smaller than what is approved by the fishery department the artisanal marine fish resources will dissipate in the long run?
Yes…….. No…….
23. Please give reason(s) for your answer to question 22

24. If ‘No’ to question 21 and ‘Yes’ to question 22 why do you use the unapproved mesh size?

(a) Because other fishermen are using it
(b) Because I am poor
(c) Any other reason Please specify

F. UNIFORM QUOTA AND FISHING TRIPS

25. Research has revealed that the fish stock could be dissipated in the near future if harvesting is not regulated. Which of the following proposed strategies will you accept to regulate the rate of harvest.

(a) Uniform quota
(b) Uniform fishing trips
(c) none of the above
(d) Any other please specify…..

27. which of the following punishments do you recommend for the rule breakers

(a) fine not exceeding 300,000.00 Cedis,
(b) forfeiting of the net used in fishing,
(c) bared from fishing

28. How do you want mesh size regulations to be enforced?

(a) Through social norms (please specify)…….
(b) Intensification of surveillance (please specify body)…….
(c) Any other (specify)……..

G. OTHERS

28. What is the name of your company/ association?

THANKS FOR YOUR CO-OPERATION