COMPARATIVE ANALYSIS OF THE PERFORMANCE OF PURSE SEINE AND DRIFT GILL TECHNOLOGIES AMONG ARTISANAL MARINE FISHERS IN THE CENTRAL REGION OF GHANA

BY

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DECLARATION

I, Daniel Kwesi Sekyi Antwi, do hereby declare that except for the references cited, which have been duly acknowledged, this thesis titled **"Comparative Analysis of the Performance of Purse Seine and Drift Gill Technologies among Artisanal Marine Fishers in the Central Region of Ghana"** is the product of my own research work in the Department of Agricultural Economics and Agribusiness, University of Ghana Legon, from August 2016 to July, 2017. This thesis is not published or submitted either in part or in whole anywhere for the award of a degree in any other University.

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Date …………………………..........   Date …………………………

DEDICATION

This dissertation is dedicated to my inspirational and dearest mother, Madam Mary Esi Baawah and my gentle father Mr. Michael Antwi Twum all of blessed memory. I pray thy care as they sleep with the hope of resurrection and welcome them into thy heavenly abode. AMEN!!!!

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ABSTRACT

This study compares the performance of two predominantly employed marine fishing technologies (purse seine and drift gill net) along the coastal stretch of central region in Ghana. Against this backdrop, productivity and technical efficiency differentials of the purse seine and drift gill net technologies is assessed. Factors delimitating fishers from achieving the maximum attainable output levels were also modeled to quantify their effect on inefficiency. A simple random sampling technique was employed to select a total of one hundred and fifty respondents from five fishing communities (Komenda, Elmina, Moree, Apam and Winneba). With the help of structured questionnaire, a cross-sectional data was obtained through personal interviews, key informant interviews and observations. The study employed the stochastic meta-frontier model to estimate and compare the productivity and technical efficiency levels whilst the maximum likelihood estimation procedure was adopted for the determinants of technical efficiency among the fishers. The result of productivity analysis revealed that labour, premix fuel and cost of other inputs were highly productive and increased output of purse seine owners as well as the drift gill net owners. Furthermore, inputs such as labour, premix fuel and fishing duration were found to be key inputs in the artisanal fishing industry in the central region. Fishers employing drift gill net technology exhibited increasing returns to scale whilst their counterpart purse seiners and that of the pooled system exhibited decreasing returns to scale. Mean meta-frontier efficiency values of 0.63, 0.61 and 0.58 were recorded under the purse seine and drift gill technologies as well as the pooled system respectively. Estimated TGR scores (0.78, 0.74 and 0.76 for purse seine, drift gill technologies and that of the pooled system) indicate that purse seiners in the central region of Ghana are closer to the meta-frontier than drift gill net owners. Factors such as gender, marital status, business experience, other occupation and alternative finance sources were found to increase inefficiency while age, formal education and depth of fishing ground had negative effects on inefficiency hence increasing the efficiency of artisanal fishers in the central region. The study concludes that meta-frontier and translog models were the appropriate models and best fit the data set. Labour, premix fuel and fishing duration were very productive inputs except cost of other inputs which negatively influence productivity. Owners of drift gill net should increase their scale of production whereas purse seiners should strive hard to stay competitive by reducing the levels of some inputs. It is therefore established that purse seine technology is more technically efficient than the drift gill technology. Following the finding from the study, it is recommended that government, NGOs, and other development partners in the fisheries industry should develop strategic policy interventions (education and training, credit schemes, input subsidies, among others) to support artisanal fisheries industry to boost their efficient and increase productivity level.

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LIST OF ACRONYMS

AP	Average Product
APP	Average Physical Product
DEA	Data Envelopment Analysis
DWF	Distant Water Fleet
FAO	Food and Agriculture Organisation
FASDP	Fisheries and Aquaculture Sector Development Programme
GDP	Gross Domestic Product
LP	Linear Programming
LR	Loglikelihood Ratio
M-FA	Meta-Frontier Analysis
MFP	Multiple Factor Productivity
MFRD	Marine Fisheries Research Division
MLE	Maximum Likelihood Estimator
MI	Malmguist Index
ML	Maximum Likelihood
MoFA	Ministry of Food and Agriculture
MP	Marginal Product
MPP	Marginal Physical Product
MSLC	Middle School Leaving Certificate
MTR	Meta-Technology Ratio
NGOs	Non-Governmental Organisations
OLS	Ordinary Least Square
PFP	Partial Factor Productivity
RTS	Return to Scale
SFA	Stochastic Frontier Analysis
SFAMB	Stochastic Frontier Analysis Method by Bruemmer
SPSS	Special Package for Social Sciences
TFP	Total Factor Productivity
TGR	Technology Gap Ratio
UN	United Nation

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CHAPTER ONE

INTRODUCTION

1.1 Background

Globally, the marine sector contributes huge amount of revenue to nations and facilitates the economic development in many ways. Statistically, almost 16% of the people in the world takes their animal protein from fish and fish products and fish contributes 6.5% of total protein consumed (Kawarazuka, 2010; FAO, 2012). About 128 million tonnes served directly to individuals as food (FAO, 2014). Bravo *et al*. (2013) also accounted that fish and its related products constitute the protein and trace nutrients for balanced nutrition and healthy life. Currently, the most traded food and feed commodity in the world is the fishery products and in the last decades both marine shipping and the marine capture industry have seen a great expansion; fleet sizes, trading volumes and fishing (Bravo et al., 2013). For the specified time frame, developing countries have seen increasing rate of employments in the fisheries industry than in the traditional agriculture (FAO, 2012). Fishing activity has become more industrialized and the industrial fishing fleet lands over 80% of the total sea catch volume (FAO, 2012). World Bank (2010) revealed that about 116 millions of individuals living in developing countries directly benefit from fisheries. According to Bene et al. (2009) and Bene and Friend (2011) thousands of people living in rural areas trace their basic livelihood from the fisheries sector.

Fisheries industry of the sub-Saharan countries cannot be sidelined in terms of its contribution to global market of fish and fish products. West Africa was one of the first areas to be exploited by the newly industrialized European and Asian tuna fishing fleets in the early seventies (FAO, 2012). Most economies of West African countries depend on the fisheries industry, which serve as source of employment, raw materials for fishery related industries and food as a major source of animal protein. The sector also serves as an avenue for debt repayment and revenue creation in the form of fish exportation, fish licensing agreements and partnerships between countries in the sub-region and overseas fishing companies (Bartels *et al*., 2007).

Nunoo *et al*. (2014) reveal that inland fresh water, coastal lagoons as well as the marine constitute the resources of the Ghanaian fisheries subsector. According to Belhabib *et al*. (2015), Ghanaian fisheries subsector consists of different kinds of fishing activities ranging from industrial to semi-industrial and to subsistence (artisanal fisheries). Nunoo *et al*. (2015) accounted that Ghana's fishery sector significantly contributes to sustained food security, livelihoods and poverty reduction. Empirical findings (FAO, 2007; Republic of Ghana Plan, 2014) attest that about 2.4 million individuals representing 10% of Ghanaian population are employed in the fisheries industry. Annual total fish production stands at 400 000 metric tonnes from aquaculture, Lake Volta, other inland fisheries, lagoon fishery and marine fishery (FAO, 2014).

The marine fisheries subsector in Ghana is the primary source of income for more than 200 coastal villages, including approximately 200,000 fishers and their dependents of about 2 million people (Nunoo *et al*., 2014). According to USAID (2012), the marine industry is the main economic activity along the coast and attracts more than half of Ghana's industries along the coastal zone. Belhabib *et al*. (2015) attest that the artisanal component of the fisheries industry is the most important and further explain that in terms of fish outputs the unit alone contributes about 75% to 80% of the total marine fish landed. More on the artisanal unit, Akyempong *et al*. (2013) also added that 3% of total national GDP comes from the artisanal fishery unit and generates revenue of $341 million annually. Some common species from the marine fisheries includes herring, cape hake, mackerel, grunt, barracuda, sea bream, tilapia, and tuna (Aseidu and Nunoo, 2013). Sarpong et al. (2005) noted that fish and fish products consumption constitute 60% of animal protein intake and accounts for 22.4% of Ghanaian household food expenditures. FAO (2014) also recounted in fishery and aquaculture country profile that the per capita consumption of fish in Ghana per annum (24.2kg) is higher than Africa (10 kg) and the world (19 kg) at large.

According to Koranteng (1998), traditional fishing craft and arts have been developed over the years to adapt to local water body conditions; the species of fish desired and targeted size. MoFAD (2013) discovered gill nets or entangling nets, cast nets, drift nets, seine nets and hook and lines as the fishing technologies (gears) employed by marine fishers in Ghana. These gears are operated with trawlers, foreign-built steel vessels and dugout canoes propelled manually or by outboard motors for both industrial and artisanal fishing. The artisanal fisheries subsector has been identified with the drift gill and purse seine net as the main technologies for fishing (FAO, 2014). The adoption and use of the drift gill and purse seine fishing technologies is a strategic approach to reduce their level of vulnerability as a result of the introduction of the laws of the sea (Mutimukuru-Maravanyika *et al.*, 2013) Though the marine fishing operations are characterised by two main fishing seasons but these technologies can be operated throughout the year (Industrial Fishing, 2013). Purse seine technology is an active and non-selective in terms of species and size of fish catch whereas the drift gill net is passive and selective in terms of fish size (MoFAD, 2013). Some common fish species landed by the artisanal fishers in Ghana include small pelagics like mackerel, chub mackerel, horse mackerel, anchovies and sardines. The most commercially important among the landed pelagics are the sardinellas, namely Madeiran sardinella (S. maderensis) and round sardinella (Sardinella aurita). Cassava fish, large head hair tail, flat sardinella, red pandora, moonfish, skipjack tuna, red snapper, groupers and yellow fin tuna are other species commonly caught in Ghana. Some valuable demersals exploited during upwelling seasons include; burros (Pomadasidae), sole, cuttlefish, shrimp, red fishes and burrito (Sparidae) (FAO, 2016).

Out of the three hundred and four (304) landing centers located in one hundred and eighty nine (189) fishing villages along the coastal stretch of Ghana, more than half are located in the central region. Central region has the widest and longest continental shelf and coastline respectively and spans about 150km across eight coastal districts (Aseidu and Nunoo, 2013). Elmina, Winneba, Senya-Beraku and Gomoa Fetteh have been counted by FAO (2016) as landing sites in central region having modern fishing harbours.

1.2 Problem Statement

Empirical studies (FAO, 2012: Bartels *et al*., 2007: Nunoo *et al*., 2014) have shown that the fisheries industry has been the livelihood of many individuals and is the backbone of the Ghanaian economy at large. However, World Bank (2011) indicates that output per fisher and size of fish caught are declining even though several infrastructural developments in a form of modern fishing harbours and storage facilities have been constructed by government and development partners. As a matter of greater concern, FAO (2014) indicates that fish production (tonnes in live weight) has fallen from 367,100mt in 2010 to 293,000mt in 2014. Ironically, annual consumption shows increasing trend of 238 500, 392 500, 585 700 and 586,900 for the years; 1980, 19990, 2000 and 2010 respectively (FAO, 2014).

Government and stakeholders in the fisheries subsector are in a dilemma for the choice of efficient fishing methods to direct policy interventions and resources. However, the lack or little productivity and efficiency research work on marine fishing inputs and technologies has led to a widened scope of government investment in the fisheries industry leading to failures in many policies.

Several economic and production frontier analyses (Onumah *et al*., 2010b; Asamoah *et al*., 2012) conducted in Ghana only address the performance of fishers in aquaculture production. Despite the significant contribution of the artisanal marine industry to the Ghanaian economy, little or no comprehensive comparative study has been conducted on the performance of fishing technologies in the marine fisheries subsector.

Fishing, like all other production activities, incorporates two or more inputs to produce an output. The choice of efficient technology, the allocation and levels of input that will yield an optimum output has been of great concern to both government and development partners as well as the fisher folks. Little or no literature has revealed findings on the most efficient artisanal marine technology, productivity of fishing inputs, and whether output variation are due to inefficiencies or random errors.

1.3 Research Question

The main issue arousing the interest for the conduct of this study is; what is the performance of artisanal marine fishers (Owners of canoe and fishing nets) employing the purse seine and drift gill fishing technologies? To unravel this major concern, the study seeks to address the following questions:

1. What are the output elasticities of fishers employing purse seine and drift gill technologies with respect to input use?
2. What are the technical efficiency levels of the two groups of fishers?

3. What are the technology gap ratios of the two groups of fishers?
4. What factors account for the technical inefficiency of the two groups of fishers?

1.4 Research Objectives

This study is set to compare the performance of fishers (owners of canoe and fishing nets) employing Purse seine and Drift gill technologies for fishing in Central Region of Ghana. To achieve this objective, specific objectives set to guide the study are:

1. To estimate and compare the output elasticities of input use of the purse seine and drift gill technologies
2. To estimate and compare the technical efficiency levels of the purse seine and drift gill technologies.
3. To estimate and compare the technology gap ratios of the purse seine and drift gill technologies.
4. To identify and estimate the determinants of inefficiency of the purse seine and drift gill technologies.

1.5 Justification

Studies on aspects of pond culture profitability and production function analysis have been conducted in Ghana. However, little or no studies on efficiency and productivity of the marine fishery subsector exist in literature. This study seeks to take a different approach to analyse the cause and suggest diagnostic solutions to the falling output of the artisanal fisheries subsector in Ghana. The study will estimate and compare the efficiency levels, technology gap and fisher's specific dynamics that implicitly influence their productivity.

Fishing as a production unit like all other producing enterprises uses several inputs to produce output. Estimating the contribution of inputs to output for the purse seine and drift gill technologies will inform fishers and investors on effective input allocation and substitution that will enhance optimum output.

In addition to the above, the estimation and comparison of productivity and efficiency levels of artisanal fishers using different technologies will direct policy attention on the viable technology for investment by government and other investment partners.

The study will also investigate and estimate production and fisher specific factors that might positively or negatively impact the productivity of the fishers under the different technologies. This will help address the issues of technology gap resulting from the technical inefficiencies.

Contributing to the development of Ghana's artisanal fisheries subsector, the outcome of this study will be a relevant document for further research, a guide to sustain the artisanal fisheries sub-sector and improve livelihood to enhance better living standard of fisher folks and their dependents in Ghana.

1.6 Organisation of the Study

The thesis consists of five chapters. Chapter one comprises the background, problem statement, research questions, research objectives, justification and organisation of the study. Related literatures that have bearing on the work are reviewed in the second chapter. Chapter three presents the conceptual framework, theoretical foundations, sources and types of data, sample and sampling techniques, data collecting instruments and methods of data analysis. In chapter four, results from the study are duly discussed and finally the fifth chapter then summarises, concludes and gives policy recommendations based on the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section of the study presents the review of relevant literature on artisanal marine fishing activities in Ghana, the theoretical underpin of the techniques for the measurement of productivity, efficiency and meta-frontier. It also discusses the empirical works on meta-frontier efficiency.

2.2 Overview of Ghanaian Marine Fishing

Located in the western Gulf of Guinea and encompassing the area between Cöte d'Ivoire and the Republic of Benin in West Africa, Ghana, has a coastline of about 550km and a very narrow and shallow continental shelf (ATLAFCO, 2012). Some years ago, it was widely believed that the resources of the sea were infinite and that fishing could go on indefinitely. This notion is still present in some fishing communities in Ghana and it is reflected in an old adage of fisher folks that "sea never dry"; which literally means there will always be fish in the sea. When a fishing season is bad, i. e. when catches are poor because the fish are not available, this is immediately attributed to the anger of the gods who are then quickly appeased with all forms of sacrifices. In view of this, artisanal fishers along the coastal stretch of Ghana see fishery resources as common to all and owned by no one and that as long as one can acquire fishing gear nothing should stop them from going fishing. With regard to the open access nature of the artisanal fishing activities in Ghana, only chief fishermen see to the observance of traditional fishing practices, settling of disputes and perform other community-related duties (Koranteng, 1998).

The current dispensation of the Ghanaian marine subsector of the fisheries industry is recorded by Atta-Mills *et al*. (2004). They counted the industrial, semi-industrial and the artisanal (canoe fishers) units as the main fishing units in the marine subsector. The industrial unit also referred to as distant water fleet (DWF) consist mainly of the foreign tuna fleets and trawlers which were initially fishing outside Ghanaian waters. Due to the introduction of the EEZ idea in 1970s, financial constrains as well as political instability in countries like Mauritania and Angola, the DWF vessels were forced to operate in Ghanaian waters. The activities of these vessels resulted in a sharp resource decline due to the narrow nature of the Ghanaian continental shelf. Nunoo *et al*. (2014) also accounted for the increased number of fishers and the mounting pressure on aquatic environment to satisfy the higher demand for sea foods. Fallaye (2008) also takes the stand that in most developing world, especially in Ghana and West Africa as a whole, local demand for fish has outstripped supply and has led to illegal fishing, poaching and poor management. The increasing degradation of the aquatic environment has threaten the sustainability of fisheries sector, food security, biodiversity and the livelihood of the many fishing dependents in Ghana (Mensah, 2012).

2.3 Fishing Crafts and Technologies of the Artisanal Marine Fisheries Subsector

The coastline of Ghana stretches about 550kilometres from Aflao (Eastern end) to Half Assini (West) and about 24,300 kilometres square area of continental shelf (ATLAFCO, 2012)

Different forms of fishing gears such as beach seine nets, purse seine nets, hook and line and drifting gill nets are identified to be used by artisanal fisher along the shores of Ghana (Bannerman *et al*., 2001). According to Akyempong *et al*. (2013), the fishing gears are operated with dug-out canoes made from wawa tree (Triplochiton scleroxylon). Amador *et al*. (2006) accounted that most of these canoes are propelled by outboard motors with engine power of up to

40 horse power capacity. Averagely, canoes may have crew up to 20 fishers. Most targeted fish species by the artisanal fleet is the sardinella, although the flat sardinella, S. maderensis, is also caught (Bard and Koranteng, 1995). Though the artisanal marine fishery is informal but strong institutional framework governs their activity at the village level (Bennett, 2000). Notable fishing villages and fish-landing sites in Ghana are; Ada Foah and Prampram, (50 km east of Accra), Chokor (Accra Metropolis) and Akwidaa (Ahanta West District of Western Region). Tema Canoe Beach, Winneba, Ningo, Ahwean, Sekondi, New Amanful, Funkoe, Akplabanya, Jamestown and Elmina are the landing sites with sophisticated modern harbours (Sarpong *et al*., 2005).

2.4 Purse Seine

As categorized under an active fishing gear, seine nets are usually used to surround school of fish and are usually set from a fishing craft. Some seine nets are designed to trap fish deep beneath the sea bottom by sweeping an area of the seabed. The most popular seine net operated by Ghanaian artisanal fishers is the purse seine and beach seine which the latter is operated from the shore. The purse seine has a purse line bordering the bottom of the net that makes the net to close like a purse to prevent the fish from escaping when surrounded. The length and height of the purse seine net varies about 35m–50m deep and 400m–500m long. About 8-24 fishermen operate the purse seine. Fishing ground for purse seining varies from 40m to 130m (*Amador et al*., 2006) and mostly operate with dugout canoe propelled by outboard motors of varying capacities. Fishers using purse seine technology are able to fish all year round but heightened during the main season (October-December). Purse seine is made of net with equal mesh and yarn size, it is non-selective in terms of species and size and harvest or catches any fish that comes within the surrounding zone. Small pelagic species of different kind like: European anchovy (Engraulis encrasicolus spp.), Sardinella spp., chub mackerel (Scomber japonicus), etc are the most targeted fish by the purse seiners. According to Akyempong *et al*. (2013), purse seine activity is associated with areas such as Winneba, Senya Beraku, Elmina, Kormantse, and Komenda (Central Region) and Teshie and Nungaa (suburb of Accra)

2.5 Drift Gill Net

Contrary to the seine nets, drift gill net is a passive fishing gear which falls under gillnets and entangling nets (Lagler, 1978). The gill nets captures by entangling, enmeshing or gilling fish in the netting. It composes of different (mesh and yarn size) layers of nets from top to the bottom and entangles or gills fish of different sizes that encounters it. The drift gill nets are drifted freely on the surface of the sea by the sea current and are operated on or below certain distance from the seabed. The netting is often anchored to the craft and allowed to stand on the sea. The net varies between 30m–50m in depth and 450m–650m in length. A typical drift gill net has about 4.5mm and R75-100 mesh size and yarn size respectively (Alverson, 1963). The depth of fishing ground for drift gill net ranges between 25m-80m and the duration for a complete fishing trip is 12 to 18 hours within which net may be set and hauled several times before returning to the beach. It is operated by 10–20 fishermen with an outboard motor of varying capacities (Lucakovic and Uphoff, 2002). Drift gill net is often employed from October until March among the fishermen of Senya Beraku, Nakwa, Otnam, Apam, Elmina and Komenda (Central Region) and Kpone and Mungo (Greater Accra Region). Most landed catch by drift gill net operators include; flat needlefish (Ablennes hians), African halfbeak (Hyporhamphus spp.), Atlantic flying fish (Cypselurus melanurus) as well as scomber and sardinella. Fish harvested with the drift gill net is referred to as scaled fish because of uniformity in size of fish during marketing (MoFAD, 2013).

2.6 Performance Measure

Performance of a production unit is measured by its productivity. Productivity refers to the ratio of output to input used in production. Productivity can be estimated as Average Physical Product (APP) which refers as the output produced per unit of input used holding all other inputs fixed. Average Physical Product is likewise termed as Partial Factor Productivity (PFP) which ideally explains the contribution of the individual inputs to total output produced. (That is, output per labour, output per land, output per capital etc.). It is the traditional means of estimating productivity as the calculation is not challenging to perform. Partial Factor Productivity (PFP) is devoid of aggregation complications which is its major advantage compared to Total Factor Productivity estimation. Partial Factor Productivity (PFP) is generally specified as:

$$PFP = \frac{Y}{Q_i} \qquad 2.1$$

Where: Y = Total output produced and Q_i = Level of input (i) used in the production process (land, labour, capital etc.).

Also, productivity can be estimated as Marginal Physical Product (MPP) which refers to change in output due to a unit change in input. Mathematically, the first derivative of the production function is expressed as:

$$MPP_l = \frac{\partial Y}{\partial L} = f_l > 0 \qquad 2.2$$

Where: ∂Y = Change in total output and ∂L = Change in labour

However, when all other inputs of production are held constant, indefinitely, use of more labour will result into diminishing marginal productivity. That is, the rapid increase in use of additional labour will lead to lower productivity (Kibaara, 2005). This renders the second derivative to be less than zero:

$$\frac{\partial MPP_l}{\partial L_i} = \frac{\partial^2 Y}{\partial^2 L} = f_l < 0 \qquad 2.3$$

The productivity of combined inputs relative to total output produced is measured by the Multiple Factor Productivity (MFP). The major challenge to the use of this measure of productivity is that all inputs must be expressed in the same unit of measurement. The MFP is generally specified as:

$$MFP = \frac{Y}{\sum_{i=1}^{n} X_i} \qquad 2.4$$

Where:

Y = Output produced and $\sum_{i=1}^{n} X_i$ = summation inputs used.

Total Factor Productivity is another approach in estimating productivity. It is the total output produce divided by the summation of individual inputs used by a firm in a production process. The main merit of estimating productivity with TFP is that the interactive process between individual inputs and output is not shown. As a result, it provides a vast basis for improving specific input used in the production process. Econometrically, the TFP is generally specified as:

$$TFP = \frac{\sum_{i=1}^{n} Y_{it}}{\sum_{j=1}^{n} X_{it}} \qquad 2.5$$

Where x_{it} denotes the quantity of inputs used in a particular time.

Returns to Scale (RTS) refer to the responsiveness of output upon average costs. The inputs are combined along the long run expansion path in any ratio that minimizes the cost at each level of output. Returns to scale is either economies or diseconomies, referring to the effect of increased output against average cost when there is equal proportionate increase in all inputs in the long-run. Returns to scale can also be defined directly in relation to output. That is, output change resulting from a proportionate change in all inputs. RTS is said to diseconomies when the proportionate output change is less than the proportionate change in all inputs. On the other hand, if the change in output is greater or equal to the proportionate change in inputs increasing or constant economies of scale exist. Elasticity of Production ($\mathcal{E}_{yi}$) is therefore the percentage change in the quantity of output produced due to a percentage change in the quantity of an input employed while holding all other inputs fixed. Econometrically, it is specified as:

$$\mathcal{E}_{yi} = \frac{\%\Delta \mathrm{Y_i}}{\%\Delta X_{\mathrm{i}}} \qquad 2.6$$

$$\frac{\partial \mathrm{Y_i}}{\partial X_{\mathrm{i}}} * \frac{\mathrm{Y_i}}{X_{\mathrm{i}}} = \mathrm{MP} * \frac{1}{AP} \qquad 2.7$$

This implies that elasticity of production can be expressed as the ratio of MP to AP Kibaara (2005). Although these measure of performance have been used by many scientists, they fail to account for the ability of the decision maker to properly combine input factors for maximum output, thus efficiency studies are paramount.

2.7 Fundamentals of Efficiency Measurement

Most researchers synonymously use productivity and efficiency to represent the same thought. Productivity according to Schreyer (2001) is the output per unit input used in a production system while Efficiency further determines the gap between the quantity of observed output and the best possible frontier for a firm in its cluster. Efficiency can be considered either from an input-orientation or the output-orientation. The input-orientation, determines the optimum combination of input used to achieve a given level output as against the output-orientation which looks at the optimum output to be produced given a set of input.

Efficiency Measure of performance are more accurate than productivity because efficiency involves comparison with the most efficient frontiers. This comparison can be; (a) observed output per the potential output produced from a given input, (b) the ratio of maximum potential output to observed input required for the production of a given output. In both cases the optimum is defined in relation to production possibilities and efficiency is termed as technical. Based on the analogical interpretation of efficiency above, technical efficiency can be defined as the combination of inputs in a way that no further output can be attained from such combination without reducing another product's output (Koopmans, 1951).

From a real situation of production observation, Farrell (1957) derived an innovative approach to efficiency frontier estimation to calculate a firm's efficiency empirically. Following Koopmans (1951) work, technical efficiency was considered as a relative measure (Farrell, 1957). The parametric (Farrell, 1957; Berger and Mester, 1997), the non-parametric by Seiford and Thrall (1990) and the semi parametric by Simar and Wilson (2007) methods of estimating efficiency evolved following the proposal of Farrell's relative measure of efficiency. Several approaches to empirical estimation of efficiency have been identified and linked to (Aigner *et al*., 1977: Meeusen and van den Broeck., 1977). In view of these findings, econometric procedure of measuring efficiency has now gained general recognition in scientific research. The mathematical programming approach developed by Charnes *et al*. (1978) has gained popularity in efficiency measurement. These approaches are adopted in varying fields of studies like aquaculture (Onumah and Acquah, 2011; Inoni, 2007) and agriculture, industry, commerce, fisheries (Holloway and Tomberlin, 2005; Badunenko *et al*., 2008; Bhasin and Akpalu, 2002).

2.8 Types of Efficiency Measurements

Efficiency measures are expressed in terms of technical and allocative efficiency. The interactions of the two efficiency measures give economic efficiency (Farrell, 1957).

2.8.1 Technical Efficiency

In describing technical efficient firm or production, Kumbhakar and Lovell (2000) proposed that it must produce greater outputs than its counterparts using the same set of inputs. Greene (1993) also added that comparing a firm's output to some potential output level is another way of determining the firm's efficiency levels. These concepts of efficiency have led to the conclusion that efficiency is a relative measure using the best frontier output as the yardstick (Pascoe and Mardle, 2003).

In a related work, Greene (2005) suggested that introduction of the stochastic model as an improved econometric modeling tool for technical efficiency analysis in agriculture has caused a paradigm shift from the use of deterministic approach in estimating technical efficiency. It is considered that stochastic model is more appropriate in modeling technical efficiency because agriculture is seen to be stochastic in nature in developing countries. Bhasin and Akpalu (2002) suggested that prevailing institutional factors, human capital as well as socioeconomic characteristics of farmers are factors that could affect farm specific technical efficiencies.

Farrell (1957) categorised economic efficiency into technical and allocative efficiencies and this has led to critical technical efficiency analysis of production units (Ozkan *et al.*, 2009). Following this, Meeusen and van den Broeck (1977) and Aigner *et al.* (1977) came out with papers about technical efficiency; the two papers used parametric approach developed from econometric perspective to estimate a firm's technical efficiency. Both papers adopted the output-output method instead of the traditional input-output method. In most literature, output-output measure is employed (Kumbhakar and Lovell, 2000).

Greene (1993) concluded that there exist some level of heterogeneity in technical efficiency results even when drawn from similar sample and proposed causal factors like variations in technology, nature of data available, the variables involved, reliability and comprehensiveness of the proxies used, biophysical variables as well as the conceptualization of the models. He also hinted on the monumental benefit of technical efficiency studies to policy makers in decision making and policy formulation.

2.8.2 The Allocative Efficiency

Allocative efficiency is also termed as price efficiency. This aspect of efficiency measure has to do with the best combination of firm's factors of production against the prevailing market prices. Bhasin and Akpalu (2002) described allocative efficiency as firm's ability to produce or individual ability to combine input factors in "optimal proportions", subject to constrained factor prices.

In developing countries, issues of allocative efficiency study are crucial to farmer's total economic performance. Several empirical findings have shown that farmers are unable to make good use of their available resources thereby obtaining lower yields. They are therefore considered to be allocatively inefficient (Adinya and Ikpi, 2008). In most literatures, technical efficiency has been considered in estimating economic efficiency but both allocative and technical efficiencies are needed. Badunenko *et al*. (2008) suggested that prices of production factors as a key input to estimating allocative efficiency is hardly to be obtained. Badunenko *et al.* (2008) devised an alternative approach to allocative efficiency measure whereby a profitoriented distance is related to frontier in a profit-technical efficiency space, without considering prices of input. Comparing this new approach to the traditional approach they concluded that no significant difference exist between them. Technical efficiency is considered supreme in total efficiency estimation and when prices of input are available, allocative efficiency is then assessed. In view of this method, determination of technical efficiency has been a prerequisite for the allocative efficiency estimation.

A reverse method of estimating allocative efficiency before technical efficiency was proposed by Bogetoft *et al*. (2006). By this approach, they considered technical efficiency to be “doing things right” whereas allocative efficiency is “doing the right thing”. Their method of estimating allocative efficiency is not based on technical efficiency

Different methods of estimating allocative efficiency have been proposed by researchers in recent times. A recent method of finding both lower and upper bounds of economic efficiency by Kuosmanen and Post (2001) does not consider complete information about input prices. This new method fits well in developing country like Ghana where price of inputs are not well recorded, inconsistent and unreliable.

2.8.3 Economic Efficiency

Schreyer (2001) differentiated productivity and efficiency in a way that productivity measures output against the employed inputs whereas efficiency equates observed output against the best potential values of inputs and outputs of a unit or firm. Economic efficiency refers to a firm’s ability to produce a predefined output subject to the lowest cost of production (Farrell, 1957). The determination of the potential benchmark (theoretical optimum) to compare the output of producing firms has been the bone of contention amongst economists (Kumbhakar and Lovell,

2003) and production units find it difficult to determine in real life settings the optimal or potential output to be obtained.

Kumbhakar and Lovell (2000) proposed that productivity of similar firms or units could be different from each other on the count of three main factors (technology available to the firm, efficiency of production process and the conditions of production environment). Base on the estimation of efficiency scores a firm could be considered as successful. Also a firm's financial and cost-revenue analysis may be used as an alternative indicator of success (Hansson, 2007). Following Coelli (1995) it was admitted that comprehensive evaluation of production units by considering all inputs and outputs is the appropriate way of estimating efficiency. This study focuses on the measurement of technical efficiency to compare the efficiency of two artisanal fishing technologies.

2.9 Construction of Efficiency Frontiers

The introduction of a seminal paper by Farrell (1957) brought to bear the parametric approach (Aigner *et al*., 1977; Meeusen and Van den Broeck., 1977) and the non-parametric approach (Charnes *et al*., 1978)

2.9.1 Non-Parametric Approach

Under this analytical procedure, there is no structural imposition on the distribution of the population when estimating the production efficiency. Here any deviation from the optimal output level is considered or assumed to be caused by inefficiency rather than error. However, there is no need in defining the frontier line and the stochastic error term when using this approach for efficiency analysis. There is also no assumption about the functional form of the density of efficiency values (Inoni and Chukwuji, 2000).

The commonly used non-parametric approach in efficiency investigation is the Data Envelopment Approach (DEA). The DEA requires no specification of functional form relating inputs and output. The first DEA model was developed by Charnes *et al*. (1978) who extended the relative efficiency concept of Farrell (1957), to include several inputs and outputs simultaneously. For this approach linear programming (LP) method is used to construct a non-parametric piece-wise frontier over sample data and then the efficiency relative to the surface is computed (Coelli *et al*., 2005). Coelli *et al*. (2005) indicated that the DEA as a deterministic technique can be applied deprived of knowing the algebraic form of the relationship between outputs and inputs. Fraser and Cordina (1999) and Krasachat (2003) suggested that the functional form restrictions that can influence the analysis and distort efficiency measures can be avoided. However, both the noise effects and inefficiency effects are interpreted as inefficiency under the non-parametric approach (Charnes *et al*., 1978). Furthermore, DEA serves as a diagnostic tool and cannot be used to prescribe any strategies to make inefficient units efficient. This weakness of the DEA aroused the interest for the development and introduction of the parametric technique.

2.9.2 Parametric Approach

The parametric frontier approach has a pre-defined functional form of the efficiency frontier. For estimations involving cross-sectional data it can be specified as:

$$Y_i = f(x_i; \beta) * TE_i \qquad 2.8$$

Where:

Y_i = scalar output of the i^{th} firm

X_i = n vector of inputs

B = parameters to be estimated

$f(x_i; \beta)$ = frontier production function

TE_i = output-oriented technical efficiency of i^{th} firm

The two main subdivision of the parametric frontier approach are the deterministic technique and the stochastic technique (Aigner *et al*., 1977; Aigner and Chu, 1968) which respectively follows the specification of the error component. Aigner and Chu (1968) proposed that the deterministic technique is estimated via either mathematical programming or econometric technique while the stochastic technique is estimated only by econometric technique.

2.9.3 Deterministic Frontier

Aigner and Chu (1968) proposed the deterministic frontier production function and specified as:

$$Y_i = f(X_i : \beta) * \exp(-u_i), \quad u_i \geq 0 \qquad 2.9$$

Where:

u_i = technical inefficiency effect of the i^{th} firm and $u_i \geq 0$ ensures the condition that $Y_i \leq f(x_i; \beta)$.

Following the above specification, the technical efficiency (TE) of the deterministic frontier model is specified as:

$$Y_i = \frac{f(X_i : \beta) * \exp(-u_i)}{f(X_i : \beta)} = \exp(-u_i) \qquad 2.10$$

The major advantage of the deterministic production frontier is its ease of usage. However, it has been criticized by Russell and Young (1983) that is attributes all deviation from the efficient frontier to the inefficiencies of firm's decision maker.

In a production system, both random (beyond firm decision maker's control) and inefficiency (under control of firm's decision maker) factors are considered to influence the performance every production unit. Random factors include; unfavourable weather conditions (including rainfall, temperature, humidity etc.), failure of markets and measurement errors, whereas socioeconomic characteristics, management practices and institutional factors are regarded as inefficiency factors. These assumptions were then incorporated to device a stochastic production frontier by Aigner *et al*. (1977) and Meeusen and Van den Broeck (1977).

2.9.4 Stochastic Frontier Model

This model has consistently been employed in several efficiency estimations across different fields since the introduction. The Stochastic Frontier Approach (SFA) decomposes the error term of specified production function into two: one that accounts for random shocks and the one that accounts for inefficiency effects. Thus, the SFA makes a clear distinction between deviations resulting from inefficiency and those resulting from the stochastic noise associated with production functions. The stochastic production function is expressed as:

$$Y_i = f(X_i : \beta) * \exp(v_i - u_i), \quad u_i \geq 0 \qquad 2.11$$

Where v_i is a symmetric stochastic error term representing effects of statistical noise (such as measurement errors, omitted variables from the production function and other unobserved factors or those outside a farmer's control e.g., diseases and weather factors). The SFA has been used in efficiency studies by a number of researchers including; Lio and Hu (2009), Ogundari and Ojo (2007), Onumah *et al*. (2010b), Nyagaka *et al*. (2010) and Onumah *et al*. (2013). The Technical Efficiency (TE) of the i^{th} firm is expressed as observed output over maximum potential output subject to available inputs while any deviation is assumed to be stochastic (Boshrabadi *et al*., 2008).

$$TE_i = \frac{f(X_i : \beta) * \exp(v_i - u_i)}{f(X_i : \beta) * \exp(v_i)} = u_i \qquad 2.12$$

The difference between model (2.11) and (2.13) is that in model (2.13), the effect of the random errors has been incorporated in the estimation of the technical efficiency levels whilst in model (2.11), the effect of the random errors has been discounted. This biases the technical efficiency estimates resulting from model (2.11). Volumes of empirical literature on the SFA involves the use of either cross-sectional or panel data. Some of the stochastic frontier applications with cross-sectional data in agriculture include Dawson and Lingard (1989) and Liu and Myers (2009), Battese and Coelli (1992).

2.10 Estimation of Efficiency under Different Technologies

The main assumption of the Stochastic Frontier Analysis (SFA) is that firms operate under a single technology or face the same geographical conditions. This makes Stochastic Frontier Analysis (SFA) fall short in situations where firms operate under different technologies or geographical locations. It is also challenged in comparing cross-regional, cross-country or multiple technology efficiencies. Overcoming the setbacks in applying the SFA, Malmquist Index (MI) and the Meta-Frontier Analysis (MFA) models were introduced to deal with the differences in the regional, country and the technological efficiencies.

2.10.1 Malmquist Index (MI)

Malmquist Index (MI) differentiates between two sources of productivity changes: (1) Changes in technical efficiency and (2) technical change. Under this approach, no assumption of an efficiency production frontier is required. However, it is able to reveal the "best-practice" country, region and/or technology in every period (in case of panel data) which indicates an efficient production. The efficiency of each country, region or technology is measured relative to the frontier. In using this approach, it is easy to identify which country or region is closer and advancing the technological frontier. In a research work to measure inter-country agricultural efficiency and productivity by Trueblood and Coggins (2001) they employed this approach and found that developed countries have positive productivity growth which has resulted in widening productivity gap with developing countries. Malmquist Index (MI) is not parametric in nature and has been a disadvantage to its application for efficiency estimations. It is a deterministic approach to measuring technical efficiency which works best with panel data. In view of these shortfalls the stochastic meta-production frontier was chosen for this study due to the cross-sectional data involved.

2.10.2 The Meta-Frontier Analysis (MFA)

The introduction of the Stochastic Meta-Production Frontier model takes its root from Hayami and Ruttan (1970) and Hayami (1969) and research works such as Binam *et al.* (2008) and Kramol *et al*. (2010) have used to compare agricultural productivities across countries and regions. It was introduced to curb the shortfalls of the stochastic frontier analysis model by serving as a function that envelops the different groups' frontiers in a way that all the observations in the different groups are defined (Battese and Rao, 2002). The null hypothesis that the two predominantly employed fishing technologies by Ghanaian artisanal marine fishers are the same forms the basis for the adoption and use of the meta-frontier production function for this study. The meta-frontier model estimates technical inefficiencies to address technological differences across firms and estimate the gaps between production units under different production possibilities. The estimated technology gap ratio (TGR) is defined by Battese and Rao (2002) as the output defined by the frontier production function for the k^{-th} group divided by potential output defined by the meta-frontier function subject to the observed inputs. TGR ranges from zero to one and values closer to one imply the closeness of a group's frontier to the meta-frontier; given the available technology for the industry as a whole. For instance, TGR score of 0.96 means averagely the group produces, 96% of the potential output. The functions of the meta-frontier make it most appropriate when estimating efficiency under different technologies. Following these attributes and the adoption in studies like; Nkamleu *et al*. (2010) and Onumah *et al*. (2013), the meta-production frontier is preferred to the conventional stochastic frontier model for this study.

2.11 Distributional Assumptions Underlying the Stochastic Frontier Approach

Stochastic Frontier Model involves the estimation of the production technology parameters and then obtaining the estimates of the technical efficiency of each unit. Following Coelli (1995), both the corrected Ordinary Least Squares and Maximum Likelihood Estimators are employed though; the MLE approach is preferred as it is asymptotically more efficient. The estimation methods are supported by distributional assumptions regarding the two error terms (v_i and u_i). Usually, the v_i is assumed to be identically and independently distributed with zero (0) mean and a constant variance.

Both error terms are also assumed to be uncorrelated with the explanatory variables, (x_i) i.e. no autocorrelation) and also with a constant variance (homoscedastic). The assumptions underlying the statistical noise (v_i) in the stochastic frontier analysis are similar to that underlying the error term in the Classical Ordinary Least Squares. According to Coelli *et al*. (2005), the inefficiency error component μ_i also has similar characteristics except that it has non-zero mean ($u_i \geq 0$). Nonetheless, a number of distributional assumptions have been made with different specifications. Generally, there are four distributional assumptions underlying the inefficiency error term (u_i). They are the half normal, truncation of the normal, exponential and gamma. In every inefficiency study, one of these assumptions is applied.

The assumption of a half normal distribution implies that the u_i is an identically and independently distributed half-normal random variable with a scalar variance σ_u^2 i.e. the probability density function of any u_i is a truncated version of a normal random variable with mean equal to zero and σ_u^2 variance. It is specified as: $\{u_i \sim {}_{ii}dN^+(0, \sigma_u^2)\}$ The truncated normal follows the same assumption underlying the half-normal except that it has a non-zero mean (μ_i). Following Green (1995), the Gamma model $\{u_i \sim {}_{ii}dG(\lambda, m)\}$ is also assumed to have a mean (λ) with m degrees of freedom. The Exponential $\{u_i \sim {}_{ii}dG(\lambda, 0)\}$ which is also identically and independently distributed has a non-zero mean (λ) but a zero variance. The choice of any distributional assumptions concerning the u_i depends on computational and theoretical considerations. In terms of theoretical considerations, some authors avoid using the half-normal and exponential assumptions because of their zero mode. These two axioms imply that the most inefficiency effects are in the neighborhood of zero indicating that the associated measure of technical efficiency would be in the neighborhood of one. On the other hand, the truncate normal and gamma models usually have non-zero modes and allow for a wider range of distributional shapes. However, the disadvantage with such estimation is that in instances where the shapes of v_i and u_i are similar, it may be challenging to differentiate noise effects from inefficiency (Coelli *et al*., 2005).

2.12 Functional Forms for Production Frontiers Estimation

Empirical analysis of technology is carried out in many contexts, for many purposes. Each situation raises specific conditions and objective which must be met in the specification of an econometric production model. This section surveys the two most popular functional forms for production processes, and discusses some of the applications for which they are suited.

2.12.1 Functional Forms for Estimating Frontier

Various functional forms are used in estimating stochastic production frontiers. Common amongst them are the transcendental logarithmic (translog) and Cobb-Douglas production functions. Each of these has its advantages and disadvantages.

Cobb – Douglas Production Function

This production function is a double-logarithmic function where output and inputs are expressed in logarithms. It is generally specified as:

$$Y = aX^k \qquad 2.13$$

Where:

Y = output quantity

X = input employed

a and k are parameters to be estimated.

The function restricts to scale in order to take the same value across all firms and assumes elasticity of substitution to be one. The model after applying the logarithmic transformation to linearize it can be specified as:

$$\ln Y_i = \ln\beta_0 + \sum_{i=1}^{n} \beta_i ln X_i \qquad 2.14$$

Where:

β_i = elasticity of input used.

In spite of the shortcoming of the Cobb-Douglas functional form, it is still used by researchers.

For instance, Tzouvelekas *et al*. (2001), Nyagaka *et al*. (2010) and Essilfie *et al*. (2011) employed the Cobb-Douglas model in their economic and Technical efficiency analysis respectively. Onumah et al. (2010b) also employed the Cobb-Douglas function in estimating the productivity differentials between hired and family labor in aquaculture in Ghana.

The Transcendental Logarithmic (Translog) Production Function

As advantaged to be flexible in its application, one distinct property of the translog function is its ability to provide a second order approximation to an arbitrary twice differentiable function. This property has considerably helped in testing structural hypotheses like separability with fewer maintained restrictions than necessary. The translog has no prior restrictions on the elasticities of substitution of production inputs and this has been one major advantage. The general functional form is specified as:

$$\ln Y_i = \ln\beta_0 + \sum_{r=1}^{4} \beta_r \ln X_{ri} + \frac{1}{2}\sum_{r=1}^{4} \sum_{v=1}^{4} \beta_{rv} \ln X_{ri} \ln X_{vi} \qquad 2.15$$

According to Coelli *et al*. (2005), the translog is separable-inflexible. That is, the inability to provide a second order approximation to an arbitrary weakly separable function in any neighborhood of a given point. For instance, a three-input translog is left with seven parameters after imposing separability, two fewer than needed to maintain flexibility. But, the most probable contribution of flexible forms does not base on their approximation properties but in the fact that they place fewer restrictions prior to estimation than the more traditional forms.

2.12.2 Choosing Functional Forms

The purpose of a particular analysis signals to the researcher the appropriate functional form to be adopted and use. For researchers, one important selection criterion is the consistence of the production technology with a theoretical property. Choosing functional form implies that some hypothesis are chosen whilst others remain testable since hypotheses are not themselves tested as part of the analysis, but are assumed to be true. Notable maintained hypothesis with economic models include homotheticity, homogeneity and separability. In specifying functional form, it is advantageous to have an estimable relationship that places relatively fewer restrictions on the technology. For a production analysis, the functional form must be flexible in nature to avoid restriction on the value of the function or its first and second derivatives (Tzouvelekas, 2001). In this regard, the linearity, regularity, robustness, the parsimonious property of that functional form could serve as the guiding principles. Commonly used functional forms are the Cobb-Douglas and Translog production functions. Each of these has their merits and demerits.

Cobb-Douglas Production Function

The Cobb-Douglas is a double-logarithmic function with which output and inputs are expressed in logarithms. The function assumes elasticity of substitution to be one by restricting returns to scale to take the same value across all firms. The function is generally specified as:

$$\ln \mathrm{Y_i} = \beta_0 + \sum_{i=1}^{n} \beta_{\mathrm{i}} \ln X_{\mathrm{i}} \qquad 2.16$$

Where:

β_{i} = elasticity of input used.

The cobb-Douglas production function though considered to have some shortcomings has being used in several research works. For instance, Onumah *et al*. (2010b) estimated the productivity differentials between hired and family labour in aquaculture in Ghana with the Cobb-Douglas function. The economic efficiency of organic farming and technical efficiency in resource use in

Irish potato farms were assessed by Nyagaka *et al*. (2010) and Tzouvelekas *et al*. (2001) respectively with the help of the Cobb-Douglas production function model.

Transcendental logarithmic production function (Translog)

The translog production function imposes no prior restrictions on the structure of the technology. The translog model is flexible and allows for the examination of interaction between inputs in different stages of production. Though considered to have some setbacks like multicollinearity and degree of freedom problems, it has been adopted and used in a number of empirical analyses. Berndt and Christensen (1973) used the translog to examine input substitution. It was also employed in other studies like: seperability and aggregation (Denny and Fuss, 1977), and productive efficiency (Park and Lohr, 2010; Onumah and Acquah, 2010: Baten *et al*., 2009; Greene, 1980: Binam *et al*., 2008; Kalirajan, 1990). The generalized translog model is specified as:

$$\ln Y_i = \ln\beta_0 + \sum_{r=1}^{4} \beta_r \ln X_{ri} + \frac{1}{2}\sum_{r=1}^{4} \sum_{v=1}^{4} \beta_{rv} \ln X_{ri} \ln X_{vi} + (V_i - U_i) \qquad 2.17$$

The coefficients of the translog model are not direct estimates of elasticities and that the elasticities are derived as:

$$\varepsilon_y = \frac{\partial lnE(Y)}{\partial lnX} = \{\beta_v + \beta_{vv} lnX_v + \sum_{i=1}^{n} \beta_{vr} lnX_{ri}\} = \beta_v \qquad 2.18$$

Where:

The subscripts v and r = input v and input r

E(Y) = elasticity of output

X's = Input Variables

β's = coefficients to be estimated

Instances where the variables are scaled to unit means, the coefficients of the first-order are interpreted as elasticities of output with respect to inputs (evaluated at the variable means). The translog production model has been rated before the Cob-Douglas model because the cross effects between variables are easily estimated. It also allows for varying returns to scale rather than assuming constant returns to scale. Both models (Cobb-Douglas and the translog) however, are constrained when there are zero data points since logarithms cannot be computed on zeros. In testing for consistency in a study, Baten *et al*. (2009) used both the Cobb-Douglas and the translog and discovered that the translog estimates were more consistent and efficient than the estimates from the Cobb-Douglas. Onumah and Acquah (2010) also tested and proved that the translog estimates were more efficient than the Cobb-Douglas. A test of fitness was conducted in this study and the translog model proved better fitness and correctness on the technologies under discussion.

2.13 Determinants of Inefficiency

According to Kumbhakar and Lovell (2000), three distinct approaches of incorporating exogenous variables to measure variation in technical efficiency are; the early approach, the two stage approach and the single stage approach.

2.13.1 The Early Approach

The assumption underlying this approach is that the incorporating exogenous variables in the frontier model influence the production of the output. The stochastic frontier model for the early approach is specified as:

$$lnY_i = \ln f(X_i\, z_i, z_i{:}\, \beta) + (v_i - \mu_i) \qquad 2.19$$

Where:

Y_i = Output

X_i = Input vectors

z_i = vectors of exogenous variables

β = production parameters to be estimated

In the formulation above, the vector of exogenous variables (z_i) are assumed to influence output directly by influencing the structure of production frontier relative to which the inefficiency of the producers is estimated and not the efficiency in itself. Here the variation in efficiency is not explained in this formulation with the assumption that the exogenous variables are uncorrelated with each disturbance component of v_i and μ_i. This is the major disadvantage to the early approach.

2.13.2 Two Stage Approach

The two-stage approach tries to link the variation in the estimated efficiency with variation in the exogenous variables which is producer specific. The estimation of the parameter of the production frontier with the two-stage approach is based on the maximum likelihood estimation under the usual distribution and independence assumption. After the estimation of the inefficiency effects, it is then regressed on the exogenous variables in the second stage as:

$$E(\mu_i | v_i - \mu_i) = g(z_i \,;\, \gamma) + \varepsilon_i \qquad 2.20$$

The assumption underlying the two-stage approach is that the exogenous variables affect output indirectly through their effect on estimated efficiency. Contrary to the early approach, the exogenous variables have no influence on the structure of the production technology but rather influence the efficiency with which producers approach the production frontier. Also the exogenous variables of z_i are assumed to be correlated with μ_i which provides some explanation to the technical efficiency. The OLS is not appropriate in this approach because the dependent variable falls between zero and one. In this case the dependent variable *(μ_i)* must either be transformed before the estimation or a limited dependent variable estimation technique like the Tobit is used. Nyagaka *et al*. (2010) and Dzene (2010) are some researchers who have applied this method in their work. Nyagaka *et al*. (2010) used two-limit Tobit model whilst Dzene (2010) employed the random effect Tobit model estimation procedure to analyze the determinants. The main shortfall of the two-stage estimation approach is that regressing the technical inefficiency effects against some specific firm characteristics violates the identical distribution assumption of the μ_i. In this estimation approach, the predicted technical efficiencies are now assumed to have a functional relationship with z_i. The μ_i*'s* will only be identically distributed under this approach if only the coefficients of the factors happen to be null simultaneously.

2.13.3 Single Stage Approach

Recently applied method is the single-stage estimation approach used by (Kumbhakar *et al*., 1991) where the inefficiency effects are defined explicitly as a function of predetermined factors specific to the producer. Under the single stage approach, the individual parameters of the frontier and inefficiency models are estimated in a single-stage using MLE procedure. Here the variations in the inefficiency are explained and the problem of identical distribution is avoided. The merit of the single-stage approach over the two-stage is that the assumption of identical distribution of the inefficiency error term is still maintained. The single stage approach has been employed for several research works (Battese and Coelli, 1995: Binam *et al*., 2008) for analyzing the determinants of inefficiency. According Battese and Coelli (1995), the inefficiency model explained by some socio-economic factors is expressed as:

$$\mu_i = \delta_0 + \delta_i z_i \quad 2.21$$

Where:

z_i = set of socioeconomic factors influencing technical inefficiency

δ = parameters to be estimated in the model

This approach was adopted in this study to analyse the determinants of the inefficiency due to the limitations of the two stage estimation approach. This is because the error term, μ_i in this study was assumed to be identically distributed, independent of the regressors (Kumbhakar and Lovell, 2000).

2.13.4 Farm Specific Factors

A number of socioeconomic factors and other exogenous variables have been identified by various researchers as influencing the technical efficiency levels of farmers. A particular factor may be identified to be significant in some work and insignificant in other works. In other instances a factor may have opposite signs (positively or negatively) in a different work. In this study, the factors assumed to influence technical inefficiency of fishers under the two technologies have been categorized under three main headings namely; (a) demographic factors (gender, age, marital status and household size), (b) managerial factors (ownership of fishing resources, experience in fishing business, formal education and other occupation) and (c) operational factors (alternative finance sources, capacity of outboard motor and depth of fishing canoe).

Most reviewed literatures (Onumah and Acquah, 2010) have it that formal education and access to credit reduce technical inefficiency. Improvement in these variables will boost the efficiency of fishers and increase their productivity. Male major decision makers have also been found to be more technically efficient compared to their female counterparts (Binam *et al*., 2008). Age is usually found to increase inefficiency. However, some researcher such as Tzouvelekas *et al*.

(2000) found a positive effect of age on technical efficiency in their study of economic efficiency in organic farming.

2.14 Econometric Packages for Efficiency Analysis

Various econometric packages have been identified in literature. Ox, LIMDEP, STATA, SHAZAM, GAUSS, and SAS, are popularly noted for estimating stochastic frontier in economic efficiency analysis (technical and allocative). The FRONTIER 4.1 and the LIMDEP employed by Coelli (1996) and Greene (1995) respectively are most preferred analytical packages for stochastic frontiers estimations. Sena (1999) assessed both packages and indicated that for stochastic frontiers estimations, FRONTIER 4.1 which is a single purpose package is the appropriate while the LIMDEP is generalised for several non-standard econometric estimation. According to Coelli (1996), estimated efficiency results from the FRONTIER 4.1 are displayed directly as output from the package. The Ox, SFAMB also have similar specifications like the FRONTIER 4.1 but it is packaged to accommodate the estimation under all the four distributional assumptions.

2.15 Empirical Review on Meta-frontier Efficiency Analyses

Meta-frontier efficiency analyses have been conducted by several researchers in many fields of human endeavours. It has proven beyond the merit of earlier discovered models to be the most appropriate model for efficiency analysis in recent dispensation. Efficiency levels of conventional and organic cocoa production systems in Ghana were compered by Onumah *et al*. (2010b) and Onumah and Acquah (2010) through meta-frontier technique. Their findings revealed that farmer under the organic system were producing under increasing return to scale while those under the conventional system were producing under decreasing return to scale. The mean meta-efficiencies of the organic and conventional farms were 0.59 and 0.71 respectively.

The study concluded that the conventional farmer are more technically efficient compared to the farmers under the organic system. Based on these findings they recommended that farmers under the organic system should strive hard to increase their scale of production so as to enhance their efficiency level.

The work of Jemaa and Dhif (2005) on agricultural productivity and technology gab between MENA region and some European countries revealed that European countries are far ahead and advancing close to the meta-frontier. Compared to the MENA region, Technical Efficiency level was 71% while the estimated Meta-frontier efficiency average and Technology gap ratio were 40.8% and 63.3% respectively.

Binam *et al*. (2008) applied the meta-frontier analysis approach and found out that most cocoa farmers in West Africa have very limited access to production credit, except those in Ondo and Osun State in Nigeria and in the Southwest Province of Cameroon.
They also revealed that more than 60% of farmers from the two regions purchased fungicides and insecticides out of a loan contracted from market intermediaries. They then recommended for in-depth appraisal of the market intermediaries and their legal and regulatory framework that has permitted their evolution, in order to replicate such institutions in other parts of West Africa. They also recommended that farmer cooperatives should help link credit to marketing services as part of their effort.

Ayinde *et al*. (2009) employed the meta-frontier model to study the technical efficiency and varietal-gap of rice production in Nigeria. Their empirical results revealed the mean technical efficiencies for Ofada, Mai-Nasara and NERICA varieties to be 55%, 58% and 57% respectively. They found that farm hired labour, size, fertilizer, seed, gender, age, amount of credit and household size significantly influenced technical efficiency of farmers producing rice in Nigeria. The mean varietal technology gap was found to be above 0.83 under ell the varieties. They concluded that increasing farm size, fertilizer usage, seed quantity and access to credit will lead increase efficiency in rice production in Nigeria.

In china, Chen and Song (2006) examined the technical efficiency and technology gap of agriculture with unique dataset (county-level). In this study, the counties were classified into four regions based on economic development and technologies of production. The Meta-frontier analysis was applied to the counties and empirically the eastern counties emerged with the highest efficiency scores in terms of the regional frontier while the Northeastern counties topped in terms of agricultural production technology nationwide. Meanwhile, the average efficiency of the Northeastern counties was found particularly to be low, suggesting technology and knowledge diffusion among the counties might help to improve production efficiency and thus output.

Following the reviewed literatures, the stochastic meta-frontier model is appropriate for the estimation of efficiency under different technologies. Though several studies reviewed have indicated a wide scope of its application, however, none of the studies considered the issue of fisheries. This study, based on the advantages of the meta-frontier over the other efficiency estimation models applies it to compare the productivity and technical efficiency levels of fisher using purse seine and drift gill technologies in the central region of Ghana.

CHAPTER THREE

METHODOLOGY

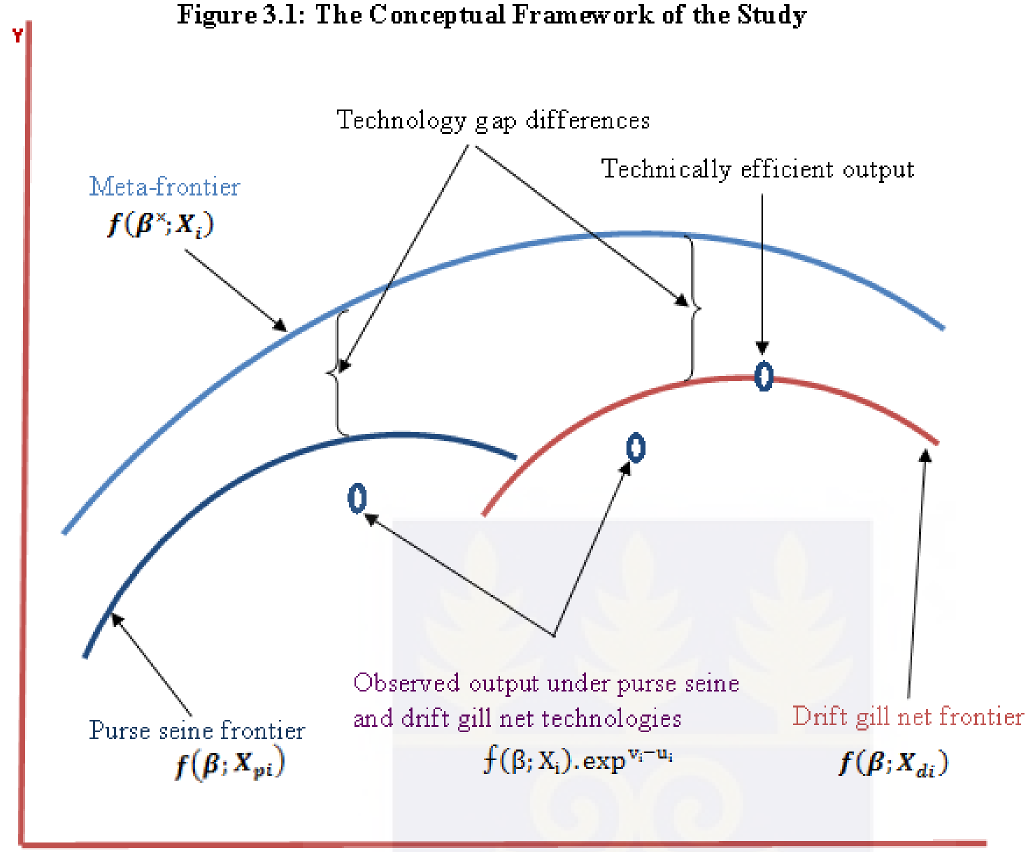
3.1 Introduction

Under this Chapter, the adopted conceptual and theoretical frameworks on the meta-frontier efficiency are discussed. It also presents the methodology and the empirical models specified to address the outlined specific objectives of the study. The chapter unfolds the stated hypotheses to be tested, outlines sources and types of data, sample and sampling techniques, data collection instrument, data analysis methods and finally ends with a brief description of the study area.

3.2 Conceptual Framework

Meta-frontier model used by Battese and Rao (2002) and (Battese et al., 2004) is also adopted and used in this study to estimate and compare the efficiency levels of artisanal fishers employing the purse seine and drift gill net fishing technologies in the study area. This model has the ability to estimate the technology gap ratio, parameters of meta-frontiers and the met-technical efficiency levels. As illustrated in Figure 3.1, the two individual stochastic frontiers representing the purse seine and drift gill net frontiers provide benchmarks to compare the efficiencies of the individual fishers. These two frontiers are canopied by the meta-frontier that serves as envelope for the two frontiers. The Meta frontier enables technical efficiencies to be estimated across fishermen to accommodate their technological differences. It also helps to measure technology gap existing between individual group frontiers relative to the best potential frontier (meta-frontier). This is illustrated in Figure 3.1.

Figure 3.1: The Conceptual Framework of the Study



Adopted from Battese et al. (2004)

3.3 Theoretical Framework

This research compares the performance of two predominantly employed fishing technologies by artisanal marine fishers along the coastline of Ghana. The stochastic meta-frontier is used in this study based on the advantage it has over the conventional stochastic frontier. Empirical studies (Hayami ,1969; Hayami and Ruttan , 1970; Battese and Rao, 2002 and Battese *et al*., 2004) suggest that the stochastic meta-frontier is an upgraded technique over the stochastic frontier for investigation of technical efficiencies among firms that work under different technologies or geographical areas.

3.4 Specification of Standard Stochastic Production Functions

Operationalising the meta-frontier model to estimate the technical efficiencies, the technologies are put into two groups (*group-*^{p} and *group-*^{d}). *Group-*^{p} represents artisanal marine fishers employing purse seine technology and *group-*^{d} also represents fishers using drift gill net technology. Group frontiers are estimated using the well-known stochastic production frontiers procedure proposed by (Coelli *et al.*, 2005). This will help address the efficiencies of individual fishers relative to their respective group frontier.

Stochastic Production Function Model for Purse Seiners

$$Y_i^p = f(x_i^p; \beta^p) e^{v_i^p - \mu_i^p} = e^{x_i \beta^p + v_i^p - u_i^p} \quad 3.1$$

Where:

i = 1, 2, 3 ….N_p of a fishers in *group-*^{p}

Y_i = total normalized fish catch (output) per annum for i^{th} fisher using purse seine in kilograms.

X_i = normalized vector of variable inputs quantities use by the i^{th} purse seiners per annum.

β^p = a vector of unknown parameters to be estimated associated with the *group-*^{p}

v_i^p = statistical noise assumed to be independent and identically distributed as $N(0, \sigma^2_{v(p)})$ random variable and

u_i^p = non-negative variable assumed to account for technical inefficiency among purse seiners and assumed to be independently distributed and truncated at zero of the $N(u_i^{(P)}, \sigma^2_{u(p)})$ distribution.

Estimating Technical Efficiency of Fisher in Relation to Purse Seine Frontier

With reference to the stochastic frontier model specified for fishers using the purse seine in equation 3.1, technical efficiency for individual fishers (i.e. i^{th} purse seiner) in *group-*^{p} can be specified as:

$$TE_i^p = \frac{Y_i^p}{e^{X_i \beta^p + v_i^p}} = e^{-u_i^p} \qquad 3.2$$

Stochastic Production Function Model for Fishers using Drift Gill Net

$$Y_i^d = f(x_i^d; \beta^d) e^{v_i^d - \mu_i^d} = e^{x_i \beta^d + v_i^d - u_i^d} \qquad 3.3$$

Where:

i = 1, 2, 3 ….N_d of a fishers in *group-*^{d}

Y_i^d = total normalized fish catch (output) per annum for i^{th} fisherman using drift gill net in kilograms.

X_i = normalized vector of variable inputs quantities use by i^{th} fisher in *group-d* per annum.

β^d = vector of unknown parameters to be estimated associated with the *group-*^{d}

v_i^d = statistical noise assumed to independently and identically distributed as $N(0, \sigma^2_{vd})$ random variable and

u_i^d = non-negative variable assumed to account for technical inefficiency among drift gill net users and assumed to be independently distributed as truncated at zero of the $N(u_i\ \sigma^2_{ud})$ distribution.

Estimating Technical Efficiency of fishers in Relation to Drift Gill Net Frontier

From equation 3.3, technical efficiency for individual fishers (i.e. i^{th} fisher) in *group-*^{d} can be deduced as:

$$TE_i^d = \frac{Y_i^d}{e^{X_i\beta^d + v_i^d}} = e^{-u_i^d} \qquad 3.4$$

3.5 Specification of the Meta-Frontier Efficiency Estimation

Equation 3.2 and 3.4 provide the possibility to relate the performance of i^{th} fisher to their group frontiers. The stochastic meta-frontier production function approach is specified in order to examine the performance of i^{th} fisher of any of the groups against the meta-frontier (the overall frontier of the artisanal marine fishing industry). The meta-frontier provides envelopment for different groups' stochastic frontier that defines all the observations in the different groups in a way that conforms to the specifications of the stochastic frontier model (Battese and Rao, 2002). Estimation of the meta-frontier efficiency forms the basis of the study and addresses the second and third objectives of the study. As specified by Battese *et al*. (2004) and Battese and Rao (2002), meta-frontier production function model is expressed as:

$$Y_i^* = f(x_I; \beta^*) = e^{x_i\beta^*} \qquad 3.5$$

Where:

$i = 1, 2, 3 \ldots\ldots N_{pd}$

Y_i^* = the meta-frontier output for all the two groups which dominates the individual group frontiers.

β^* = meta-frontier parameter, vectors satisfying the constraints:

$X_i\beta^* \geq X_i\beta$: for all k = 1, 2, K (i.e. *group-*^{p} and *group-*^{d}) 3.6

3.6 Estimating Technology Gap Ratio

The technology gap ratio refers to the ratio of the output of the frontier production function for the individual group to the potential output frontier defined by the meta-frontier function, subject to the observed inputs (Battese *et al*., 2004; Battese and Rao, 2002). Objective three is addressed by this analysis. The observed output defined by *group-*^{p} and *group-*^{d} stochastic frontier models in Equation 3.1 and 3.3 can also be specified in terms of the meta-frontier function as:

$$Y_i = e^{-u_i^{pd}} * \frac{e^{X_i\beta^{Pd}}}{e^{X_i\beta^{*}}} * e^{X_i\beta^{*}+V_i^{Pd}} \qquad 3.7$$

The first term on the right-hand side of equation 3.7 is the same as in equation 3.2 and 3.4, which represents the technical efficiency of fishers relative to their group (*group-*^{p} and *group-*^{d}) frontiers. The second term is the technology gap ratio (TGR) whereas the third term represents the meta-frontier output without inefficiency effect proposed by Battese and Rao (2002). The technology gap ratios fall between zero and one of which a value closer to one means fishers are producing nearer to the meta-frontier (maximum potential output) subject to the available technology for the artisanal marine fishing industry as a whole. This is expressed as:

$$TGR_i = \frac{e^{X_i\beta^{Pd}}}{e^{X_i\beta^{*}}} \qquad 3.8$$

3.7 Estimating Meta-Technical Efficiency

Separate estimates of the stochastic frontier for the individual fishing technologies permit the parameters of the empirical model to be different for each of the two groups. This stochastic group frontier analysis is desirable because it is likely that the fishers in each group are operating under different technologies.

Estimation of meta-frontier production function will help compare the technical efficiencies of fishing businesses employing different technologies and together analyse their technology gaps relative to the potential output that is defined by meta-frontier function, given the observed input. Proposed by Battese and Coelli (1992), empirical results from the stochastic frontier production model with inefficiency effects are used. The technical efficiency of i^{th} fisher in a particular group (*group-*^{p} or *group-*^{d}) relative to the meta-frontier is therefore specified as:

$$TE^{*} = \frac{Y_i^{Pd}}{e^{X_i\beta^{*}+V_i^{Pd}}} \qquad 3.9$$

The meta-efficiency (TE^{*}) is similarly defined as in equation 3.2 and 3.4. That is, the observed output over the last term on the right-hand side of equation 3.7. Looking at the terms in equation 3.2, 3.4, 3.7 and 3.8, the technical efficiency of i^{th} fisher in *group-*^{p} or *group-*^{d} relative to the meta-frontier can be specified as:

$$TE^{*} = TE_i^{pd} \text{ X } TGR_i \qquad 3.10$$

3.8 Operationalising the Frontier Models for Efficiency Estimation

The translog functional form used in this study has the advantage of being flexible which helps to examine the cross effects inputs on output at different stages of production. It has been adopted for several works under different field of study (Onumah and Acquah, 2010; Baten *et al*., 2009). The translog production is proven as an effective model for estimating efficiencies in production process. The translog stochastic frontier production function models, assumed to represent the production technology for fishers of a particular group and that of the meta-frontier are specified in equation 3.11 and 3.12.

Group Stochastic Frontier- Transcendental Logarithmic Model

$$\ln Y_i = \ln\beta_0 + \sum_{r=1}^{4} \beta_r \ln X_{ri} + \frac{1}{2}\sum_{r=1}^{4} \sum_{v=1}^{4} \beta_{rv} \ln X_{ri} \ln X_{vi} + (V_i - U_i) \qquad 3.11$$

Meta-Frontier Transcendental logarithmic Model

$$\ln Y_i = \ln\beta^*{}_0 + \sum_{r=1}^{4}\beta^*{}_r \ln X_{ri} + \frac{1}{2}\sum_{r=1}^{4}\sum_{v=1}^{4}\beta^*{}_{rv}\ln X_{ri}\ln X_{vi} + (V^*{}_i - U^*{}_i) \quad 3.12$$

Where:

ln = natural logarithm

i = i^{th} fisher of a particular technology (*group-^{p}* or *group-^{d}*)

β = vector of unknown parameter to be estimated; Note: $\beta_{rv} = \beta_{vr}$ for all v and r

Y_i = total normalised output of fish catch per annum (GH₵)

X_{i1}, X_{i2}.....X_{i4} = normalised vector of variable input quantities (annual) employed in production process.

From equations (3.11) and (3.12), restricting their respective squared and crossed product terms to zero (0) change the models to Cobb-Douglas production function models illustrated in equation 3.13 and 3.14.

Group Stochastic Frontier-Cobb-Douglas Model

$$\ln Y_i = \ln\beta_0 + \sum_{r=1}^{4}\beta_r lnX_{ri} + (V_i + U_i) \quad 3.13$$

Meta-Frontier Cobb-Douglas Model

$$\ln Y_i = \ln\beta^*{}_0 + \sum_{r=1}^{4}\beta^*{}_r lnX_{ri} + (V^*{}_i + U^*{}_i) \quad 3.14$$

Using a model proposed by Battese *et al.* (2004), this study estimates the parameters of the meta-frontier model by minimizing the sum of the squares of the deviations of the values on the meta-frontier from those of the individual stochastic frontier production systems at the observed input levels. A modified Ox programme developed by Brummer (2003) is considered to obtain the maximum likelihood (ML) estimates for the parameters.

3.9 Variables in the Frontier Production Function Mode

Table 3.1 presents the summary description of the variables in the frontier production function.

Table 3.1: Frontier Production Function Variables and their A-prior Expectation Signs

Variable (X1-X4)	**Description**	**Measurement**	**A-priori Expectation**
Y_i	Total output of i^{th} fisher (dependent)	GH₵	
Input variables			
X_1	Labour (hired and family)	Man-day	+ve
X_2	Litres of Premix fuel	Litres	+ve
X_3	Duration	Hours	+ve/-ve
X_4	Cost of Other input used	GH₵	+ve

3.10 Detail Description of Variables in the Frontier Production function Model

The variables to operationalise the frontier models were categorized into two (output and input) variables. Both categories comprise of annual statistics of output and input levels of fishers selected from the study area. The output and input variables were scaled by the size of fishing canoe to neutralise canoe size effect (Onumah *et al*., 2010b).

The Output Variable: This study captured output in value terms, measured in New Ghana Cedis (GH₵) of the total annual volume of fish harvested by i^{th} fisher in a particular group. The output was normalized by scaling the total annual value of fish by the canoe size of i^{th} fisher in a group to neutralise the size effect (Onumah *et al*., 2010b).

The Input Variables: These variables comprise of Labour, Quantity of premix fuel used, Duration of fishing operation and cost of other inputs incurred.

Labour: The labour is measured in man-day which constitutes the total number of crews employed during fishing trip. Labour use in artisanal marine operation is gender bias employing only men. Labour is predicted to add unto output quantity because fishing unlike crop production depends highly on human effort and chance. In view of this, as more hands are employed, the quicker the rate of casting and hauling the net and swifter the canoe during fishing operation at the fishing ground. It was also scaled by dividing the number employed by the canoe size of i^{th} fisher in a group to take account of differences in canoe sizes. Hired and family labour was considered in this study and was assumed to be equally productive.

Quantity of premix fuel: This is a specialized fuel consumed by outboard motors that propel the fishing crafts (dugout canoes). The fuel per this research work is measured in quantity of litres per annum. It is assumed that the availability, accessibility and increase use of the premix fuel will lead to increased output. This is because fishers can travel far and swifter during fishing operation to reduce escapement of fish. The quantity of premix used was scaled by dividing the total quantity used by the canoe size of i^{th} fisher in a group in order to neutralise the canoe size effect.

Duration: Fishing activity is mainly characterized by the intensity of the human effort in relation to time. Therefore this variable, measured in hours, considers the effect of time on fish catch (output). Under this variable, consideration is given to the total time spent (duration) during the following activities; sailing from the beach to a fishing ground, casting and hauling of the net and sailing from a fishing ground back to the beach. Duration is indeterminate at this point because increased fishing duration could imply travelling far in search of unavailable fish and also facing problem in casting and hauling the net. Extended fishing duration could also be as a result of heavy harvest or catch slowing the activities of hauling and sailing back to the beach.

Duration is also normalised by scaling to total time spent by the canoe size of i^{th} fisher in a group to do away with the effect of canoe size differences.

Cost of other input used:

All other input used that falls outside the ones discussed are considered under this variable. Since these inputs were in different units of measurement, their monetary values in Ghana cedi (GH₵) were used instead of their respective quantity levels. Except the cost of signal light and dry cell borne by only fishers using drift gill net, food, ice block, tax and royalty were common costs borne by users of both technologies. Straight line approach for depreciating cost was used to obtain the cost of signal light as fishers assured could be used for a period of one month. This variable is expected to have positive influence on output. Other cost was scaled by dividing the total value employed in Ghana cedi by the canoe size of i^{th} fisher in a group in order to take care of the differences in canoe size.

3.11 Estimating the Elasticity of Output with Respect to each Input

In translog production functional form, the estimated coefficients cannot be interpreted straight forward. This is because the first-order and second-order coefficients together with the level of input variables constitute the output elasticities with respect to the inputs (Onumah and Acquah, 2010). This is resolved by rescaling the variables to have unit means which implies the coefficient of the squared term (β_{vv}) and the cross terms (β_{vr}) turns to zero leaving the first term (βr) to be interpreted as direct elasticities as expressed in equation 3.15.

$$\varepsilon_y = \frac{\partial lnE(Y)}{\partial lnX} = \{\beta_v + \beta_{vv} lnX_v + \sum_{i=1}^{n} \beta_{vr} lnX_{ri}\} = \beta_v \qquad 3.15$$

From equation 3.15:

Letters (v and r) = Input v and r, E(Y) = Elasticity of output, X's = Input variables, β's = Coefficients to be estimated.

Return to Scale (RTS) for a production unit is expressed in equation 3.16 which is the sum of the elasticities of output with respect to each inputs used.

$$RTS = \sum_{i=1}^{n} \varepsilon_{yi} \qquad 3.16$$

Decision rule: RTS>1 implies increasing returns to scale, RTS<1 implies decreasing returns to scale and RTS=1 implies constant returns to scale.

3.12 Determinants of Meta-Frontier Inefficiency

This analysis addresses the objective four of the study by looking at the causes of variation in the technical and meta-frontier efficiency levels of fishers employing the purse seine and the drift gill net technologies. Fishers' demographic, management and operational characteristics assumed to influence their technical and meta-frontier efficiency levels were specified in the inefficiency model as:

$$\mu_i = \delta_0 + \sum_{m=1}^{11} \delta_m Z_{m_i} \qquad 3.17$$

Where:

u_i =non-negative error assumed to be technical inefficiency effects relative to the stochastic production frontier

δ_0 = constant or intercept

δ = parameters to be estimated

Z = vector of variables explaining the inefficiency effects. (ie. Z_1 = Gender, Z_2 = Age, Z_3 = Marital status, Z_4 = Household size, Z_5 = Ownership of fishing resources, Z_6 = Years of experience in fishing business, Z_7 = Formal education, Z_8 = Engage in other occupation, Z_9 = Alternative finance sources, Z_{10} = Capacity of outboard motor and Z_{11} = Depth of Fishing ground).

The variance parameters from the inefficiency model will be specified as:

$$\sigma = \sigma_u^2 + \sigma_v^2 \qquad 18$$

Referring from Onumah *et al*., (2010b), the variance ratio parameter which relates the variability of μ_i to total variability of both μi and v_i will be estimated as:

$$\gamma = \frac{\sigma_u{}^2}{\sigma_u{}^2 + \sigma_v{}^2} \qquad 3.19$$

Where:

$0 \leq \gamma \leq 1$ that is, the closer the value of γ is to 1, the further way (deviation) the observed output from the frontier which is attributed to the inefficiency factors. On the contrary, the closer the γ to zero (0) implies the variation in output are due to the stochastic factors. The variables included in the inefficiency model in equation (3.17) are presented in Table 3.2.

Table 3.2: Description and A-prior Expectations of Inefficiency Variables

Variable	Description	Measurement	Unit	A-priori signs
δ_0	Constant			
Demographic Factors of Major Decision-Maker				
Z_1	Gender	1 = male 0 = female	Dummy	+ve/-ve
Z_2	Age	Number	Years	+ve/-ve
Z_3	Marital status	1 = Married 0 = others	Dummy	+ve/-ve
Z_4	Household size	Number	Number	+ve/-ve
Business Managerial Factors				
Z_5	Ownership of fishing resources	1 =solely owned 0 = Otherwise	Dummy	+ve/-ve
Z_6	Experience in Fishing Business	Number	Years	+ve
Z_7	Formal education	1 = Formal 0 = No Formal	Dummy	+ve/-ve
Z_8	Other Occupation	1 = Yes 0 = No	Dummy	+ve/-ve
Fishing Operational Factor				
Z_9	Alternative finance source	1 = Market queens 0 = Other	Dummy	+ve/-ve
Z_{10}	Capacity of outboard motor	1 = 40hp 0 = Others	Dummy	+ve/-ve
Z_{11}	Depth of fishing ground	Number	Metres	+ve/-ve

3.13 Description of the Variables in the Inefficiency Model

The details of the variables used in the inefficiency model are presented below:

3.13.1 Demographic Factors of Major Decision Maker

These factors are considered paramount because fishing operations start from home. It is therefore wealthy to identify and quantify the levels to which these fisher-specific socioeconomic factors can affect and influence their performance (productivity). Factors considered under this study are gender of fishers (owners who are major decision makers), age, marital status and household size.

Gender of Primary Decision Maker

Under this variable, a dummy is used where a male owner of canoe and net is assigned a value of one (1) and a female owner also assigned a value of zero (0). The expectation of gender's effect on inefficiency and productivity cannot be determined at this point because empirically various works of research have had different expected signs depending on the type of agricultural enterprise under study.

Age of Primary Decision-Maker

The effect of age cannot be predicted at this stage because it is expected that younger fishers are energetic and could be more productive. However, older fishers may also apply their experience and other production resources at their disposal to influence productivity level. This variable is measured in years.

Marital Status of Primary Decision Maker

This variable as a determinant of efficiency/inefficiency is a dummy measurement where number one (1) is assigned to major decision makers who are married and zero (0) to those of other marital status. The effect of marital status on efficiency/inefficiency is indeterminate at this point because some schools of thought suggest that married fishermen do not spend time on household chores, get helping hands on fishing operations and have the luxury to plan and execute the fishing operations with peace of mind. Others also hold it that married fishers are often disturbed by marriage and its family-related responsibilities which affect the peace and the capital base of the fishing business hence contributing to inefficiency.

Household Size

This is captured as the total number of people under the household expenditure of the major decision makers. The expected sign cannot be determined now because empirically, it is argued from one angle that large household size translates into labour in a form of family labour thereby reducing the spending on hired labour. This can enable fisher to use financial resources meant for hiring labour to acquire other inputs as when needed. On the other side, it is held that higher household size leads to greater household expenditure (food, shelter, health care, accommodation, educational spending etc.) hence pressure on the limited resources to meet the demand of fishing business and that of the household expenditure.

3.13.2 Business Managerial Factors

Factor considered for this study are ownership of fishing resources, years of experience in the fishing business, level of formal education and other occupation of major decision maker.

Ownership of Fishing Resources

The net influence of ownership of fishing resources on efficiency/inefficiency cannot be determined at this point of the research. As a dummy measurement (1 = solely owned, 0 = others), solely owned businesses have liberty and luxury in making quick decision to affect productivity. However, there is some level of disadvantages for individually owned businesses to acquire credit and some productive resources for business operations and development hence considered to have indeterminate effect on inefficiency/efficiency at this point.

Years of Experience in Fishing Business

Measured in years, business experience captures the total number of years major decision maker has engaged in the fishing business. All other things equal, it is expected that greater number of years in business will translate into higher efficient and productive level of major decision maker.

Formal Education

This variable is defined whether a major decision maker has some level of formal education or not. It is measured as a dummy where major decision makers without formal education are assigned number zero (0) and those who have had some level of formal education assigned one (1). The variable formal education is indeterminate, though some level of formal education induces literacy and understanding to apply new and improved methods of fishing/farming but it is also argued that most educated fishers/farmers are complacent and do not follow strict instructions.

Other occupation of major decision maker

This variable is measured as dummy. Major decision makers who engage in other occupation are assigned the value one (1) and zero (0) for those into fishing alone. The effect of this variable is indeterminate because those undertaking additional occupation may have an alternative source of finance for the fishing business. On the other hand, there will be divided attention and conflicts of interest that may negatively affect the productivity and efficiency.

3.13.3 Fishing Operational Factors

Alternative finance sources

This variable is a dummy where one (1) is assigned to major decision makers that receive financial support from market queens who buy directly from fishers and zero (0) assigned to those getting financial support from other sources. This variable has indeterminate influence on inefficiency/efficiency at this point because many empirical works have had different expected signs depending on the type of agricultural enterprise under study.

Capacity of outboard motor

This variable is measured as a dummy whereby fishers propelling their craft with 40hp outboard motors are assigned number one (1) and zero to those using other capacities of outboard motors. The net effect of this variable is indeterminate at this stage.

Depth of fishing ground

The depth of the fishing ground is measured in metres. Observation from the field survey revealed that fishers employ two methods to determine the depth of the fishing ground. These methods were the electronic method (using speedtech hand echo sounder) and the manual method (rope is attached to a metallic load-lead and dropped into the sea to measure the length extending unto the sea bed). The expectation of this variable cannot be determined at this stage of the study. According to Barros and Clarke (2009), the further away you sail from the beach, the deeper the ocean depth and the higher the probability of increasing output. However, the greater the distance fishers sail from the beach, the higher the expenses on fuel and other cost (food, ice block etc.) which negatively affect productivity.

3.14 Statement of Hypothesis

Table 3.3 outlines important hypotheses underlying the assumptions and the relevance of the specified models in this study; the hypotheses were set to check the validity of the specified model, the presence of inefficiency, the relevance of the assumed inefficient factors included in the inefficient model, whether inefficiency effects are stochastic or non-stochastic and the necessity to specify the meta-frontier model.

The hypotheses are validated using the generalized likelihood-ratio test (LR) specified in equation 3.21.

$LR = 2[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$ 3.20

Where:

$L(H_0)$ and $L(H_1)$ are values of the likelihood function under the null (H_0) and alternative (H_A) hypothesis respectively.

LR has approximately a Chi-square (or mixed Chi-square) distribution if the given null hypothesis is true with a degree of freedom equal to the number of parameters assumed to be zero (0) in (H_0). Coelli (1995) proposed that all critical values can be obtained from the appropriate Chi-square distribution. However, if the test of hypothesis involves $\Upsilon = 0$, then the asymptotic distribution necessitates the mixed Chi-square distribution (Kodde and Palm, 1986; Table 1).

Table 3.3: Statement of Hypotheses for Technical and Meta-frontier Efficiency Models

Hypothesis	Description
1. H_0: $\beta_{rv} = 0$	Coefficients of the second-order variables in the translog model are zero
H_1: $= \beta_{rv} \neq 0$	Coefficients of the second-order variables in the translog model are not zero
Purse seine Drift gill net Pooled	
2. H_0: $\Upsilon = \delta_0 = \delta_1$------$\delta_{11} = 0$	There are no inefficiency effects
H_1: $\Upsilon = \delta_0 = \delta_1$------$\delta_{11} \neq 0$	There are inefficiency effects
Purse seine Drift gill net Pooled	
3. H_0: $\delta_1 = \delta_2$--,--,--,$= \delta_{11} = 0$	Inefficiency variable included in the model are not relevant and have no effect efficiency/inefficiency
H_1: $\delta_1 \neq \delta_2$--,--,--,$\neq \delta_{11} \neq 0$	Inefficiency variable included in the model have relevant effect on efficiency/inefficiency
Purse seine Drift gill net Pooled	
4. H_0: $\Upsilon = 0$	Inefficiency effects are non-stochastic
H_1: $\Upsilon \neq 0$	Inefficiency effects are stochastic
Purse seine Drift gill net Pooled	
5.H_0: $f_p(X:\beta_p) = f_d(X:\beta_d)$	Both technologies (purse seine and drift gill net) are the same and specification of the meta-frontier model is unnecessary.
H_1: $f_p(X:\beta_p) \neq f_d(X:\beta_d)$	Both technologies (purse seine and drift gill net) are never the same and deemed appropriate to specify of the meta-frontier model.

3.15 Source and Type of Data

Both quantitative and qualitative data were solicited from primary and secondary sources for this study.

3.15.1 Primary Data

Primary data was collected from owners of canoes and fishing nets who are the major decision makers from five fishing communities that employ the purse seine and drift gill net technologies. Relevant information acquired from the major decision makers included: demographic and socioeconomic characteristics, fishing business management details, production or fishing operation details and output details. Personal observations as well as focus group discussions were also employed to identify and record the types of fishing net and the material made of, scaling and selling of fish, mending of fishing net and cost involved and among others.

3.15.2 Secondary Data

Reviewed literatures from libraries, newspaper, and internet deepened and broadened the understanding of fishing technologies used by artisanal marine fishers. Also personal encounter with management and personnel of fishing cooperatives, Marine Fisheries Research Division (MFRD), Districts, Metro and Municipal Assemblies unveiled the notable fishing communities, fishing terminologies, quantity measurements as well as the cost and revenue analysis principles in fishing.

3.16 Study Area:

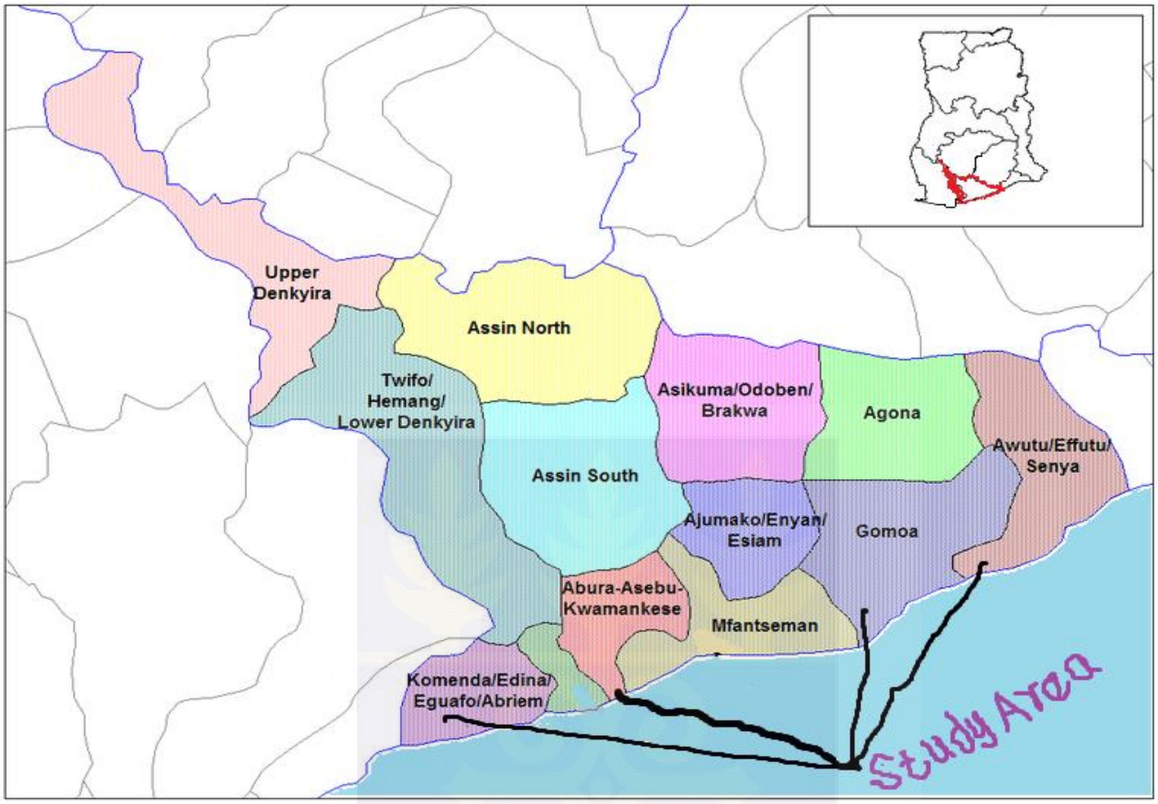
Central region can be found in the south-western centre of Ghana, stretching from longitude 3° 06' W to 1° 10' E and lies between latitudes 4° 30'S and 6° 6' N. The region is bordered on the North by Ashanti Region, Eastern Region to the North-East, Greater Accra Region to the South-

East and on the West by the Western Region. Beyond the southern boundary lies the Gulf of Guinea.

It is one of the smallest regions in Ghana, only bigger than Upper East and the Greater Accra Regions. This region is focused for this work because it has the widest and longest continental shelf and coastline respectively in Ghana and spans about 150km across eight (8) coastal districts. From the Gomoa East through Effutu Municipal, Gomoa West District, Mfantsiman East District, Mfantsiman Municipality, Abura Asebu Kwamankese District, Cape Coast Metropolis and Komenda Edina Eguafo Abirem Municipality in the West. Among these coastal districts are 43 coastal towns and villages from Gomoa Nyanyano in the East to Kafodzidzi in the West with a total of 103 landing sites. Mumford and Elmina are very important landing sites where boat building activities are prominent (FAO, 2016).

Fishers of this region are mainly artisanal or canoe fishers that employ drift gill net, purse seine, beach seine and hook and line as fishing technologies or gears. Lobsters, Squid and Octopus, Shrimps, Sole, Sea Bream, Mackerels, Grouper, Skipjack tuna, Yellow Fin tuna, Round and Flat Sardinellas and Sailfish are the main fish landed. Central region alone contributes about 36% of the nation fish production hence dear to the socio-economic development of Ghana (MoFA, 2012). Fig 3.2 shows the study area.

Figure 3.2: The Map of the Study Area



Source: Wikipedia (2006).

3.17 Sample and Sampling Techniques

Multi-stage sampling approach was employed to identify the respondents in five coastal communities along the coastal stretch of central region. Central region was purposively selected as the center stage for this research work because Amador *et al.*, (2006) revealed in a related work that Central and Greater Accra regions of Ghana jointly account for the majority of canoes (64.49%) and fishermen (63.98%) along the coastal belt of Ghana.

150 canoe and net owners (major decision makers) were sampled through a multistage sampling technique from two coastal districts and two municipalities (Komenda Edina Eguafo Abirem municipality, Abura Asebu Kwamankese, Gomoa West and Effutu municipality).

One community was purposefully chosen from Abura Asebu Kwamankese, Gomoa West and Effutu Municipality but two were selected from Komenda Edina Eguafo Abirem based on the dominance of sampling frame and the vibrancy of fishing activities in the municipality.

Respondents were stratified based on the two fishing technologies and Simple random sampling approach was then used to select fifteen respondents from each stratum in each community.

3.18 Data Collection Instruments

Data collection methods included personal interviews, key informant interviews and observations. The personal interview was used with the aid of questionnaire administered to solicit the socio-demographic characteristics, quantity and cost of inputs, quantity and prices of output and other qualitative and quantitative variables from the owners of fishing businesses and other stakeholders. Key informant interviews with community chiefs, chief fishermen and assembly men revealed issues on; community profile, fishing organisations and cooperatives, government policies and interventions in fishing communities, royalty settlement among others. Personal observation was employed to capture marketing processes at the landing sites.

3.19 Statistical Software Data Analysis Methods

SPSS and Microsoft excel were used to analyse and present the demographic, management and production factors in the form of means, maximum, minimum, standard deviations and relative frequencies (percentages). Additionally, the Ox programme, specifically the SFAMB (Stochastic Frontier Analysis Method by Bruemmer) was used to estimate the individual stochastic frontiers and the meta-frontier parameters.

CHAPTER FOUR

RESULTS AND DISCUSIONS

4.1 Introduction

This chapter discusses the findings of the study. It begins with the discussion of the assumed inefficiency factors (demographic, management and operational characteristics) of fishers. Discussion of the inputs productivity (output elasticities) result is preceded by result of the tested hypotheses. Following is the discussion of technical efficiency of fishers relative to their group frontiers. Technology gap ratio scores, meta-efficiency and the effects of the assumed characteristics influencing inefficiency/efficiency of fishers employing the purse seine and drift gill technologies are discussed in that order respectively.

4.2 Demographic Characteristics of Artisanal Fishers

This aspect highlights on gender, age distributions, marital status and household size of the sampled artisanal fishers who employ the purse seine and drift gill net technologies. Asiedu and Nunoo (2013) suggested that to have successful strategies for fisheries management, it is necessary to consider the fishery and socio-economic status among diverse groups, region, landing beaches and management types. The demographic characteristics of fishers are presented in Table 4.1.

4.2.1 Gender Distribution

The statistics in Table 4.1 show that in total about 57% and 43% of the sampled respondents were males and females canoe and net owners respectively. For the individual technology wise, 55% of males and 45% of females were identified to be owners of purse seine net while males and females owning drift gill net were 59% and 41% respectively. The biasness revealed by this research is a clear confirmation of the old traditional saying and adage "women never go to sea" literally means it is unaccepted for women to go for fishing on the sea. The face of this saying is gradually changing as this result and other related findings (Asmah, 2008) revealed the involvement of some female investors in the fishing business.

Table 4.1: Demographic Characteristics of Artisanal Fishers

Demographic Factor	**Purse Seine**		**Drift Gill Net**		**Pooled**	
	Absolute N=75	Percentage 100%	Absolute N=75	Percentage 100%	Absolute N=150	Percentage 100%
Gender Distribution						
Female	34	45	31	41	65	43
Male	41	55	44	59	85	57
Age Distribution (Years)						
30-39	0	0	1	1	1	1
40-49	32	43	39	52	71	47
50-59	31	41	30	40	61	41
60-69	11	15	5	7	16	10
70-Above	1	1	0	0	1	1
Mean	52		50		51	
Minimum	30		30		30	
Maximum	75		62		75	
Marital Status						
Single	9	12	10	13	19	13
Married	36	48	31	42	67	45
Divorced	10	13	13	17	23	15
Separated	18	24	17	23	35	23
Widowed	2	3	4	5	6	4
Dummy						
Married	36	48	31	41	67	45
Others	39	52	44	59	83	55
Household Composition						
Mean	9		7		8	
Minimum	4		2		2	
Maximum	15		20		20	

Source: Field Survey, 2017

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4.2.2 Age Distribution

It was revealed that majority of purse seine (43%) and drift gill net owners (52%) interviewed were within the age range of 40-49 years. This effect was also highlighted under the pooled system as 47% of the total respondents were identified within the same range. The average ages recorded under the purse seine, drift gill net as well as the pooled system were 52years, 50years and 51years respectively. These statistics imply that ownership and control of fishing equipment and resources are dominated by middle aged individuals who have the capital, skills and some level of experience in the fishing business. FAO (2007) hinted on child labour in the fishing industry but the result of this study shares a contrasting view.

4.2.3 Marital Status of Respondents

Emphases were placed on owners of the fishing business (canoe and net owners) who were single, married, divorced, separated and widowed. From Table 4.1, 48%, 42% and 45% represent married respondents for purse seine, drift gill net as well as the pooled system respectively. However, 12%, 13% and 13% were single purse seine and drift gill net owner as well as the pooled system respectively. Among the total selected respondents, 15%, 23% and 4% were identified with divorce, separated and widow status respectively. This implies that a considerable number of sampled artisanal fishers are single parent.

Dummy analysis of the marital status (married against the other status) revealed that 45% of the total respondents (150) are married while the other statuses combined make a percentage of 55. About 48% and 41% of purse seine and drift gill net owners respectively held married status while the other halves of the percentages (52 and 59) stands for all the other status. This finding relates to the polygamous marriage of fishing communities revealed by koranteng (1998) though this study did not consider the types and forms of marriage.

4.2.4 Household Size

The mean household size under the pooled system is approximately eight dependents per respondent and ranges from a minimum of two persons to a maximum of twenty persons. Meanwhile, purse seine owners' dependents ranged from 4-15 persons with a mean of nine persons. On the part of those using the drift gill net, a mean of seven dependents was recorded and ranged between 2 to 20 minimum and maximum dependents respectively. These statistics indicate that averagely owner of purse seine net have higher household size that could translate into family labour hence less would be spent on hired labour. Comparably, the lesser average household size of drift gill owner implies more hire labour would be required, however, household size was found to decrease the efficiency under both technologies.

4.3 Management Characteristics of Artisanal Fishers

This section of the study discusses the artisanal fishing as a business and the characteristics of management behind the conducts of the routine day to day fishing operations. Areas of great concern included in this study were ownership of fishing resources, years of business experience, levels of formal education and alternative occupation of fishers (whether main decision maker also engages in either waged, salaried or any form of unpaid personal work). These factors are presented in Table 4.2.

4.3.1 Ownership of Fishing Resources

The survey conducted revealed three forms of ownership to fishing resources or businesses among fishers in the study area. Fishing resources (businesses) are owned either by individuals, captured under this study as "solely owned businesses" or group of individuals coming together to pool their capital and other resources to acquire and operate fishing business. This ownership form is considered in this study as "Group owned businesses". Finally "Family owned businesses" which are owned and operated by either a nuclear or extended family were also identified. Displayed in Table 4.2, most encountered fishing business (48%) was solely owned businesses. The remaining 28% and 24% were family owned and group owned fishing businesses respectively. Under the individual technologies, 19%, 26% and 55% of family, group and solely owned business respectively employ the purse seine technology. However, the percentages of family, group and solely owned businesses using the drift gill technology were 37, 21 and 42 respectively. This finding signals that artisanal fishers in the study area prefer working as an individual business to group business.

4.3.2 Experience in Fishing Business

The mean respondents' years of business experience was estimated to be 19years for the pooled system, while that of purse seine and drift gill net owners were 17years and 22years respectively. Estimated maximum years of business experience for purse seine and drift gill net owners were about 43 and 35 years respectively. This implies that fishers along the coastal stretch of central region are appreciably experience. This confirms the finding of Aseidu and Nunoo (2013) that fishers along the coast of Ghana are of age and have attained a considerable fishing experience.

4.3.3 Level of Formal Education

Consistent with Atta Mills *et al*. (2004), fishers along the coastal stretch of Ghana are of low level of formal education. From Table 4.2, the majority of the sampled fishing business owners in the study area (55%) had no formal education. About 7% and 2% of them have attained senior high or technical or vocational school level and tertiary level education respectively. It also came to bear that none of the drift gill owners have attained tertiary level of education as against three owners of purse seine. The statistics on respondents' education show that purse seine owners are formally educated than their counterparts owning the drift gill net.

Table 4.2: Managerial Characteristics of Artisanal Fishers

Variables	Purse Seine		Drift Gill Net		Pooled	
	Absolute N=75	Percentage 100%	Absolute N=75	Percentage 100%	Absolute N=150	Percentage 100%
Ownership of Fishing Resources						
Family Owned Business	14	19	28	37	42	28
Grouped Owned Business	20	26	16	21	36	24
Solely Owned Business	41	55	31	42	72	48
Dummy						
Solely Owned Business	41	45	31	41	72	52
Other Ownership	34	55	44	59	78	48
Years of Experience in Fishing Business (years)						
1-10	14	19	2	3	16	11
11-20	42	55	37	49	79	27
21-30	12	16	24	32	36	29
31-40	6	9	12	16	18	12
40-Above	1	1	0	0	1	1
Mean	17		22		19	
Minimum	6		10		6	
Maximum	43		35		43	
Level Formal Education						
No Formal Education	41	55	41	55	82	55
Primary	11	15	17	23	28	19
JHS/MSLC	14	19	12	16	26	17
SHS/TECH/VOC	6	8	5	7	11	7
Tertiary	3	4	0	0	3	2
Dummy						
Formal Education	34	45	34	45	68	45
No Formal Education	41	55	41	55	82	55
Alternative Occupation						
Yes	15	20	20	27	35	23
NO	60	80	55	73	115	77

Source: Field Survey, 2017

4.3.4 Alternative Occupation of Major Decision Maker

Trying to identify alternative occupation (waged, salaried or unpaid work) of respondents, about 77% of the respondents declared fishing as their only source of livelihood, while 23% indicated that they have an alternative work. The statistics presented in Table 4.2 also shows that 80% and 73% purse seine and drift gill net owners respectively solely depend on fishing business. This finding has confirmed the finding of Nunoo *et al*. (2014) that fishing is the source of income for more than two hundred coastal villages, including about two hundred thousand fishers with approximately two million dependents.

4.4 Operational Characteristics of Fishers

This section discusses the activities that have direct influence on the way fish are caught from the sea and the business as a whole. Areas considered for this study are alternative sources of business finance, Brand and capacity of outboard motor and the depth of fishing ground.

4.4.1 Alternative Sources of Fishing Business Finance

The research revealed that owners of the fishing businesses were unable to acquire credit facilities from formal banks and other financial institutions because they are always considered not to be credit worthy due to their inability to meet credit and loan conditions. Further interrogations with respondents brought to bear that bureaucratic and pressure in attaining and repayment of loans from these institutions scare them from approaching their doors for financial support. In the light of these, market queens who are considered as the aggregators or direct buyers of fish caught from fishermen, friends and relatives and local money lenders were identified as the three main alternative sources of finance for the fishing business owners in times of financial constraints. Presented in Table 4.3, majority (43%) of the sampled respondents obtained financial support from the market queens while the remaining percentage (57), are shared by friends and relatives (35%) and money lenders (22%). It was also revealed that 47%, 24% and 29% of purse seine owners seek financial support from market queens, friends and relatives and money lenders respectively. Also 40%, 47% and 13% of drift gill net owners were found to be supported by market queens, friend and relatives and money lenders respectively. The findings suggest that on the average market queens are the key sources of financial support for fishers along the coastal stretch of central region. This result supports the finding of Bene and Friend (2011) in a related study that artisanal fishers are poor and vulnerable.

Table 4.3:Operational Characteristics of Artisanal Fishers

Variables	**Purse Seine**		**Drift Gill Net**		**Pooled**	
	Absolute N=75	Percentage 100%	Absolute N=75	Percentage 100%	Absolute N=150	Percentage 100%
Alternative Finance						
Market queens	35	47	30	40	65	43
Friends and Relatives	18	24	35	47	53	35
Money lenders	22	29	10	13	32	22
Outboard Motor Brand						
Chrysler	10	13	15	20	25	17
Johnson	5	7	10	13	15	10
Yamaha	60	80	50	67	110	73
Outboard Motor Capacity (hp)						
8hp	3	4	10	13	13	9
15hp	10	13	4	5	14	9
20hp	21	28	17	23	38	25
40hp	41	55	44	59	85	57
Fishing Grounds Depth (m)						
Mean	74.09		73.99		74.04	
Minimum	26		35		26	
Maximum	124		99		124	

Source: Field Survey, 2017

4.4.2 Brand of Outboard Motor

The survey revealed Chrysler, Johnson and Yamaha as the main patronised brands of outboard motor by fishers. Proportionately, the percentages of use of these brands of outboard motors among the respondents were revealed to be 17%, 10% and 73% for Chrysler, Johnson and Yamaha respectively. The Yamaha outboard motor brand was highly patronised by fishers under both technologies indication their preference for the Yamaha brand to the other brand of outboard motor. Capacities of outboard motors were also looked at and were revealed that 57% of the outboard motors used by respondent were 40hp capacity, while 43% were other capacities (8hp, 15hp and 20h). Amador *et al*. (2006) also accounted that most canoes used by artisanal fishers are propelled by outboard motors with engine power up to 40 horse power which have been confirmed in this study.

4.4.3 Depth of Fishing Ground

Discussion with respondents revealed that the further away you travel (sail) from the beach, the deeper the depth of the sea and higher the probability for good catch. This revelation from the fishers supports the empirical finding of Barros and Clarke (2009). From Table 4.3, the mean depth of fishing ground recorded by the pooled system is 74.04 metres. On the average, operators of purse seine fishing technology go deeper (74.09 metre) than their counterpart using the drift gill net (73.99 metres). The maximum depth of fishing ground recorded were 124 and 99 metres for the purse seine and the drift gill net operator respectively. These statistics on depth of fishing grounds are in line with the findings of Amador et al. (2006) which revealed that depth of fishing grounds for most fishers in Ghana ranges between 40m to 130m.

4.5 Results of Validated Hypotheses

Table 4.4 presents the results of the tested hypotheses on the fitness and correctness of the specified model used for the individual fishing technologies.

Table 4.4: Hypotheses Test for the Technologies and Meta-frontier Model Assumption

Null Hypothesis	LR Statistics (λ)	Critical Values	Decision
H_0: $\beta_{rv} = 0$			
Purse seine	47.41	23.21	H_0 Rejected
Drift gill net	44.67	23.21	H_0 Rejected
Pooled	164.29	23.21	H_0 Rejected
H_0: $\Upsilon=\delta_0=\delta_1=\delta_2$--,--,$=\delta_{11}=0$			
Purse seine	58.48[a]	27.03[b]	H_0 Rejected
Drift gill net	62.59[a]	27.03[b]	H_0 Rejected
Pooled	83.26[a]	27.03[b]	H_0 Rejected
H_0: $\Upsilon = 0$			
Purse seine	63[a]	5.41[b]	H_0 Rejected
Drift gill net	23[a]	5.41[b]	H_0 Rejected
Pooled	75[a]	5.41[b]	H_0 Rejected
H_0: $\delta_1=\delta_2$--,--,$=\delta_{11}=0$			
Purse seine	41.35	26.3	H_0 Rejected
Drift gill net	47.83	26.3	H_0 Rejected
Pooled	54.26	26.3	H_0 Rejected
H_0: $f_p(X:\beta_p) = f_d(X:\beta_d)$			
Only pooled	163.46	10.5	H_0 Rejected

Source: Field Survey, 2017. [a]= Values of test for one sided error obtained from the Ox output of the ML estimates. [b] = critical values at 0.001 for the test of hypothesis involving γ obtained from Kodde and Palm (1986: Pp. 1246).

The first Hypothesis which states that the Cobb-Douglas model specification is adequate representation for the purse seine, drift gill net as well as the pooled data set is strongly rejected in favour of the translog frontier model. This means that the coefficients of the second-order variables in the translog model are not zero. The greater LR test statistics against the critical value for all the models indicate acceptance of the results from the translog model to be accurate and consistent as against that from the Cobb-Douglas model. This implies that specification of the translog stochastic frontier models were more suitable to derive valid conclusion in the data.

The second hypothesis was set to test for the presence of inefficiency effects for all the models. The result from this test revealed that inefficiency effects were present in all the three models hence the decision to exclude them was rejected. This is in consonance with the findings of Onumah *et al*. (2010b)

A third hypothesis was set to test the null hypothesis of the average production response function (OLS) against the stochastic model. That is, inefficiency effects are non-stochastic in nature. This decision was rejected in favour of the stochastic model implying that the stochastic frontier model was the most appropriate to be used for all the analyses.

The forth hypothesis that all the coefficients but the constants terms of all the specified three inefficiency models are zero (0) was rejected. The test result attained implied that the combined effects of the assumed inefficiency factors included in the inefficiency models are relevant in explaining the variability of the total output of fish catch by artisanal fishers, though some individual variable effects were not significant.

Log likelihood ratio (LR) was computed in pursuance to validate the null hypothesis that purse seine and drift gill net technologies adopted by the two fisher groups were the same. The null hypothesis was rejected in favour of the alternative as the calculated likelihood ratio test statistics (163.46) was far greater than the critical (17.67) value at a higher significant. This result forms the basis for this research work and has attested to how important to specify the meta-frontier model as the two technologies are different. The revelation of this fifth hypothesis reaffirms similar results by Onumah *et al*. (2013), Battesse *et al*. (2004), O'Donnell *et al*. (2008) and Binam *et al*. (2008).

4.6 Statistics of the Output and Input Variables

The observed annual output (GH₵**)** and input statistics are presented by their respective mean, minimum, maximum and standard deviation. The statistics in Table 4.5 signals some level of disparities among the individual respondents in a group in terms of their respective means and standard deviation of the outputs and inputs levels.

Table 4.5: Summary of Output and Input Variables

Fishing Technology	Output (GH₵/yr)	Labour (Man/trip)	Premix Fuel (Litres/yr)	Duration (Hours/yr)	Other Cost (GH₵/yr)
Purse Seine					
Mean	67612.8	548.50	25706.24	3647.52	7536.48
Minimum	58000	413.08	15682.40	2420.30	5516
Maximum	94000	614.84	30255.20	5072.41	9152.20
St. Dev.	538.32	118.09	417.91	402.73	313.58
Drift Gill Net					
Mean	64414	463.41	24058.88	4528.54	8789.76
Minimum	54500	284.52	14020	2740.00	5926.08
Maximum	84500	531.84	28872.8	6280.10	10251.88
St. Dev.	683.45	107.23	325.61	427.11	553.61
Pooled					
Mean	65760.2	578.09	24882.56	3686.72	14062.40
Minimum	54500	284.52	14020	2420.30	5516
Maximum	94000	614.84	30255.20	6280.10	10251.88
St. Dev.	476.63	184.25	301.19	418.05	438.2

Source: Field Survey, 2017

The mean output value (GH₵65760.2), minimum output value (GH₵54500) and maximum output value (GH₵94000) recorded under the pooled system indicates a wide variation in outputs values among the respondents. The output values of owners using the purse seine net ranges from a minimum of GH₵58000 to a maximum of GH₵94000. This indicates considerable differences in output values among the purse seiners. Respondents using the gill net had an output value range of GH₵54500 to GH₵84500. However, the mean values GH₵67612.8 and GH₵64414 recorded under the purse seine and drift gill net suggest that on a critical day, the respondents using the purse seine technology earn more than their counterparts using the drift gill net.

Labour statistics in Table 4.5 reveals an average of 578.09man-trip labour quantity under the pooled system whereas an average of 548.50man-trip labour quantity and 463.41man-trip labour quantity were employed by owners of purse seine and drift gill net annually. Labour quantity employed by purse seiners ranges from 413.08man-trip to 614.84man-trip. Purse seiners' demand for labour is a little higher than their counterparts whose labour demand ranges between 284.52man-trip labour quantity to 531.84man-trip labour quantity.

Premix fuel consumption records indicate that on average basis, purse seining requires more fuel than fishing with the drift gill net. The average quantity of premix fuel recorded were 25706.24litre/year and 24058.88litre/year for purse seine and drift gill net respectively. The range of premix fuel consumption recorded were 15682.40litre/year to 30255.20litre/year for operating purse seine and 14020litre/year to 2882litre/year for the drift gill net. The least quantity of premix fuel consumed by fishers was 14020litre/year, while none of the exceeded 30255.20litre/year.

From Table 4.5, the mean annual fishing duration of 3647.52hours/year, 4528.54hours/year and 3686.72hours/year were recorded for purse seine, drift gill net and that of the pooled system. This implies that the duration of fishers employing the drift gill net is more than that of the purse seiner. The ranges of duration for the two groups indicate considerable variations among fishers in their respective groups. The duration of Purse seiners ranges from 2420.30hours/year to 5072.41hours/year, while that of drift gill net users was 2440hours/year to 6280.10hours/year. The study also revealed that for a fisher to adopt any of the technologies, an average duration of 3686.72hours/year would be required. Lucakovic and Uphoff (2002) also revealed that a round trip for fishing may last from 12 to 18 hours.

Cost of other inputs (Other cost) was captured as aggregation of all other inputs in monetary (GH₵) terms. The annual cost of other inputs incurred by fishers ranged from GH₵5516 to GH₵10251.88 with a mean of GH₵14062.40. The minimum and maximum annual costs of other input incurred by owners of purse seine were GH₵5516 and GH₵9152.20 respectively. However, GH₵5926.08 and GH₵10251.88 were recorded as minimum and maximum annual cost of other inputs incurred by owners of drift gill net. On the average, annual cost of other input incurred by drift gill net owners (GH₵8789.76) was higher than that of the purse seine owners (GH₵7536.48).

4.7 Parameter Estimates of the Stochastic Frontier and Meta-frontier Models

Table 4.7 presents the summary statistics of maximum-likelihood estimates of purse seine and drift gill net users' frontiers and the meta-frontier but the discussion covers only the output elasticities. At a significance of one percent, estimated sigma-square values for purse seine and drift gill technologies net as well as the pooled system demonstrated strong fit of the models and the correctness of the specified distributional assumptions.

Another statistic of great concern to this analysis is the gamma value which explains how much variation in total outputs is due to inefficiencies and stochastic factors. The estimated gammas for purse seine, drift gill net as well as the pooled system suggest that 93%, 81% and 88% of the variation in total outputs are due to inefficiencies in the use of fishing inputs and other fishing practices among the fishers, whereas 7%, 19% and 12% of the deviations of actual output from the frontier outputs of purse seiners, drift gill netters and that of the pooled system respectively are due to stochastic factors. These stochastic factors could be high tidal shocks, unfavourable weather on the sea, moon light effects, influence of foreign vessels among others.

From Table 4.7, all the input variables except duration of fishing trip were positive and significantly add onto output under the purse seine technology. It is therefore worthy to say that purse seiners' allocation and use of labour, premix fuel and other inputs were productive and that increase in these inputs will result in an increase in fish catch. However, fishing duration of purse seiners must be critically looked at since it reduces productivity. It is also observed that premix fuel had the greatest contribution to output and that purse seiners must capitalize on it use to increase their productivity.

Table4.6: Parameter Estimates of Stochastic Frontier and Meta Frontier Models

Variables	Parameters	Purse Seine (ML)	Drift Gill net (ML)	Pooled (ML)	Meta (LP)
Constant	β0	0.054 (5.72)***	0.119 (18.9) ***	0.090 (0.80)	6.072 (2.92) ***
LnLabour	β1	0.159 (3.76)***	0.114 (1.75)*	0.357(3.40)***	0.552 (0.73)
LnPremix fuel	β2	0.737 (3.08)***	0.605 (2.65)*	0.475(3.87)***	5.605 (4.23)***
LnDuration	β3	-0.086 (-1.64)	0.390 (4.98)***	0.155(2.34)**	2.551 (-4.13)***
LnOther cost	β4	0.184 (2.57)*	0.651 (9.87)***	-0.062(-2.29)***	1.062(2.39)**
Labour square	β5	-1.156(-3.81)***	-2.372 (2.80)***	0.329(1.42)	5.068(-0.73)
Premix square	β6	5.418(1.61)	18.725 (5.33)***	0.143(0.192)	3.104(0.73)
Duration square	β7	-0.599(-1.49)	20.118 (4.19)***	1.228(2.27)**	1.745(1.23)
Other cost square	β8	1.084(1.88)*	-3.509 (-5.92)***	-1.294(-6.73)***	0.7843(2.49)**
(LnLab)*(LnPre)	β9	0.407(0.39)	0.853 (0.403)	0.165(0.78)	4.506(1.78)*
(LnLab)*(LnDura)	β10	0.727(4.06)***	3.712 (2.32)*	1.078(3.97)***	-0.2345(-2.03)**
(LnLab)*(LnOC)	β11	0.832(2.10)*	3.701(6.10)***	-0.047(-0.24)	-0.047(-0.24)
(LnPre)*(LnDura)	β12	-0.685(-0.84)	13.864 (4.04)***	-2.867(-7.08)***	-0.289(-0.32)
(LnPre)*(LnOC)	β13	-4.549(-2.54)*	-3.891 (-2.16)*	-0.788(-1.88)**	-1.432(-2.32)**
(LnDura)*(LnOC)	β14	0.309(1.02)	0.648 (0.517)	0.837(3.86)***	0.992(1.62)
Sigma-square		0.83	0.79	0.73	
Gamma		0.93	0.81	0.88	
Log likelihood		167	168	344	

Note: Values in parenthesis are the t-statistics ***, ** and * represents significance at 1%, 5% and 10% levels respectively. Source: Field Survey, 2017.

With respect to input use under the drift gill net technology, output elasticities were found to be positive and significant for all the inputs used. This result suggests that a percentage increase in the individual inputs employed by fishers using the drift gill net results in an increase in output. Productivity estimates under the pooled system revealed that except the cost of other inputs, all the inputs (labour, premix fuel, and fishing duration) positively appreciated the levels of output of fishers. This result suggests that Labour and premix fuel are key inputs and could be managed to enhance the productivity of artisanal fishers. Labour and other cost of inputs have been found to be productive in other studies like Villano *et al*. (2010) and Onumah *et al*. (2013). Fishers must be mindful of the amount spent on food, ice block, signal light, dry cell, royalties and taxes to prevent or reduce the negative influence of cost of other inputs on productivity.

Highlighting on the meta-frontier estimates, the study indicated some level heterogeneity in the production structure (fishing technologies) culminating into the differences in the estimated parameters between the stochastic pooled estimates and the meta-frontier estimates. All input variables met their priori expectations. All were positive (increasing) and influenced the meta-frontier output significantly except labour found to be insignificant. Table 4.7 presents the parameter estimates of stochastic frontier and the meta-frontier models

4.8 Summary Statistics of Output Elasticities and Returns to Scale

The responsiveness of output to each input used in the fishing operation is presented in Table 4.7. Mean output elasticity with respect to the individual inputs were positive under purse sine technologies except fishing duration which exhibit the opposite. This implies that a percentage increase in the quantity of labour, premix fuel and cost of other inputs results in an increase in the output of fish caught by fishers using the purse seine technology. Meanwhile all the inputs were positive and increased productivity under the drift gill net technology. This result implies a percentage increase in the quantity of labour, premix fuel, fishing duration and cost of other inputs lead to an increase in the output of fish caught by fishers using the drift gill net technology. In a related study, Onumah *et al*. (2013) discovered labour and cost of other inputs to be productive in efficiency analysis of organic and conventional system of cocoa production in Ghana.

Under the pooled system, all but the cost of other input except other cost of inputs exhibited a positive influence on output. In other words, a percentage increase in the quantity of labour, premix fuel and fishing duration results in an increase in the output of fishers. In a related work on aquaculture by Onumah and Acquah (2010) labour was found to influence output positively.

Table4.7: Output Elasticities and Returns to Scale (RTS)

Variables	Purse Seine	Drift Gill net	Pooled
Labour	0.159	0.114	0.357
Premix fuel	0.737	0.605	0.475
Duration	-0.086	0.39	0.155
Other Cost	0.184	0.651	-0.062
Return to Scale (RTS)	**0.994**	**1.76**	**0.925**

Source: Field Survey, 2017

Also presented in Table 4.7 are the values of return to scale for the two fishing technologies and that of the pooled system. This is the summation of the partial elasticities of production with respect to all inputs used under each technology as well as the pooled system. The recorded values of return to scale under the purse seine and drift gill net technologies as well as the pooled system were 0.994, 1.760 and 0.925 respectively.

The total output elasticity (1.760) recorded under the drift gill net technology indicates that a percentage increase in all inputs factors result in a 1.760% increase in level of output for fishers using this technology. This explains that fishers using drift gill net technology are operating under increasing return to scale and therefore have more room to expand their scale of production in order to increase their output in the long run.

The values; 0.994 and 0.925 were the recorded as the total output elasticity under the purse seine technology and that of the pooled system respectively. These values imply that a percent increase in all input factors results in a 0.994% and 0.925% increase in the level of output for purse seine users as well as the pooled system respectively. This implies that fishers under the purse seine technology and that of the pooled system are operating under decreasing return to scale and that they can only increase their productivity by reducing the levels of some inputs (fishing duration and other cost of other inputs).

4.9 Technical Efficiency and Technology Gap Ratios (TGR)

Table 4.8 presents the summary statistics of the group technical efficiencies (TE), meta-frontier efficiencies (TE*) and the technology gap ratios (TGR).

Table 4.8 reveals the mean technical efficiencies of the stochastic frontier model to be 0.82, 0.79 and 0.72 for purse seine and drift gill technologies as well as the pooled system respectively. These values imply that owners of purse seine and drift gill and that of the pooled system are operating 18%, 21% and 28% below their group frontiers. In this regard, if owners have to attain 100% efficiency level, then they would have to bridge the gap between their current output levels and the frontiers defined by their output.

From Table 4.8, mean technology gap ratios for purse seine technology is 0.78 while that of the drift gill net is 0.74. These results imply that if owners of purse seine and drift gill net were to be 100% efficient, they could have expanded their output levels by bridging the gap of 22% and

26% respectively if the most efficient meta-technology were adopted. The technology gap ratio of purse seiner ranges from 0.15 to 0.98 whilst that of the drift gill net is 0.07 to 0.94. These statistics imply that artisanal marine fishers employing the purse seine technology are closer to the meta-frontier than those using the drift gill net technology.

Table 4.8: Summary Statistics of Technical Efficiency and Technology Gap Ratio

Technology/TE/TGR	Mean	Minimum	Maximum	St. Deviation
Technical Efficiency (Stochastic Frontier)-TE				
Purse seine	0.82	0.37	0.98	0.06
Drift gill net	0.79	0.31	0.95	0.20
Pooled	0.72	0.23	0.97	0.22
Technical Efficiency (Meta-Frontier)-TE*				
Purse seine	0.63	0.31	0.96	0.22
Drift gill net	0.61	0.29	0.93	0.24
Pooled	0.58	0.21	0.91	0.25
Technology Gap Ratio (TGR)				
Purse seine	0.78	0.15	0.89	0.16
Drift gill net	0.74	0.07	0.84	0.23
Pooled	0.76	0.11	0.86	0.21

Source: field survey, 2017

As revealed in Table 4.8, the mean meta-technical efficiency scores for purse seine and drift gill net technologies were 0.63 and 0.61 respectively. It can therefore be deduced that on the average, purse seiners are more technically efficient and that users of the drift gill net technology need to be strategic in the use of their fishing inputs and address operational setbacks in order to match up with their counterparts.

4.10 Determinants of Technical Inefficiency

Derivation of policy recommendation base on the estimated technical efficiency levels among the two groups of fishers alone is not enough for the justification of this study. In a single stage, the inefficiency model was estimated simultaneously with the stochastic frontier models of each technology. The result of the inefficiency analysis is illustrated in Table 4.9.

Table 4.9: Parameter Estimates of the Inefficiency Model

Variables	Parameter	Purse seine	Drift gill net	Pooled
Constant	δ_0	0.081 (2.22)**	0.106 (3.48)***	0.070 (0.02)
Gender	δ_1	-0.053 (1.55)	0.047 (3.62)***	0.045 (3.50)***
Age	δ_2	-0.06 (-2.27)**	-0.08 (-1.20)	-0.001 (-2.55)**
Marital Status	δ_3	0.112 (1.61)	0.059 (3.19)***	0.099 (4.57)***
Household size	δ_4	4.173 (2.49)**	0.004 (1.52)	-0.001 (-1.40)
Resource ownership	δ_5	0.017 (2.91)***	0.059 (3.19)***	0.020 (0.96)
Business Experience	δ_6	0.003(-1.59)	0.005 (1.03)	0.004 (1.73)*
Formal education	δ_7	0.002 (-3.53)***	0.019 (1.34)	-0.011 (-2.22)**
Other Occupation	δ_8	0.017 (2.91)***	0.047 (3.62)***	0.047 (4.71)***
Alternative finance	δ_9	0.053 (1.55)	0.047 (3.62)***	0.045 (3.50)***
Fishing ground depth	δ_{10}	-0.002 (-4.53)***	-0.004 (-2.39)**	-0.005 (-2.68)**
Motor Capacity	δ_{11}	-0.0117 (2.98)**	-0.059 (3.19)***	0.005 (0.377)

Source: Field Survey, 2017. Note: Values in parenthesis are the t-statistics; ***, ** and * means significance at 1%, 5% and 10% respectively

Presented in Table 4.9, the variable gender was positive and significant under the drift gill net technology but negative under the purse seine though insignificant. The positive significance implies that drift gill net owners who are males are less technically efficient and produce inefficiently as compare to their female counterparts. The positive effect of gender again reflected under the pooled system. This can be explained that male fishers who are always the bread winners of families as custom demands in most fishing communities spend a lot on other expenses outside the fishing business. In other words, they are more likely to engage in other competing income generating venture that may affect the smooth operation of their fishing businesses. In a related study, Onumah and Acquah (2010) presented a contradicting result from their study.

The study also found age to be negative in all the estimated models but insignificant under drift gill net technology. An implication of this outcome is that ages of major decision makers under the purse seine as well as the pooled increase technical efficiency. This confirms the finding of Tzouvelekas *et al*. (2001). Further the explanation to this finding is that younger major decision maker are less technically efficient which can be attributed to low managerial skills and to some extent their deficiency in terms of fishing resources (labour, capital etc.).

Marital status was found to be positive under all the two fishing technologies as well as the pooled system. However, was insignificant under the purse seine technology. Positive influence on inefficiency implies that owners who are married were less efficient than those of other status (single, separated, divorced and widowed). This result contrasts the proposition of Koranteng (1998) that fishers marry more than one woman to increase output as a result of increased family labour. This can be explained that married decision makers might be disturbed by marriage and its family-related responsibilities which affect their capital base and smooth operation of the fishing business hence contributing to inefficiency.

Household size increases inefficiency under the two technologies but insignificantly reduces inefficiency under the pooled system. This implies that as increasing household size (dependent) of major decision makers translate into reduction of technical efficiency. This result contradicts the finding of Ogundari and Akinbogun (2010) that large household size contributes to timely supply of labour. It can therefore be explained that higher household size leads to greater household expenditure (food, shelter, health care, accommodation, educational spending etc.) hence pressure on the limited resources to meet the demand of fishing business and that of the household expenditure.

The study revealed resource ownership to be positive and significantly influence both technologies. This implies that fishing businesses owned by individual persons (solely owned) are less efficient and increase inefficiency. It can be deduced that purse seine and drift gill fishing businesses owned and operated by more than one person are more efficient than those owned and operated by single person. This finding supports the reason that individually owned businesses are constrained to some extent in acquiring credit and some productive resources for business operations and development (expansion).

Years of business experience was revealed to be positive but only significant under the pooled system. This indicates that as owner of fishing businesses advances in years of operating and managing the fishing business, their level of efficiency reduces. This finding affirms that of Onumah *et al*. (2013) on cocoa production in Ghana. This finding might be explained that experience owners become complacent, reluctant and diverse income (profit) into different ventures thereby reducing efficiency levels.

Table 4.9 revealed that formal education was negative and significantly influenced inefficiency under the pooled system. However, it was positive under the two technologies. This finding implies that owners with some level of formal education and operating under purse seine and drift gill net were less efficient. A similar result was obtained in a related study by Onumah *et al*. (2010b).

The variable, other occupation was found to be significant and positive under all the technologies including the pooled system. An implication to this finding is that owners engage in an alternative work (salaried, wages or unpaid personal) are less technically efficient. This can be justified that engaging in other work distracts their attention from the fishing business and are also constrained to divert or split the little and insufficient-production resources among the fishing business and the alternative work. This result affirms the finding of Asmah (2008) who justified that full time fish farmers tend to allocate many resources into their fish farming activities to achieve high productivity.

Alternative finance source was found to be positive under both technologies as well as the pooled but insignificant under the purse seine technology. This result implies owner who seek financial support from market queens are inefficient. Empirical findings from Onumah *et al*. (2013), Binam *et al*. (2008) and Nyagaka *et al* (2010) revealed that access to credit is vital to improving the performance of farmers. Though fisher were unable to access credit from formal financial institutions but the credit they had from the market queens did not make them better off. The explanation to this might be that the quantum amount received from market queens could only be used for operational activities (purchase of input) and not for maintenance and expansion needs.

Depth of fishing ground was found to be negative and significant under both technologies as well as the pooled data. Implication to this finding is that the deeper the depth of the fishing grounds, the greater the output of fish catch. This is further explained that output of the fishers increased with increasing depth of the sea which confirms the finding of Barros and Clarke (2009).

Capacity of outboard motor was negative and significant under purse seine and drift gill net. This finding implies that both purse seiners and drift gill netters propelling their fishing crafts with outboard motors of 40hp capacity are more technically efficient than those using outboard motors of other capacities. In a related study, Amador *et al*. (2006) found out that the capacity of outboard motor in fishing depends on the size of the fishing craft. This study however, has revealed that technical efficiency increases when fishing crafts are propelled with 40hp outboard motors.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Introduction:

This chapter contains summary of the findings drawn from the study, conclusions based on the major findings and policy recommendations for future interventions.

5.2 Summary and Major Findings

The study was conducted to take a technical dimension to join in the chase for solution to the declining performance of the Ghanaian fisheries industry. Against this background, technical efficiency analysis was conducted to compare two predominantly employed fishing technologies by artisanal marine fishers in central region of Ghana. The stochastic meta-frontier model was adopted and applied to measure the productivity levels and technical efficiency differentials of the two technologies (purse seine and drift gill net). The adopted methodology (meta-frontier) allows the estimation of parameters of frontiers, technology gap ratios and technical efficiency levels using empirical results from the stochastic frontier models and the meta-frontier.

Validations of hypothetic model specification were conducted to establish the appropriateness of the methodology model specifications. Decisions were made in favour of the meta-frontier as well as the stochastic frontier model. Estimation of parameters and technical efficiency scores were obtained for each technological stochastic frontier. Identified demographic, managerial and operational factors assumed to influence inefficiency were modeled to ascertain their effects on technical inefficiency. The study based on a multi-stage sampling approach to select a total of one hundred and fifty (150) major decision makers (owners of fishing canoes and net) under the two technologies. Model test was conducted and the translog model was chosen over the Cobb-

Douglas model because it gave a consistent estimates. The stochastic frontier models showed a better fitness to the data set than the ordinary least square function (OLS). In addition the combined effect of exogenous variables showed variations in efficiencies.

Estimated output responses to inputs used revealed that labour, premix fuel and cost of other inputs were positive and significantly influenced productivity of fishers operating under both technologies. Output responses under the pooled system indicated that labour, premix fuel and duration of fishing were positive and significantly added on to output. Contrary to priori expectation, duration of fishing and cost of other inputs were found to be reducing the productivity of owners employing purse seine technology as well as the pooled system respectively. Owners of drift gill net were operating under increasing return to scale while purse seiners as well as the pooled system had a decreasing return to scale.

Stochastic efficiency analysis revealed 0.82 mean efficiency level for owner of the purse seine nets while the drift gill net owners recorded 0.79 mean efficiency level. It was found to be 0.72 under the pooled system. This indicates that fishing under the purse seine and drift gill net as well as the pooled system were operating 18% and 21% and 28% respectively below their group frontiers. The estimated technology gap ratios (0.78% and 0.74% for purse seine and drift gill net owners respectively) imply if they were technically efficient (100), they could have expand output levels by bridging the gaps 22% and 26% respectively. Analysis of meta-efficiency levels revealed mean efficiencies of 0.63%, 0.61% and 0.58% for purse seine and drift gill net owner as well as the pooled system respectively. It empirically points to the fact that owners of fishing businesses who employ the purse seine technology are more technically efficient compared to their counterparts using the drift gill net. They could be competitive by reconsidering their personal, managerial, operational characteristics as well as the level and allocation of input use.

The inefficiency of the purse seine owners were influenced positively by the following characteristic; marital status, household size, ownership of fishing business, business experience, formal education, other occupation and alternative finance. This further explains that married purse seine owners, purse seine owners with large household size, solely owned fishing businesses, experienced purse seine owners, formally educated purse seine owners, purse seine owners with alternative work and owners who receive financial support from market queens are less technically efficient. On the contrary, depth of fishing ground and capacity of outboard motor were negative and significantly influence inefficiency. This indicates that purse seiners who propel their fishing crafts (canoes) with forty horse power outboard motor capacity and have deeper fishing grounds were more technically efficient than those who were using other capacities of outboard motor and operate on shallow fishing grounds.

Inefficiency estimation for the drift gill net model revealed that only two of the predetermined inefficiency factors (gender and outboard motor capacity) negatively influenced inefficiency. This implies drift gill net owners who were females and propelled their crafts with forty horse power outboard motor capacity were more technically efficient.

Under the pooled system, gender, marital status, ownership of fishing business, business experience, other occupation, alternative source of finance and motor capacity were found to be positive and increasing inefficiency of fishing businesses. However, age, household size, formal education and depth of fishing ground had a decreasing effect on inefficiency. This result suggests that aging business owners, owners with smaller household size, owners who have attained some level of formal education and fishers who had deeper fishing grounds were more technically efficient.

5.3 Conclusion

Based on the findings identified from the study, it is established that the meta-frontier and the transcendental logarithmic models are most appropriate and best fit the data for this study. Furthermore, labour, premix fuel and cost of other inputs increased output of purse seine owners as well as the drift gill net owners. This suggests that labour, premix fuel and cost of other inputs are highly productive and increase fishers' efficiency level. Productivity estimates under the pooled system indicate that labour, premix fuel and fishing duration are productive and significantly increase the output levels of artisanal fishers in the central region.

Based on the RTS scores obtained, the study concludes that productivity increases more proportionately with increase in the level of all input factors employed by drift gill net owners. However, productivity increases less proportionately with increase in all input factors employed by owner using the purse seine net.

Following the findings from the technology gap ratio scores, owners employing the purse seine fishing technology are closer to the best practice meta-technologies in the artisanal marine fisheries subsector than their counterparts operating under the drift gill technology. Empirically, the meta-frontier efficiency scores reinforce that purse seine technology is more technically efficient compared to the drift gill technology. It can be further established that purse seiners have the highest potential to close the gap between their frontier and the maximum potential frontier (meta-frontier).

Based on the inefficiency analysis, the study concludes that artisanal fishing activities in Ghana are characterised by inefficiencies. Findings from the inefficiency analysis establishes that male owners of fishing businesses, owners who are married, experienced owners, owners having alternative work, owner who seeks financial support from market queens are less technically efficient. However, aging owners of fishing businesses and owner with some level of formal education are more technically efficient.

5.4 Policy Recommendations

The study recommends that owners of fishing businesses under the drift gill technology should strive to increase their scale of production by adopting productive measures that will boost their productivities through better management practices and effective allocation and utilization of inputs. Purse seine owners operating under decreasing return to scale are advised to reconsider (reducing fishing duration) the level of inputs use and address some inefficiency factors like source of financial support, effects of their alternative occupations, among others in order to increase their scale of production.

Owners of both technologies were identified to be operating below their group frontiers which suggest that they are less technically efficient. It is therefore recommended that artisanal marine fishers should strive hard to reduce their inefficiency levels by addressing some issues pertaining to their personal, management and operational characteristics.

It is also recommended that government and stakeholders of the fisheries industry should help provide coastal-specific education and monitoring systems in the fishing communities. This will help alleviate or reduce the ever-existing and ever-increasing illiteracy rate among coastal folks and to also help boost fishers' productivity level.

To reduce the level of inefficiencies among fishers in the artisanal fishing industry, the study recommends that stakeholders in the fisheries industry (government, MFRD, MoFAD, NGOs and other development partners) should support owners of canoes and fishing nets in the area of fishing education and training, timely supply of subsidised inputs, more importantly premix fuel and forty horse power outboard motors.

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APPENDICES

APPENDIX: SURVEY QUESTIONNAIRE

COMPARATIVE ANALYSIS OF THE PERFORMANCE OF PURSE SEINE AND DRIFT GILL TECHNOLOGIES AMONG ARTISANAL MARINE FISHERS IN THE CENTRAL REGION OF GHANA

TOPIC

PERFORMANCE OF PURSE SEINE AND DRIFT GILL NET TECHNOLOGIES AMONG ARTISANAL MARINE FISHING FIRMS IN CENTRAL REGION OF GHANA

PREAMBLE:

This is a research work of MPhil Agribusiness student of University of Ghana. You are humbly requested to help provide all necessary answers to each question below. NB: All information given would be treated confidential and only be used for the purpose stated above.

Serial Number: | | | |

Date of interview | d | d | m | m | 2 | 0 | 1 | 6 |

A. INTRODUCTION

Name of Enumerator...

District..

Community/Village/Town………………………...

Name of Respondent…………………………………………………………………………….

Telephone Number | | | | | | | | | | |

Type of Fishing Technology……..**1= Purse Seine [ ]** **2= Drift Gill Net [ ]**

Certified by………………………………………….. (Sign only after questionnaire is complete)

Serial Number: | | |

B. DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS OF OWNER

1. What is the gender of fishing firm's owner? 1= Male [ ] 2= Female [ ]
2. Age? ....years
3. Marital status? 1= Single [ ] 2= Married [ ] 3= Divorced[ ] 4=Separated [ ] 5= Widowed [ ]
4. Household size? 1= male Children (<18yrs) [ ] 2= female Children (<18yrs) [ ] 3= male Adult (>18yrs) [ ] 4= female Adult (>18yrs) [ ]
5. Religious background? 1= Muslim [ ] 2= Christian [3=Traditionalist [ ] 4= Otherwise (specify…………………………………………………..……..…………..….)
6. Ethnic group……………………………………………………………………………..
7. Ownership of the fish farm: 1= Solely owned [ ] 2= Family [ ] 3= Group owned [ ] 4 = Other (Specify)…………………………………………………………………………..
8. How did you enter into the fishing business? 1= Inheritance [ ] 2= Personal Investment [ ] 3= Otherwise (specify…………………………………….)
9. Maximum level of education? 1= No schooling [ ] 2= Primary [ ] 3=JHS/MSLC [ ] 4= SHS/TECH/VOC [ ] 5= Tertiary [ ]
10. How many years did you spend to attain your maximum education level? …………..…years
11. What is your major occupation? 1= Fishing [ ] 2= Trading [ ] 3= Salary worker [ ] 4= Otherwise (specify…………………………………………………………..…………)
12. Do you engage in any other work? 1= Yes [ ] 2= No [ ]
13. If yes, then specify………………………………………………………………………….
14. Have you undergone any technical fishing education before? 1= Yes [ ] 2= No [ ]
15. If Yes then specify…………………………………………………………………………
16. How many years have you been in the fishing business? ……………………………..years
17. What motivated you into the fishing business? ……………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
18. What informed your decision to choose this community for the fishing business? ....
………………………………………………………………………………………………
……………………………………………………………………………………………....
……………………………………………………………………………………………

Serial Number: [| |]

19. What informed your choice of fishing technology? ....
………………………………………………………………………………………………….
…………………………………………………………………………………………..
………………………………………………………………………………………………
20. What is the total number of crew employed per trip? …………………………………..crew
21. Are you a member of any fishing Association? 1= yes [ ] 2= No[ ]
22. If yes, specify………………………………………………………………………………
23. Are you a native of this community? 1= Yes [ ] 2= No [ ]
24. If No to question 19 above specify where you come from…………………………………..
25. How did you become a fisher in this community? ……………………………………………..
……………………………………………………………………………………………...
……………………………………………………………………………………………...
26. Do you have access to credit? 1 = Yes 2 = No
27. If yes; which of the following sources do you receive credit from? 1 = Personal saving [ ] 2 = Family and/or Relatives [ ] 3 = Commercial banks [ ] 4 = Microfinance institutions [ ] 5 = Money lenders [ ]

C. PRODUCTION SYSTEM AND LEVEL OF INPUTS

C1. Variable inputs use per one fishing trip

24. Please help provide the age and gender distribution of crews employed per one fishing trip?

Main Season

Main Season

Age group of crew	Hired Labour	family Labour	No. of people	Work days per week	No. of trips per day	hours of work per day	Rate per hrs or day	Wage per month if permanent
Male<18								
Female<18								
Male>18								
Female>18								
Total								

Serial Number: | | | |

Lean Season

Age group of crew	Hired Labour	family Labour	No. of people	Work days per week	No. of trips per day	hours of work per day	Rate per hrs or day	Wage per month if permanent
Male<18								
Female<18								
Male>18								
Female>18								
Total								

Pre-mix fuel use per one fishing trip

25. What is the source of the pre-mix fuel you use for fishing?...
26. How often do you get access to the pre-mix fuel? 1= Daily [ ] 2= Weekly [ ] 3= Fortnight [ ] 4= Monthly [ ] 5= Otherwise (specify……………….…………..)
27. What is the unit of measurement? 1= Gallon [ ] 2= Litres [ ] 3= Bowl [ ] 4= Tins [ ]
28. If answer to question 27 either 3 or 4; what is the equivalent of one in gallon………… or liters?..........
29. How much is one unit of the pre-mix fuel? ……………………………………....(GH¢)
30. How many units of pre-mix does it take to complete the fishing operations at the fishing ground? ……………………………..…
31. What do you do during shortage of pre-mix fuel? .... ………………………………………………………………………………………….
32. How much do spend on the above stated alternative?...(GHC)

Duration per one fishing trip:

33. What time within the day do you set in for fishing? ……………………………………....
34. How many minutes or hours do you spend to sail from the beach to the fishing ground?......mins/hrs
35. At what depth of the sea do embark on the fishing?........................Phantom
36. What is the total time spent between casting and hauling of the net?.......................mins/hrs
37. How many minutes or hours does it take to return from the fishing ground to the beach.….mins/hrs?
38. What time do you normally return from the fishing to the beach? …………………………..

Serial Number: [| |]

C3 FIXED INPUTS USE PER ONE FISHING TRIP

Canoe expenses per one fishing trip

39. Which type of fishing canoe do you use? 1= Small size one man canoe [ ] 2= Medium size lines and nets canoes [ ] 3= Large ali poli canoes [ ] 4= Large beach seine canoes [ ]
40. How did you acquire your fishing canoe? 1= Purchased [ ] 2= Inheritance [ ] 3= Hired [ ] 4= Otherwise (specify……………….……………………………………)

Continue question 41 to 49; if respondent answered 3 and/ or 4 to question 40, skip to question 50 if otherwise

41. Where do you hire the canoe? ....
42. What is the system of hiring (terms)? 1= Amount per hour [ ] 2= Amount per trip [ ] 3= Amount per day [ ] 4= Otherwise (specify……………………………………….)
43. What is the mode of payment? 1= Cash [ ] 2= Kind [ ]
44. If answer to question 43 is **1= cash**, how much do you pay for using the canoe per one term of contract? .... (GH¢)
45. If answer to question 43 is **2= Kind** (specify……………………………………………..
……………………………………………………………………………………………)
46. Find the equivalent in monetary term…………………………………..………….(GH¢)
47. Do you bare any maintenance cost of the canoe? 1= Yes [ ] 2= No [ ]
48. What is the routine maintenance schedule? 1= per trip [ ] 2= Daily [ ] 3= Weekly [ ] 4= Monthly [ ] 5= Otherwise (specify……………………………………………….)
49. How much do you pay for one maintenance schedule? ………………………………(GH¢)
50. Where did you purchase your canoe? ....
51. When did you purchase you canoe? …………/……………/…………….
52. How much did you spend to acquire the canoe? ……………………………………(GH¢)
53. What source of fund did you use to acquire the canoe? 1= personal savings[ ] 2= Loan from friends and relatives [ ] 3= Loan from bank [ ] 4= Money lenders [ ]

Continue from question 54 to 61; if respondent answered 2 and/or 3 and/or 4 to question 53 or skip to question 62 if otherwise

54. What is the name of the institution or money lender? ....……………………………………
………………………………………………………………………………………….
55. What is the interest rate? ....per annum.
56. What is the repayment duration? From ………/…….../…..... to …..…. /...…../..……..

Serial Number: | | | |

57. What is the repayment system? 1= Cash payment [ ] 2= Kind payment
58. What is the repayment schedule? 1= per trip [ ] 2= per day [ ] 3= per month [ ]
59. How much do you pay in cash? ……………………………………………………..…(GH¢)
60. If answer to question 62 is **57= Kind** (specify…………………………….……………………
……………………………………………………………………………………………….…
…………………………………………………………………………………………………)
61. Find the equivalent in monetary term…………………………………………...…..(GH¢)
62. When did you start using the canoe……………. /………………. /………………
63. How many years do you think the canoe will last? …………………………………years
64. What is the routine maintenance schedule? 1= per trip [ ] 2= Daily [ ] 3= Weekly [ ] 4= Monthly [ ] 5= Otherwise (specify……………………………………………………)
65. How much do you pay for one maintenance schedule? ……………………………….(GH¢)
66. How much will you spend to acquire a new canoe currently? .... (GH¢)

Outboard motor expenses for one fishing trip

67. Which brand of outboard motor engine do you use? 1= Yamaha [ ] 2= Chrysler [ ] 3= Johnson [ ] 4= Otherwise (specify……………………..…………………….…..)
68. What is the horse power of the outboard motor?...hp
69. How did you acquire your outboard motor? 1= Purchased [ ] 2= Inheritance [ ] 3= Hired [ ] 4= Otherwise (specify………………………………………………)

Continue question 70 to 78; if respondent answered 3 and/ or 4 to question 69, skip to question 84 if otherwise

70. Where do you hire the outboard motor? ....
71. What is the system of hiring? 1= Amount per hour [ ] 2= Amount per trip [ ] 3= Amount per day [ ] 4= Otherwise (specify………………..……………………)
72. What is the mode of payment? 1= Cash [ ] 2= Kind [ ] Otherwise (specify…………………………….....……………………………..…)
73. If answer to question 72 is **1= cash**, then how much do you pay for using the outboard motor per one term of contract?... (GH¢)
74. If answer to question 72 is **2= Kind or 3=otherwise**, (specify…………………………..…..)
…………………………………………………………………………………………….…)
75. Find the equivalent in monetary term……………………………………..……………(GH¢)

Serial Number: [| |]

76. Do you bare any maintenance cost of the outboard motor? 1= Yes [ ] 2= No [ ]
77. What is the routine maintenance schedule? 1= per trip [ ] 2= Daily [ ] 3= Weekly [ ] 4= Monthly [ ] 5= Otherwise (specify………………………………………………..)
78. How much do you pay for one maintenance schedule? …………………… ...……(GH¢)
79. Where did you purchase your outboard motor? ....
80. When did you purchase it? ………../…………../…………….
81. How much did you buy the outboard motor? ……………………………….……(GH¢)
82. What source of fund did you use to acquire the outboard motor? 1= personal savings[ ] 2= Loan from friends and relatives [ ] 3= Loan from bank [ ] 4= Money lenders [ ]

Continue from question 83 to 90; if respondent answered 2 and/or 3 and/or 4 to question 82, skip to question 91 if otherwise

83. What is the name of the institution or money lender? ...…………………………………..
    ………………………………………………………………………………………
84. What is the interest rate? ....per annum.
85. What is the repayment duration? From ……../…../….. to ……. /..….../..…..
86. What is the repayment system? 1= Cash payment [ ] 2= Kind payment [ ] 3= Otherwise (specify…………………………………………………………………….)
87. What is the repayment schedule? 1= per trip [ ] 2= per day [ ] 3= per month [ ]
88. How much do you pay in cash? …………………………………………………(GH¢)
89. If answer to question 86 is **2= Kind or 3=otherwise**, (specify……………………….….. ……………………………………………………………………………….… ……………………………………………………………………………………..)
90. Find the equivalent in monetary term……………………………………………(GH¢)
91. What is the current price of the outboard motor? .... (GH¢)
92. When did you start using the outboard motor………… /………… /……………..
93. How many years do you think the outboard motor will last? …………………………...years
94. What is the routine maintenance schedule? 1= per trip [ ] 2= Daily [ ] 3= Weekly [ ] 4= Monthly [ ] 5= Otherwise (specify………………...………..)
95. How much do spend on one maintenance schedule? …………………..………………(GH¢)

Serial Number: [| |]

Details of Fishing Net and expenses per one fishing trip

96. What type of material is your fishing net made of? 1= Cotton [ ] 2= Nylon [ ] 3= Linen [ ]
97. What is the mesh size of your fishing net? …………………………..….millimetres
98. What is the yarn size of your fishing net? ……………………………………….R
99. What is the length of the fishing net? ……………………..……………..metres
100. What is the height of the fishing net?...metres
101. How did you acquire your fishing net? 1= Purchased [ ] 2= Inheritance [ ] 3= Hired [ ] 4= Otherwise (specify……….…………………………..……………..….)

Continue question 102 to 110; if respondent answered 3 and/ or 4 to question 101, skip to question 111 if otherwise

102. Where do you hire the fishing net? ....
103. What is the system hiring? 1= Amount per hour [ ] 2= Amount per trip [ ] 3= Amount per day [ ] 4= Otherwise (specify………….. ……………………………)
104. What is the mode of payment? 1= Cash [ ] 2= Kind [ ] 3= Otherwise (specify……………………….…………………………………………….)
105. If answer to question 104 is **1= Cash**, then how much do you pay for using the fishing net per one term of contract? .... (GH¢)
106. If answer to question 104 is **2= Kind or 3= Otherwise** (specify………..………….. ……………………………………………………………………………………………….. ……………………………………………………………………………………………….)
107. Find the equivalent in monetary term………………………………………(GH¢)
108. Do you bare any maintenance cost of the fishing net? 1= Yes [ ] 2= No [ ]
109. What is the routine maintenance schedule? 1= per trip [ ] 2= Daily [ ] 3= Weekly [ ] 4= Monthly [ ] 5= Otherwise (specify…………………..…..……)
110. How much do you pay for one maintenance schedule? …………..……..……(GH¢)
111. How much did you spend to acquire the fishing net? ……………………..…(GH¢)
112. What source of fund did you use to acquire the fishing net? 1= personal savings[ ] 2= Loan from friends and relatives [ ] 3= Loan from bank [ ] 4= Money lenders [ ]

Continue from 118 to 121; if respondent answered 2 and/or 3 and/or 4 to question 112, skip to question 122 if otherwise

Serial Number: [| |]

113. What is the name of the institution or money lender? ....…………………………….

………………………….……………………………………………………………………….

114. How much did you receive? ………..…………………………………….. …. (GH¢)

115. At what interest rate? ....per annum.

116. What is the repayment duration? From ……../…../….. to ..…. /..…. /…...

117. What is the repayment system? 1= Cash payment [ ] 2= Kind payment [ ]

118. What is the repayment schedule? 1= per trip [ ] 2= per day [ ] 3= per month [ ]

119. How much do you pay in cash? ……………………………………………..……(GH¢)

120. If answer to question 117 is **2= Kind** (specify………………….……..

…………………………………………………………………………………………….….

……………………………………………………………………………………………….)

121. Find the equivalent in monetary term………………………………………….(GH¢)

122. When did you start using the fishing net? ………../………../…………

123. How many years do you think the fishing net will last? …………………..years

124. What is the routine maintenance schedule? 1= per trip [ ] 2= Daily [ ]
3= Weekly [ ] 4= Monthly [ ] 5= Otherwise (specify…………………………….)

125. How much do spend for one maintenance schedule? …………………………(GH¢)

C4. INFORMATION ON OUTPUT LEVELS PER ONE TRIP

126. What do you use to measure your fish catch? 1= Calibrated instrument [ ]
2= Non-calibrated instrument [ ]

127. If answer to question 131 above is **2= Non-calibrated**, specify……………………..

………………………………………………………………………………………………….

128. What is the kilogram equivalent of one unit of the material used for measurement? ....Kg

Please help complete (fill) the table below

Output per one fishing trip per Season

Season	**Total Qnty (Pan)**	**Total Qnty (bowl)**	**Kilogram equivalent**
Main season			
Lean season			
Total			

Serial Number: | | | |

Marketing Points and Price Levels of Fish

129. Do you have access to ready market? 01 = Yes [ ] 02 = No [ ]

130. Please which of these places do you sell your catch? help complete the tables below

Marketing Points and Price levels

Market centres	**Main season fish price**					
	Pan	**Unit Price**	**Bowl**	**Unit Price**	**Kilogram**	**Unit Price**
On-Shore						
Beach						
Local market						
External market						
Export						
Others						

Marketing Points and Price levels

Market centres	**Lean season fish price**					
	Pan	**Unit Price**	**Bowl**	**Unit Price**	**Kilogram**	**Unit Price**
On-Shore						
Beach						
Local market						
External market						
Export						
Others						

131. What is your perception about the fishing business?

1 = Very Good 2 = Good 3 = Normal 4 = Poor 5 = Very Poor