COMPARATIVE ECONOMIC ANALYSIS OF REGULATED AND UNREGULATED NATURAL LAKES FISHERIES IN PLATEAU STATE, NIGERIA

BY

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PhD/AGRIC/11965/07-08

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS.

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY,
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October, 2012

DECLARATION

I hereby declare that this dissertation titled "**Comparative Economic Analysis of Regulated and Unregulated Natural Lakes Fisheries in Plateau State Nigeria"** has been written by me and it is a record of my research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All borrowed ideas have been acknowledged in the text and a list of references provided

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CERTIFICATION

This dissertation titled "**Comparative Economic Analysis of Regulated and Unregulated Natural Lakes Fisheries in Plateau State**, **Nigeria"** by Naanpoes Charles **Dawang** meets the regulations governing the award of the Degree of Doctor of Philosophy of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the memory of my departed parents **Pastor and Mrs. Sylvanus Dawang** and Sister **Ms. Rachael Dawang** may your souls rest in the bosoms of our Lord and Savour Jesus Christ. Amen.

ACKNOWLEDGEMENT

I am profoundly indebted to my supervisors, Prof. J. O. Olukosi, Prof. S. A. Sanni, Prof. S. A. Rahman and Prof. S. J. Auta for their professional guidance, valuable advice and strong support, which greatly contributed to the success of this work. I cordially thank Prof. I. I. Dafwang, Prof. Ben Ahmed, Prof. J. F. Omokore, Prof. Ajala, Dr. A. Zakari and Dr. D. Maiyaki for their valuable discussions help and friendship and I also give appreciation to Mrs. M.E. Azaka and Mr I.A. Akaa for her kind help in administrative work. I extend big thanks to Dr. O. N. Ndam, Dr. Gilbert, Dr. A. Dasbak, Dr. A. Banta, W. Manggoel, Polycarp M. Dachuk, Mailumo S. S., Kayili, John Bilat, Victor and Charles of NVRI, Vom, Jos for their friendship during my study. Dr. Rapheal Omolehin willingly gave me LIMDEP software for the analysis; thank you. Gratitude is also extended to Ms Esther Pam and Mr. Stanley; the officials of Pandam Wildlife Park for their help and facilitation during the data collection and special thanks to the fishing families at the study area for their hospitality and willingness to provide me and my enumerators with information during our stay in the study area. I sincerely appreciate Mrs. Grace S. Mundat and Mrs. A. Guwo for the unlimited tolerance as well as their unreserved support, which made my time in Zaria warm and enjoyable. I wish to also thank my brothers and sisters for their support. I also thank Ahmadu Bello University, Zaria, for giving me the chance to study. Finally, I would like to express my appreciation to Ajiguenaan, Moenshinaan and my wife, Helen for bearing my absence during the course of the study, their continuous prayers for me, understanding, encouragement, patience, trust and above all their love, for the LORD will do you good. God bless you all. Amen

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ABSTRACT

This study examines the comparative economics of resource exploitation levels of government regulated (RENLAF) and unregulated (URENLAF) fisheries through the assessment of socio-economic characteristics, determinants of participation in regulated fishing, determinants of site choice among the unregulated fishers, estimate level of compliance, costs, returns, profitability, technical efficiency and evaluate constraints of natural lakes artisanal fishers in Plateau state, with a view to examine the economic efficiency of effort allocation and exploitation of fisheries as renewable resource in the country. Daily fishing observations were made during catch assessment survey (CAS) for 4 weeks and recorded in a logbook. Data were collected through questionnaire from 20 fishers' randomly selected each from Polmakat, Shimankar, Deben, Janta lakes and 30 other fishers purposively selected from regulated Pandam Lake. This gives a sample size of 110 respondents from a sample frame of 656. The analyses were carried out using descriptive statistics, logistic regression, multinomial logit, ordered probit, corrected least square and stochastic frontier production function models. The result indicated that both RENLAF and URENLAF fishers had similar socio-economic characteristics. The logit result suggested that heterogeneous fishing skills, catch-per-unit-of-effort and extension contact significantly influence decision to participate in regulated fishing. Furthermore, the study observed that age, family size, alternative source of income, extension contact and heterogeneous fishing skills significantly determine lake choices, with socio-economic, deterrence, social and legitimate variables were found to significantly influencing management regulatory compliance. Both fisheries were found to be profitable with net farm income (NFI) of ₦52, 194.46 per month and ₦38, 017.01 per month for RENLAF and URENLAF respectively, while, RENLAF was more profitable than URENLAF by 37%. Furthermore, it was found that RENLAF cost more than URENLAF by 46%. The mean technical efficiency of URENLAF and RENLAF fishers were 0.83 and 91.29 respectively, suggesting that RENLAF efficiency was higher than URENLAF by 8%. The URENLAF sites shows about 68% variation in output were as result of the presence of technical inefficiency effect, with some observable variables relating to socioeconomics characteristics such as extension contact, age and educational status positively and significantly affects technical efficiency. The major constraints to fishing at both fisheries were hippopotamus and high cost of fishing gears. Transformation for effective and sustainable fisheries exploitation will need the involvement of educated fishers, extension education, and setting more RENLAF sites through redefinition of property rights as well as gears limit regulation at RENLAF.

Chapter 1

INTRODUCTION

1.1 Background to the Study

The global captured fishery is in a crisis with a majority of the world's fisheries being fully exploited and about one third of them being either depleted or over-exploited (FAO, 2003). This crisis has been brought about by both market and policy failures which manifest themselves through, among other things, improper management and inadequate property rights. Fisheries classified under agriculture, have been regarded until very recently as an extractive industry whose development was identified with increased extractive capacity (Bohnsack, 1993).

FAO (2004) estimated in 2002, about 72 per cent of the world's fish stocks were being harvested faster than they could reproduce and one fourth of total catch are by-catches. FAO (2004) also stated that deterioration of global fisheries is raising significant concern, mainly because an estimated one billion people, mostly in low-income countries, depend on fish as their primary source of protein. They further stated that fish, long regarded as "poor man's protein" is diminishing globally as a result of increasing market demand and over fishing. On the average, fish supplies 16% of animal protein consumed by people. The industry, ranging from subsistence fishermen to large-scale mechanized fishing vessels, directly or indirectly employs some 200 million people worldwide (UNEP, 2006).

Fisheries management has been introduced in some form in most countries in an attempt to either limit further resource degradation or aid in the recovery of depleted stock. A survey of FAO member states found that 90% of respondents had introduced at least some form of limited

access to their fisheries resources (FAO, 2004). Fisheries development plans in Nigeria have spanned for a period of 44 years. However, the key objectives to make Nigeria self sufficient in fish production, conservation of the resource and other economic factors were considered targets of fisheries management remains unfulfilled.

Foreign observers frequently comment that fishing in African lakes, rivers and their associated wetlands is usually haphazard. This is not unconnected with the fact that there are usually no laws and regulations controlling the exploitation of the fisheries of most African inland waters. Even where such laws and regulations exist, they are not often enforced. Freshwater resources comprise a mere 2.5% of earth's water with 99% frozen in glacier or ground water. Lakes hold only about 0.4% of global freshwater (Wetzel, 1983), but cover around 8% of the land area and contain about 40% of all fish species (Moss, 1988).

In contrast to their diminutive volume, the relative productivity of lakes and wetlands is enormous contributing about 15% of the world fisheries production. It is estimated that about 10% of the 1500 largest lakes in the world are located in Africa with majority of riverine (40%) or coastal (20%) origins. Bearing in mind that the majorities of marine fish resources are considered fully exploited or over fished, it is difficult to imagine that there is still room for increased production within African lakes (Kolding, 1993). For example, Kolding (1993) reported inland fish production of Africa to be 2.1 million ton per year. It is the widening gap between the increased demand for fish and the apparent limited growth potential for natural production from captured fisheries that various forms of culture base systems are invoked as panacea, even enhancement to natural production of Lakes and rivers.

When the importance of fisheries emerges globally and even locally; the Federal Government of Nigeria decided to create an Institute for Inland Fishery Research now National Institute for Freshwater Fisheries Research, (NIFFR) to conduct research on rivers and lakes and improve on it to enable the country become self-sufficient in fish production, reduce hunger, poverty and to export for foreign exchange. Recently, several fishery biologists have shown considerable support for direct government regulatory management of fisheries with protected areas, reserves formation, seasonal closures, entry limitations, and gear restrictions (Walter, 2000). This is believed to conserved fishery against stock collapse from overfishing; improve biological diversity, productivity and bring economic benefit (Bohnsack, 1990). Furthermore, fisheries economists have viewed regulations as valuable in conserving habitat, biological diversity and revenue – generating and tourist can enjoy them. However, decision makers have also believed that regulation impose the cost (besides administrative cost) of the value of lost harvest. Therefore, the decision on whether or not to establish regulations requires comparison of the two systems.

The Plateau State Government in the last seven years (2004) adopted a contemporary fisheries management mechanism at Pandam Wildlife Park lake fishery – close season, limited entry and mesh size limit. It is believed to conserved fishery against stock collapse from overfishing; improve productivity and bring economic benefit (Bohnsack, 1998). The other natural lakes in the state are not regulated and managed as open access or as a common property. However, the decision to develop an empirical models of fishers' behaviour, effort allocation, costs, returns, profitability, determinants of choice of site to fish and regulation compliance for the state

government's regulated fishery (here forth referred to as regulated fishery) and non government regulated fishery (here forth referred to as unregulated fishery) is essential for predicting, understanding and recommending efficient and sustainable fishing program that will benefit present and future generations.

1.2 Statement of the Problem

Over 70% of Sub- Saharan African population lives in rural areas and draws its livelihoods mainly from smallholder production systems centred on agriculture, forestry and fisheries. Making then frequently compelled to exploit their surrounding for short-term survival, and make up the group most regularly exposed to natural resources degradation (WB, 2002). Furthermore, the problem smallholders are facing by a changing climate: food insecurity and poor nutrition for many people who depend on small-scale agriculture and weak environmental feedbacks such as the critical between captured fishing practice as affected by climate change through unregulated fishing and intensifying weather extremes and how remedies from management strategies and conservation incentives, that may deal with the climate change variability challenges.

The rich and diverse resources of sea and inland waters are being exploited by these group of people up to and beyond sustainable levels in many areas and the fisheries resources are often of a common pool type, which implies problems with over exploitation that sometimes are hard to manage (Pauly, 1996). These fisheries are frequently open access with no restriction on entry or total catch. The results of these are extinction of species, disturbances of delicate ecosystem, collapse of important fisheries, and destruction of natural environment, less dramatic, but of enormous importance, is the decrease in yield, income, and employment from fisheries. This

crisis has been brought about by both market and policy failures which manifest themselves through, among other things, improper management and inadequate property rights. However, Nigeria self sufficiency in fish production and supply is stills a mirage (Azionu *et al.,* 2005). There are repeated episodes of declining yields and economic returns, stock collapse and crises of social dislocation and loss of biodiversity. This could be arrested if the contemporary fisheries management precepts and practice such as in Pandam Wildlife Lake fisheries are adopted and vigorously sustained.

The other lakes in the State are frequently open access with no restriction on entry or total catch, these fishery resource provides an insight of a prevailing social dilemma and tension between long term collective good (i.e. preservation of fish-stocks) and appropriators short term benefit (i.e. maximizing profit from fishery). Sustainable fishery resource management requires the understanding of fishing effort allocation, fishing behaviour, cost, motivation and behaviour of the harvest sectors which jointly determine fishery outcomes (Clark, 1990). There is therefore, the need to provide empirical evidence on the effects of policy variations in fisheries. By this, the research questions put forth were:

i. What are the socio economic characteristics of fishermen in the regulated and unregulated fisheries?

ii. What are the factors that influence fishermen`s participation in a regulated fishery?

iii. What determines the choice of fishery sites among unregulated fishers?

iv. What are levels of compliance or otherwise with management regulations of regulated fishers?

v. What are costs, returns and profitability of fishing activity in the regulated and unregulated fisheries?

vi. What are the levels of technical efficiencies of fishermen at regulated and unregulated fisheries?

vii. What are challenges facing fishermen of regulated and unregulated fisheries?

1.3 Objectives of the study

The broad objective of this study is to compare economics of fishing at the regulated and unregulated natural lake fisheries. The specific objectives are to:

i. describe socio-economic characteristics of fishermen in both regulated and unregulated lake fisheries;

ii. determine the factors influencing fishermen participation in a regulated fishery;

iii. evaluate the determinants of fishery site choices among fishers of unregulated fishery;

iv. evaluate the level of compliance or otherwise of fishermen to close season regulations;

v. determine costs, returns and profitability under both regulated and unregulated fisheries;

vi. estimate the levels of technical efficiencies of fishermen under both regulated and unregulated fisheries; and

vii. identify the constraints facing fishermen in the regulated and unregulated fisheries.

1.4 Hypothesis

This study will test the following null hypotheses;

i. there is no significance difference in profit between regulated and unregulated fisheries

ii. there is no technical inefficiency effects in both regulated and unregulated fisheries

iii. there is no management regulations violation among regulated fishers

1.5 Justification for the Study

The empirical assessment of the two systems will provide economic and environmental policy information to decision makers in light of the developmental priorities of the present government of Nigeria on economic transformation through sustainable job creation and empowerment. Another cluster of rationale is the projection that these research findings will lead to new information on a current policy concern that can assist in the formulation of a better policy. Furthermore, the research was to encourage the adoption of innovations to promote sustainable use of renewable natural resources, enhance environmental quality as well as to provide a source of sustainable income and employment to vulnerable social groups.

There is no known empirical investigation into the regulated management of Pandam wildlife park fishery since its establishment and other unregulated natural lakes within the state.

Therefore, the research results will be used for the development of a new thesis and add literature in the field of study, production of pieces and publications furthering knowledge beyond what is presently known. Furthermore, it will be useful to political interest group, community people, researchers and management officials, on re-strategizing resources management and utilization for both short term and long-term exploitation.

The economic evaluation study can best be understood and appreciated because it expresses a variety of impact in a common unit of measurement- a currency value. This allows tradeoffs to be more clearly seen and weighted. The study investigated and unearthed the likely reasons for rule breaking among regulated fishers. This will be useful to Department of Fisheries of Ministry of Agriculture in Plateau State. Thus, it will help the department to evaluate and improve the existing effort-limiting strategies in the artisanal inland fisheries.

Chapter 2

LITERATURE REVIEW

2.1 Needs for Management of Natural Resources

A challenging class of environmental/natural resource problems emerges when ecological, physical and economic systems are linked by spatial dynamic processes. Biological reserve site selection, provision of ecosystem services, management of marine and terrestrial species each depend on the biophysical and economic mechanisms that can be characterized by diffusion or dispersal processes and harvesters behaviour respectively. There is a growing consensus among ecologist, conservationist, biologist and fisheries managers that conventional season length and gear restriction management methods are bound to fail in the future, and that a new approach is therefore needed. (Bohnsack, 1993)

In the political arena, there is a growing view among Non-Governmental organizations' and influential environmental lobbying groups that network of protected areas similar to the terrestrial park system will best achieve long-term biodiversity, conservation goals and economic benefit . Marine reserves have long been an important part of marine conservation (Smith *et al*, 2002). Considerable attention in recent years has focused on using reserves explicitly to manage commercial fishery yields (Bohnsack, 1998). According to Polacheck (1990), the management of reserves involves regulatory restrictions such as closed seasons, minimum size restrictions and limited entry program. Numerous biological science studies argue that reserves could benefit fishery management (Davis 1989; Bohnsack, 1993; Man *et al.,* 1995; Mangel, 2000)

2.2 The Basic Biological Premise of Fish Production using Reserve Formation

Biological scientist and ecologist have put forward five interrelated justification for using reserve to manage fisheries resources. The first is by Polacheck, (1990) stated that "reserve formation can rebuild over- exploited areas". Secondly, Davis (1989) and Lauk *et al.* (1998), accorded that "reserve can take advantage of dispersal mechanism in boosting system-wide biological production". Thirdly, "it can encourage return to scale and size in system-wide production" (Bohnsack, 1993). "Reserve can preserve the natural life cycle of an organism" and finally, "providing an hedge against stock collapse" (Clark, 1996).

2.2.1 Production, size and area for fisheries activities and yield.

The world inland capture fisheries are estimated at about 7.5 million tons, with Africa contributing about 2.1 million tons. On a per capita basis, Chad Republic is second only to Cambodia in the world with 25.2kg. Inland capture fisheries are particularly important in most African land locked countries (Chad, Uganda, Zambia, Mali, Nigeria, Tanzania, Malawi) with a range of 3.3 to 9.7kg per capital (FAO, 2003).

Africa is considered a sleeping giant when it comes to fisheries potential but has at present only limited total production (FAO, 2003). Townley (1992) estimated the potential production for inland rivers and lakes in sub-Saharan Africa alone at 1 million ton per year. Inland freshwater water bodies producing finfish, indigenous carp species, catfish, Tilapine species etc. The Natural lakes productivity follows the same fundamental ecological principles and limnological process. While some physical and perhaps societal differ in terms of management. The impacts have normative cultural and political overtones.

Natural lakes in Africa are rare and mainly found in rift valley and in vast basis of Congo River (Payne, 1986). Based on water surface alone, Africa seems to have large potential for enhancement with considerable larger size and size range of African Lakes. According to Duncan (1999), this account for under-fishing from many African lakes compared to the extremely high fishing intensities and over fishing from Asian lakes. Most African lakes are less than 5km depth which is most frequent depth class in African lakes (Duncan, 1999). On the average, African artisan fishermen produce between 2000 and 3000kg per year. According to Crul (1992) Africa has 525 to 12975kg per fishermen per year, with only 10% of the fisheries with densities of more than 5km fishermen Km^2.

2.3 The Biophysical Base for Productivity

Understanding the basis for the observed high productivity in tropical freshwater and lakes is fundamental for evaluating the potential for increase and enhancements. The biological production itself is fundamentally link to the rate of photosynthesis, with three main limiting constraints; temperature, light, and nutrients. Availability of, and interaction between energy and nutrients, are the primary constraints on a fish production system (Ryder, 1978). As temperature and light regimes, everything else being equal, is a relatively constant function of latitude and altitude, the most dynamic variable is the generation, addition or cycling of primary nutrient. For these processes climatic and edaphic factors are important.

2.3.1 Climatic factors

Latitude is perhaps the most important single physical factor for classifying a freshwater system and to determine its potential productivity (Lewis, 1987). This determines climatic conditions which in turn control temperature, light, wind and precipitation. All these play a major role in the nutrient cycles and hence the regeneration of biomass. Firstly, the combination of high annual isolation and low seasonal variation at low latitudes, creates aquatic systems with corresponding high temperatures with low seasonal variability, i.e. the difference between annual minimum and maximum temperatures are small (Stra@Kraba, 1980).

This again creates, relatively warm and homogenous water column temperatures reduces the formation of density layers and thus potential stratifications. This is important in metabolism (Lewis 1987). Seasonal trade winds along the length axis cause the large scale oscillation of the thermocline and with that nutrient rich colder water mix with the hypolimnion (Menz, 1995). The result is a seasonal change in productivity that is translated into fish biomass.

2.3.2 Edaphic factors

The chemical compositions of the Soil in the Surrounding watershed determine supply of nutrients and trace element for Organic synthesis (Talling, 1986). Highly fertile zones are usually associated with fluvial deposit, whereas relatively infertile zones are mainly associated with old, pre-Cambrian bedrock formation. Lateritic substrates are relatively rich, but subject to rapid leaching and nutrient losses (Payne, 1986). Lakes are supplied with nutrient, largely through their inflowing rivers, and partly from rain water.

2.4 Morphological factors

The morphology of a lake, particularly area, volume, depth, and shoreline development or gradients, is of major important to the productivity (Ryder, 1978). The mean depth, or the volume to area ratio, determines the energy needed for vertical mixing and hence the rates of recycling nutrients into the trophogenic production zone. These effects become more extreme in meronictic lakes, such as Lake Tanganyika and Lake Malawi, where the concentrated dissolved solids below the chemocline provide additional resistance to overturn.

A high shoreline development (the ratio of shore length to the circumference of a circle enclosing the same area as the lake) and /or a low land gradient represent a large littoral zone and along ectone (the land-water interfaces). The ecotone is the most productive part of an aquatic ecosystem because it combines both terrestrial and aquatic processes (Junk, 1996). The changing interlinked set of inorganic chemical and bacterially mediated reactions (solution, oxidation, nitrification, denitrification, etc) as a function of the fluctuating redox potential creates a particular efficient nutrient transfer.

2.4.1 Seasonality and dynamics

Standing inland waters and lakes are perhaps the most diverse of aquatic systems and the variety and extremes of tropical lakes exceed those from temperature climate (Payne, 1986). Classification of tropical lakes is traditionally attempted on the basis of the water chemistry and conductivity (Rai and Hill, 1980), which mostly have a close relationship with productivity (Ryder *et al.,* 1974, Henderson and Wellcomme, 1974). Fresh water systems are, however,

rarely closed entities and their chemical composition is therefore a function of the hydrological require a geological nature of the surrounding catchments area.

Schindler (1978) found that external nutrient loading explained most of the variance in phytoplankton production in global lake review, irrespective of Mixture pattern and/or latitude (i.e. Climatic seasonality). Similarly in tropical waters, with high temperatures and small seasonal variations, temporal biological variability is often prominent and caused mainly by seasonal injections of nutrients (Lowe-McConnell, 1999).

2.4.2 Hydrological changes.

Melack (1979) suggested that there are three patterns of periodic changes in the production of tropical lakes; those with pronounced seasonal fluctuations, those with a lower degree of fluctuations and finally those with irregular but abrupt changes. The first category constitutes the majority, although the range of variation in seasonal production is mostly smaller than that observed in temperate waters. In these systems it is the recurrent vertical mixing of the water masses (the mixture pattern) driven by the wind regimes and the resulting periodic establishment and destruction of thermo clines that govern the recycling of nutrient and hence the production rates. There are, however, some waters in which production is dominated by changes in the hydrological regimes and among these are lakes intimately associated with rivers (Payne, 1986 and Talling, 1986).

This strongly suggests that nutrient inputs from rivers and the flooded marginal areas are very important in stimulating fish production in lakes. When lake level raises terrestrial vegetation is

submerged and nutrient leaching from decomposing organic Matter (dung, grass, shrubs, and tress) and directly firm rivers, result in increased plankton and fish production (Marshall, 1982 and Talling, 1986). Flooding of marginal areas and increased river flow result in between spawning conditions especially for, potamodromous species, and excellent conditions for growth and survival of Juveniles of inshore fish species. For most tropical freshwater fish species, the dominant breeding Peak coincides with the local rains, monsoons, or floods (Payne, 1986).

2.5 The Biological Bases for Productivity

Predator-prey interactions and top down versus bottom up control while the primary productivity in lakes mainly is governed by the nutrient concentration and loading from physical and climatic attributes of the environment, including the seasonal oscillations (Schindler, 1978), there is no simple uniform relationship with the fish production at higher atrophic levels. The energy flux and pathways through the system depend on complex interactions between bottom up and top down control and cascading effects among these.

The atrophic cascade hypothesis state that while, the potential productivity of lakes is set by the nutrient, then deviation from the potential are due to food-web effects (Carpenter and Kitchell, 1993). It is a general tenet in system ecology that predator-prey interactions tend to generate coupled time-lagged oscillations due to shifting phases of abiotic (Bottom up) and biotic (top down) cascading effects, particularly in fluctuating environment. Herbivore and Detrivore fish are relatively more frequent in tropical lakes (Nilscen, 1984). Primary consuming fish species in the tropics wide distribution and high abundance makes them disproportionately well represented in individual aquatic ecosystem (Bowen, 1988).

Tilapiine species support the mainstay of most African small-scale freshwater fisheries (FAO, 2003). And high yields in tropical lakes. The main reason for the success of Carps, Clarias and Tilapia is their direct connection to the base of the food web, which make them 5-10 times more efficient than secondary consumers (Bowen, 1988).

2.5.1 The basic economic premise of fish production (effort) and fisheries management.

In terms of assessing the impact of fisheries management, three main areas of research have attracted the attention of economist over recent years. These are fisher's profit maximisation, effort location, entry /exit behaviour, and compliance or otherwise with management regulations. Economic models of fisher behaviour – both theoretical and empirical are based on the general premise that the key objectives of the individual fisher is to maximize his/her individual profits. Profit maximizing behaviour does not necessarily mean that fishers actually obtain the highest level of profits possible. Instead, they respond in a way that would potentially increase their profitability.

Fishers will switch gear if the benefit from the use of an alternative gear exceeds the benefits of the current gear and the costs of switching gear. Similarly, fishers will not go to fish if the expected revenue from the catch does not cover the fuel and other running costs associated with the trip. The assumption of profit maximizing behaviour does not preclude the existence of other social constraints. Roy(1998) considered the marginal cost of an additional week fished to include not only the cost of the fuel and other variable inputs, but also the forgone leisure time (the value of which increased as the quantity available decreased). Similarly, other social

restrictions (e.g. birth-days, worship days, Holidays etc) can affect the level of fishing activity. However, within these constraints, behaviour has generally been considered profit maximizing.

A number of alternative hypotheses have been proposed to explain fisher behaviour. In particular, habit has been thought to be characteristic of fishers' behaviour. Holland and Sutinen (2000) stated that fishers are assumed to prefer to fish in the same areas with the same gear year after year. Also, shepherd and Garnod (1981) and Placenti *et al.* (1992) assumed "inertia" exist in the fishery, with major improvements being necessary to encourage fishers to change their behaviour. In some studies, this "habit" or "inertia" has been linked to risk aversion (Strand, 2004). That is, fishers are assumed to prefer to go where they know the likely outcome rather than try somewhere new where the outcome is unknown. However, while habit, inertia and risk aversion may influence fisher behaviour in the absence of any changes in their regulatory, economic or natural environment, any disruption to this environment is likely to result in a response based on the economic incentives that exist.

2.5.2 Modelling entry and exit

Early models of entry and exit essentially assumed that entry and exit was unrestricted and linked to the profitability of the fishery. The earliest fisheries economics models (Gordon, 1954 and Scott, 1955) suggested that fishing effort would increase in an unregulated fishery through the entry of new vessels as long as the profitability in the fishery exceeded the rate of return the fisher might expect on their investment elsewhere in the economy.

Conversely, vessels where assumed to exit the fishery if they could achieve greater returns on their capital investment elsewhere. Based on this theory, simple dynamic models of entry and exit have been developed that link the entry and exit to the level of profitability. Mackinson *et al.* (1997) developed a model of North Sea Herring fishery, with changes in effort (i.e. entry and exit) modelled as a function of total profitability. The models assumed that fishery efforts are free to move in and out of the fishery as a result of free and open access to the fishery or stock. With the advent of fisheries management, the ability of fishers to move in and out of fishery has become more constrained. Entry is restricted by the availability of licences or permit, while exit is made more difficult as is no alternative employment opportunities as in low developed countries.

2.5.3 Capture fish production (Effort) and reserve formation

Most research that supports the idea that reserve will increase fishing yields is counter factual policy modelling that is, researchers build an analytical or simulation models that strive to assess what would happen if a reserve were created in a particular fishery. There certainly is substantial empirical evidence that support population recovery within a reserve (Roberts and Polunin, 1991; Dugan and Davis, 1993). However, McClanaham and Kauda- Arara (1995) found that long-term fishing yields decreases. The most compelling argument in favour of reserve have come from biological modelling efforts that show how a reserve can simultaneously increase spawning biomass and fishing yield. Using a constant level of effort that would otherwise result in over fishing, Biological models indicate that reserve would increase the yield of the fishery relative to convectional Management (National Research Council 2001 p.143).

In contrast, economists have shown more scepticism about reserve formation, although they have identified some conditions under which reserve will lead to fishery gains for an exploited resource. By extending existing bio economic model to space, economists' stress that whether a reserve generates net economic benefit involves a complex function of economic and biological factors (Wilen *et al.,* 2002). One immediate economic concern is that the long-term gains from reserve creation, when discounted, may not outweigh short term costs (Conrad, 1999). Also, that reserve do not address

open access rent dissipation forces that are at work in the remaining fished areas (Hanneson, 1998).

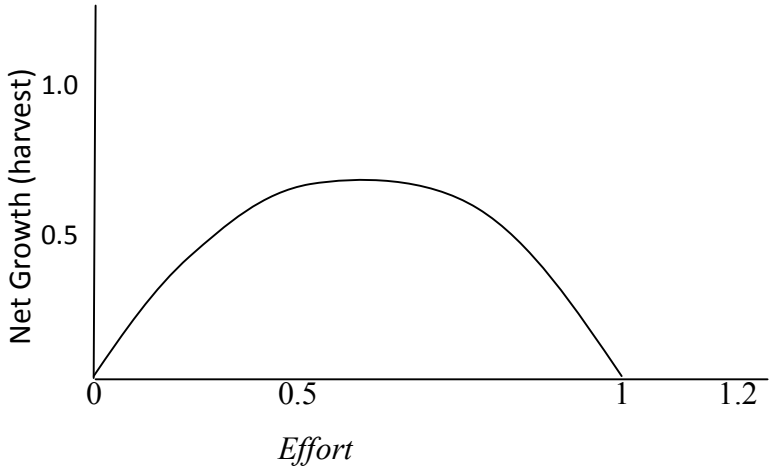


Fig.1: Logistic growth curve

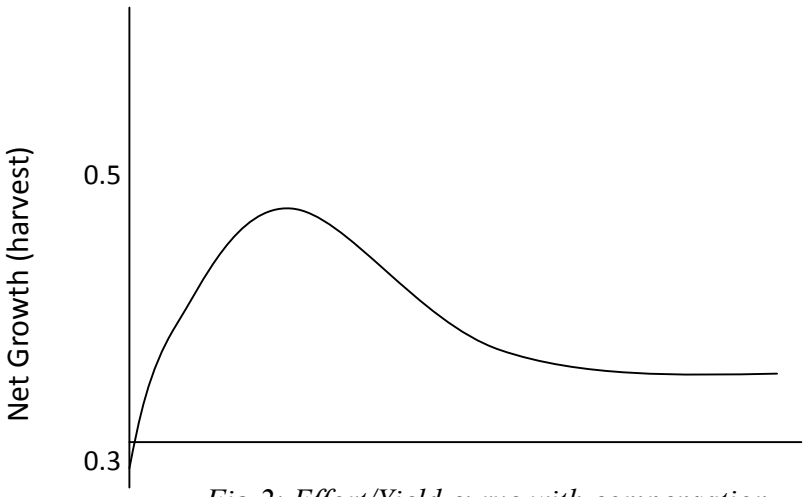


Fig.2: Effort/Yield curve with compensation.

2.5.4 Fishery production efficiency.

This is a bioeconomic model that relates catch to fishing effort (fishing input) Smith et al. (2005) equation is specify as;

$$Q = f(E_1, E_2, E_3,)$$

Where Q is an index of catch (weight of mixed species caught) and E_1, E_2, E_3 stand, respectively, for length of gear, fishing duration, number of gears owned. For econometric estimation with empirical data, the above equation can be given a Cobb-Douglass or a translog stochastic specification.

$$\text{In } Q = \sum_i b_i \text{ln} E_i \text{ - - - - - - - - - - - - - (Cobb – Douglass)}$$

$$\text{InQ} = \sum_i b_i \text{ln} E_i; + 0.5 \sum_i \sum_i b_i \text{ In} E_i \text{ In} E_i \text{ - - - - - - (Translog)}$$

Wilen *et al.* (2002) stated that the most common specification error in studies of production relations involve the omission of variables related to management factors. The effect of

introducing better management is to shift the entire production function to the right, thus producing more output from a given amount of resources.

This change is reflected in an increase in the marginal productivity of each input factor. Furthermore, the difference among fishers in Managerial ability may cause variation in catch. Difference from managerial ability may arise from such factors as age, experience, education and family size reflects the ability of a fisher to obtain maximum output from a given set of inputs and available technology. A stochastic frontier production can be specified as follows (Kumbhaker and Lovell, 2000):

$Yi = f(E_i\beta_j) + (v_{ij} - \mu_{ij})$.

The frontier production function $f(E_j\beta_j)$ is a measure of maximum potential output for any particular input vector $E_{i,}$ while the V_i and the μ_i cause actual production to deviate from this frontier (Greene, 2003).

The production technology of fishers involved in capture fishing was estimated using translog-frontier production function specified in the log form as follows:

$$InQ = \sum_i b_i \ln E_i; + 0.5 \sum_i \sum_i b_i \, InE_i \, InE_i + (V_i - \mu_i)$$

Where:

Subscript $_j$ refers to the $_j^{th}$ fisher in the sample

ln denotes the natural logarithm (base e)

Y_i = value of fish output (kg)

E_1 = length of gear (m)

E_2= period of passive gears are active in water (hr)

E_3= Number of gears owned

Vi = Error term which are assumed to be independently and identically distributed with zero mean and constant variance and independent of μ_i.

μ_i = non-negative random variables associated with technical inefficiency in production (effort allocation). The function will be estimated using the maximum likelihood method. Two separate models will be estimated to capture the influences of technically inefficiency in production.

The first model will consider the response function of output to the inputs without the inefficiency effects. That is;

$$\ln Y = \beta_o + \beta_1 \ln E_1 + \beta_2 \ln E_2 + \beta_3 \ln E_3 + \beta_{12} \ln E_1 \ln E2 + \beta_{13} \ln E_1 \ln E_3 + \beta_{23} \ln E_2 \ln E_3 + \tfrac{1}{2} \{\beta_{11} (\ln E_1)^2 + \beta_{22} (\ln E2)2 + \beta_{33} (\ln E_3)^2\} + V_i$$

Model 1 assumes that the total variation of output due to technical inefficiency is zero ($\mu_i = 0$). That is, the variation in output not captured by the variations in the levels of inputs used in production is due to the random error term (V_i).

The second model II is the general frontier model where μ_i the technical inefficiency effects, assumed to depend on some selected fishing-specific variables, will be included to indicate their possible influence on the technical inefficiencies of the fisher;

$$\ln Y = \beta_o + \beta_1 \ln E_1 + \beta_2 \ln E_2 + \beta_3 \ln E_3 + \beta_{12} \ln E_1 \ln E_2 + \beta_{13} \ln E_1 \ln E_3 + \beta_{23} \ln E_2 \ln E_3 + \tfrac{1}{2} \{\beta_{11} (\ln E_1)^2 + \beta_{22} (\ln E_2)^2 + \beta_{33} (\ln E_3)^2\} + (V_i - \mu_i)$$

Where $\mu_i = b_o + b_1 D_1 + b_2 D_2 + b_3 D_3 + b_4 D_4$

Where; D_1, D_2, D_3, D_4, represents, Age of the fisher, years of experience in fishing, educational status, and family size.

Models I and II are compared for the presence of technical inefficiency effects using generalized likelihood ratio test, which is defined by Chi-square (X^2) test statistic (Greene, 2003);$X^2 = -2\ln(Ho/H_a)$.

Where; X^2 has a mixed Chi-square distribution with the degree of freedom equal to the number of parameters excluded in Model I.

H_o: Total variation in output due to technical inefficiency = 0.

H_a: Total variation in output due to technical inefficiency ≠ 0.

Letting μ_i be the technical inefficiency error term, technical efficiency is estimated as the ratio of the expected value of the predicted frontier output conditional on the value of μ_i (Predicted value of Yi from model II) to the expected value of the predicted frontier output conditional on the value of μi being O (Predicted value of Yi from model

I).

The technical efficiency of fisher i can be expressed as,

$TE_i = E(Y_i^{**}/u, E_t)/E(Y_i^{*}/u = 0, E_i) = E\{Exp(-u,/\square,)\}$

Where; E {Exp (-u,/□)} is the mathematical expectation (mean) of the exponent of technical inefficiency effects (-u) given that □ = $V_i - \mu_i$

TE_i = Technical efficiency of the i^{th} fisher

Y_i^* and Y_i^{**} are the predicted values of Y_i from models I and II respectively.

E = expectation Equation (IV) can also be expressed as the ratio of the predicted model II and model I as follows:

$$\ln Y = \beta_o + \beta_1 \ln E_1 + \beta_2 \ln E_2 + \beta_3 \ln E_3 + \beta_{12} \ln E_1 \ln E_2 + \beta_{13} \ln E_1 \ln E_3 + \beta_{23} \ln E_2 \ln E_3 + \tfrac{1}{2}\{\beta_{11}(\ln E_1)^2 + \beta_{22}(\ln E2)2 + \beta_{33}(\ln E_3)^2\} + (V_i - \mu_i) -$$

TE = $\ln Y = \beta_o + \beta_1 \ln E_1 + \beta_2 \ln E_2 + \beta_3 \ln E_3 + \beta_{12} \ln E_1 \ln E_2 + \beta_{13} \ln E_1 \ln E_3 + \beta_{23} \ln E_2 \ln E_3 + ½ \{\beta_{11} (\ln E_1)^2 + \beta_{22} (\ln E_2)^2 + \beta_{33} (\ln E_3)^2\} + V_i$

Where, the βs are the estimated scalar parameters. Since μ_i (technical inefficiency error term) is a non-negative random variable, the technical efficiency predictions (TE_i) are between zero and one. If $\mu_i = 0$, then production lies on the stochastic frontier and hence technically efficient ($TE_i = 1$ (and the fishermen obtain maximum possible output given the level of inputs. $\mu_i > 0$, implies that production lies below the frontier and the fishes area said to be technically inefficient ($0 < TE_i < I$).

2.5.4.1 *Functional forms in stochastic frontier*

In literatures, a number of functional forms have been used in the estimation of stochastic frontier production function. The Cobb-Douglass has been commonly used in the empirical estimation of frontier models. The Cobb-Douglass form is quite simple which all attractive features are. A logarithmic transformation provides a model which is linear in the logarithmic of the input and, hence, the Cobb-Douglass form is easy to estimate.

The Cob-Douglass has some restrictive properties. It has constant inputs elasticity and returns to scale for all firms in the sample. Further, the elasticity of substitution for the Cobb-Douglass is equal to one. The applicability to fishery economics vary common with truncated normal distribution as adequate representation. Apart from Cobb-Douglass, two other functional are common in literature. Those are Zellner-Revanker generalized production function (forsund and Hjalmarson, 1979). The Zellner-Revankar forms:

$Ye^{ey} = A_{x1}{}^{b1} X_2{}^{b2}$

This allows return to scale (RTS) to vary across output levels by removing the RTS restriction. The applicability of this form in fisheries economics in literature is not clear. The other functional form is the translog which imposes no restrictions upon return to scale or substitution possibilities. Although some Authors have indicated that the translog has a drawback of being Susceptible to multicollinearity and degree of freedom (resulting in rejecting a hypothesis that would be accepted). This can be overcome by using system estimators. The advantage of using translog is that it belongs to a class of functional forms that is called flexible functional form; it is can be manipulated (coelli, *et al*. 1996).

2.5.4.2 Application of stochastic frontier efficiency estimate to captured fishery management

Technical efficiency is defined (Kumbhakar and Lovell, 2000) as the ability of a decision-making unit (DMU) to obtain the maximum output from a set of inputs (output orientation) or to produce an output using the lowest possible amount of inputs (input orientation) Technical efficiency, its measurement and the factors determining it are crucial importance in production theory. Technical efficiency of a DMU and the degree of use of variable inputs determine the output and capacity utilization. Determining those factors affecting of allows stakeholders to take measures to limit or improve it (Sharma and Leung, 1998).

In the fisheries context, there is a growing interest in the measurement of technical efficiency of different fishing fleets. This interest is twofold: to establish the underlying factors (Kikley et al., 1998), and to assess the effects of management measures on technical efficiency and potential catch. Fishery managers may reduce technical efficiency by constraining the use of certain inputs (Pascoe et al., 2001), or alternatively, they may improve of by expanding these inputs or by taking measures that properly define the properly rights of the fishery. Any assumption on the

economic behaviour of fishermen leads to the concept of Economic efficiency which is also sensitive to management measurers (Grafton et al., 2000). From the end of the 1970s onwards, several techniques have been developed for efficiency analysis, based on the comparison of the output (input) of a group of DMUs. Methods to measure efficiency can be classified into non-parametric and parametric models.

The non-parametric are exemplified by Data Envelopment Analysis (DEA); and parametric models, incorporating Deterministic Frontier Analysis (DFA) and stochastic frontier Analysis (SFA). In measuring efficiency, applications of SDA and SFA has been recommended by FAO (1998) from the late 1990s onwards to measure also fishing capacity (Kirkley et al., 1998). Although several studies compared results using Parametric and non-parametric estimates of same fleets (Kirkley et al., 1998; Reinhard et al., 2000), comparative studies for fisheries management systems in developing countries are scarce. The study is to compare results obtained using SFA on regulated and unregulated management systems of the natural lakes in Plateau State.

2.5.5 Discrete choice models

Many discrete choice formulations can capture the essence of decision-making in a captured fishery setting. The general approaches fall in to the following categories. The logit, probit, multinomial (and conditional) logit, discrete choice dynamic programming, and random (Mixed) Parameters logit, multinomial probit, ordered probit and nested logit: Discrete choice dynamic programming is quite attractive to the researcher because it's an empirical model that is consistent with intertemporal optimizing behaviour of individual agents and it avoids 11A. But it is computationally burdensome. The random parameter (mixed) logit and multinomial probit

model can allow for heterogeneity of individual responses to independent variables and do not suffer from 11A problems, but the requirement that multivariate normal integrals be evaluated to estimate the unknown parameters and they are mostly appropriate in large industries Panel data and also computationally cumbersome.

Nest logit is a structural model of the interdependent decisions of whether to go fishing and where to go fishing, also quite flexible. It is simple to use for policy simulation as it neither requires calculation of an individual agent's entire optimal path nor integration over individual heterogeneity that is manifested in random parameters. But not appropriate for the objectives of the present study.

The basic multinomial (and conditional) logit is easy to estimate though it imposes Independence of Irrelevance Alternatives (11A); the relative choice probabilities are unchanged by a change in the choice set. A spatial closure analysis with a model that imposes 11A would, in essence, assume the answer to the policy Question. However the log likelihood tests to check for 11A assumption using Limdep version 9.0 Software is possible. By this, the study used multinomial logit, it is simple to use for policy simulation as it neither requires calculation of an individual agent's entire optimal path nor integration over individual heterogeneity that is manifested in random parameters.

Multinomial logistic regression model was used to evaluate determinants of lake choices among fishermen of unregulated fishery. The multinomial logistic regression analysis was used to identify the relationship between dependent variables fishery resources substitution behaviour

(location choices) and independent variables (i.e. socioeconomic characteristics, personal attributes). This logistic regression is powerful in its ability to estimate the individual effects of continuous or categorical independent variable on categorical dependent variable (Wright, 1995). The model used is generally effective where the dependent variable is composed of a polytomous category having multiple choices. The basic concept was generalized from binary logistic regression (Hosmer and Lesmeshow, 2000).

In the model, the estimates for the parameters can be identified and compared to a baseline category (Long, 1997). In this study having no willing to substitute regulated fishery was specified as the baseline category. The multinomial logistic regression model with a baseline category would be expressed as follows;

$\text{Logs}\ (\pi_i/\pi_1)\ a_i + \beta_i\ x_i \quad i = 1, \ldots I - 1$

The logistic model uses the baseline category logit with a predictor x. This multinomial regression model can be a useful tool for modeling where the dependent variable is a discrete set of more than two choices (Agresti, 1996). The study used the model to estimate the effects of individual variable on the probability of choosing a type of alternative fishery resource location substitution in the unregulated fishing activities. The advantage of using a multinomial logistic model is it computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987).

The main limitations of the model is the Independence of Irrelevant Alternatives (IIA) Property, which states that the ratio of the probabilities of choosing any two alternatives is independent of

the attributes of any other alternatives in the choice set (Hausman and Mc Fadden, 1984). Alternatively, the multinomial probit model specification for discrete choice model does not require the assumption of the 11A (Hausman & Wise 1978) But the requirement that multivariate normal integrals be evaluated to estimate the unknown parameters.

This complexity makes the multinomial probit model an inconvenient specification test for the multinomial model (Hausman and Mc Fadden, 1984). The study uses the log likelihood test to check for 11A assumption in a Limdep version 9.0 Program (Greene, 2003). Let A_i be a random variable representing fishery resource chosen by any fishing household, assuming that each fisher faces a set of discrete, mutually exclusive choice of unregulated fishery. These choices of lake measures are assumed to depend on a number of site attributes, socioeconomic characteristic and other factors x.

The multinomial logistic model for fishery choice specifies the following relationship between the probabilities of choosing option A_i and the set of explanatory variable x as (Greene, 2003);

$$\text{Prob } (A_i = j) = \frac{e^{\beta j x_i}}{\sum_{k=o}^{j} e^{\beta j x_i}} \quad \text{j = O, 1 . . . J}$$

Where;

β_j is a vector of Coefficient on each of the independent variable X. Equation (1) can be normalized to remove indeterminacy in the model by assuming that β_o= o and the probabilities can be estimated as;

$$\text{Prob } (A_i = j) = \frac{e^{\beta k x_i}}{1 + \sum_{k=1}^{j} e^{\beta k x_i}} \quad \text{j = O, 2 . . . J, } \beta_o = O$$

Estimating equation (2) yields the J log-odds ratios

$$\text{In}\left[\frac{P_{ij}}{P_{jk}}\right] = \text{xi}\,(\beta_j - \beta_k) = X_i\,\beta_j, \text{ if } K = O$$

Where; the dependent variable is therefore the log of one alternative relative to the base alternative (regulated fishery).

2.6 Compliance and Fishery Regulations

Poor people are frequently compelled to exploit their surroundings for short-term survival, and make up the group most regularly exposed to natural resource degradation (World Bank, 2002). Natural resources are often of a common pool resource type, which implies problems with overexploitation that sometimes are hard to manage, even in well-developed countries. Fish is a major source of protein for many poor people (UNEP, 2002) almost half of the world's landings are from tropical waters (Pauly, 1996) and from countries where development is at a low or medium level. These fisheries are frequently open access with no restrictions on entry or total catch, and regularly lack even rudimentary tools for management, Such as landing records. In such poor institutional settings, how individuals act and interact is of outmost importance to whether or not fish stocks can be sustained.

Predictions from the traditional economics of crime model are quite pessimistic. The seminal contribution by Pecker (1968) basically outlines a choice between the legal and the illegal option. The major determinant for this choice is the expected payoff, which simply put, is a function of the risk of being punished, the expected punishment and the net profit from violating the law. On the one land, the management implications from the deterrence model are that monitoring must increase and that penalties must be higher. On the other hand, it is socially desirable that enforcement policy creates marginal deterrence, which rules out the use of severe

penalties for relatively mild violation such as fishing a closed area or landing fish below minimum size. Monitoring and enforcement of fisheries is costly and accounts for 25-50% of the public expenditures on fisheries (Sutinen and Kuperan, 1999), which raises doubt as to whether increased monitoring and enforcement leads to social net benefits. Recent research in the social sciences also extends the deterrence model to include normative aspects of complying with the law such as personal morality and legitimacy (Tyler, 1990).

The original deterrence model by Becker (1968) led to a large number of empirical papers testing the hypothesis (Erlich, 1973 and Gaviria, 2000 is a recent extension), which by and large confirmed the theory. Whether the deterrence conclusion is confirmed has been debated, however, and one level of critique is methodological. This critique stresses that the theory is developed on the individuals' level, while much of the empirical work is based on some level of aggregation. If crime rate is defined as crime per capita, and probability to be arrested is measured as the ratio of arrests to crimes. We have the number of crimes in the denominator of the independent variable and in the numerator of the dependent variable crime can imply spurious correlation. Similarly, if notorious criminals are arrested and kept in custody, it implies a lower crime level, but the negative correlation between crime and arrest rates is not due to the risk of being arrested, but to the actual captivity.

Finally, more crimes lead to more expenditure on law enforcement, which implies a simultaneous relationship between crime and enforcement levels. Manski (1978) suggested survey-collected individual self-reports as a means of avoiding these problems, since each individual will have a negligible impact on each of the three objections raised. Furlong (1991)

applied these ideas to Canadian fishers and found the fishers to be most sensitive to changes in the likelihood of detection, while fines appeared to create the greatest deterrence among various penalties.

Social science research on why people follow the law has been dominated by the instrumental perspective, which is based on deterrence literature and reaches the same policy conclusion as the economics research following the Becker approach. However, given the weak deterrent threat facing people for minor violations, this approach cannot explain why the vast majority of people act in a way consistent with the law (Robinson and Darley, 1997). Recent contributions to legal thought, which to a large extent are revivals of older ideas, provide several suggestions. One reason for following the rules is to avoid the disapproval of your social group; another is that you see yourself as a moral being who wants to do the right thing (Robinson and Darley, 1997). A third factor is legitimacy, which means that the individual feels that the authority enforcing the law is entitled to dictate behaviour. This in turn depends on whether individuals think that the law is fair and applied in a fair manner. Whether legitimacy is maintained or undermined is dependent on people's experiences with legal authorities (Tyler, 1990).

Enforcement in fisheries has been a fairly neglected area (Sutinen and Hennessey, 1986). The early contributions are theoretical and deal with optimal stock if non-zero enforcement costs are introduced (Sutinen and Andersen, 1986 and Milliman, 1986) and his choice of optimal government policy (Anderson and Lee, 1986). The first empirical study confirmed the deterrence model showing that an increased risk of detection and conviction reduce the violation rate in a fishery (Sutinen and Gauvin, 1989). The simple deterrence model predicts that most

fishers will violate the regulation if the risk of detection is low, fines are modest, and the profits from violation are substantial. Still, a vast majority of fishers in various fisheries seem to comply with the regulation, which contradicts the predictions based on this model (Sutinen and Kuperan, 1999; Eggert and Ellegard, 2003). Extended analysis is therefore necessary to include both the judgemental and the normative perspective.

The empirical evidence from such an approach is mixed; Kuperan and Sutinen (1998) found that compliance in a Malaysian fishery depended on the tangible gains and losses, as well as the moral development, legitimacy, and behaviour of others in the fishery. Hatcher et al. (2000) reached similar conclusion while Hatcher and Gordon (2005) found less evidence in favour of normative influence on fisher compliance, while again confirming the deterrence effect. These studies deal with trawl fisheries where the capital input is substantial; this study is the first to analyze artisanal fishers of the Plateau State government regulated fishery. The fishers in the sample all have low levels of capital inputs, i.e. they operate simple open wooden-hulled vessels. Some multinomial choice variables are inherently ordered, e.g. opinion of fishers regarding their compliance to management regulation at Pandam Lake, where outcome of fishers responses are coded 0, 1, 2, or 3. In this case, although the outcome is discrete, the multinomial logit or probit model wound fails to account for the ordinal nature of the dependent variable.

The ordered probit model has come into fairly wide use as a framework for analyzing such response (Zavoina and McElvey, 1975). The ordered probit model is built around a latent regression in the same manner as the binomial probit model. The violation was measured in the numbers of times in which the fisher violated the last close season of 1st June-30th Oct 2010. The

dependent variables where therefore specified as zero for Never (i.e. non-violators), One for 1-5 times (occasional violator) and two for frequent (persistent violator). In general the model was specified as:

$VL^{*} = xi\,'\beta + \varepsilon.$

VL^{*} is unobserved

Where;

X is a vector of an observable variable possibly governing VL^{*}, and ε is normally distributed with mean O, and standard deviationδ. Data on VL^{*} are only observed when VL = j for some j in (0, 1, 2), where O is for non-violators, 1 is for those who violated for one to five times (occasional violators), and 2 is for those who violated frequently (Persistent violators). The study was interested in why fishers may choose to comply rather than violate the rules. It is often found that for any regulation there is a small subgroup of persistent violators (Feldman, 1993) a condition which seems to also exist in fisheries (Kuperan and Sutinen, 1998).

It is also believed those who always obey (violate) the rules may on some occasions be attracted to deviate from their normal behaviour, but lack the possibility to do so. A simple reason could be that the enforcement authorities at the lake (guards) may be on patrol (absent), which implies that the model will fit those who actually alternate between violation and compliance. But excluding the others would lead to information wastage and biased estimates, as it was a voluntary participation. Moreover, when decision process by farmers to adopt a new technology requires more than one step, models with two- step regressions are employed to correct for the selection bias generated during the decision making processes. For instance Stan and William

(2003) employed the Heckman's two- step procedure to analyze the factors affection the awareness and adoption of new agricultural technologies in the United States of America.

By the same token, Eggert *et al.* (2008) employed the Heckman's selection model to analyze the two-step processes of regulatory compliance in Lake Victoria fisheries. Thus, this study adopts the Heckman's two-step procedure (Heckman, 1976) to analyze the factors that affect violation rate categories and factors influencing occasional violators in the close season regulation in the Pandam Lake fishery. In the first step of the analysis, the probability that a given individuals fisher will violate the close season regulation was determined from an ordered probit model using all observations from the fishers in the three categories. In the second step, the least square regression method was used in the regression of the sub-sample of occasional violators. Using least square method has advantage that it allows one to directly interpret the parameter in the selection model as conditional marginal effects.

2.7 An overview of Property Rights.

Property right, according to Ostrom (1993), define actions that individuals can take in relation to other individuals regarding some "thing". And if an individual has a right, other individual(s) has the commensurate responsibility. The samples for unregulated fishery were drawn from a purpose to respect that right. Resources that do not have ownership or control are referred to as open access. It is important to distinguish among some property regimes. Worthy of note are, common property (which is divided into unregulated common property, regulated common property or common pool), state property and private property. Common property denotes resources that are owned by a community and rules of access to the resource are defined by the

community that owns the resource (Helberg, 2001). Typical examples of these resources are some natural lakes and rivers fisheries stock in plateau state.

Common property could either be regulated, where the rules governing the resource utilization are clearly specified or unregulated where the rules do not exist or are not enforced to limit the use of the resource (Baland and Platteau, 1996 and Helberg, 2001). The unregulated common property is also known as the common-pool (Helberg, 2001).These resources have two main characteristics; difficulty or high cost of excluding potential users, and every user subtracts from benefit to other users (Ostrom, 1992). Most Natural lakes resources of plateau state fishery stocks are good example of these resources. The two characteristics are recipes for over-exploitation of say inland water fishery resources, a phenomenon known as the "tragedy of the commons". The five property rights that are very relevant for the use of common pool resources are access, withdrawal, management, exclusion, and alienation (Ostrom, 1992 and Ostrom, 1993).

State Property, on the other hand are resources owned by the state, and rules of access and conservation are enforced by the state (Heltberg, 2001). The Pandam wildlife park lake fishery is an ideal example in plateau state. It is not uncommon that due to high cost of enforcement, state property degenerates to open access or common property. In many developing countries, and Nigeria in particular inland fishery stock is state property, however due to high cost of monitoring many of these resources become common pool to fishers. Finally, private property exits when an individual has a property right over a resource. This right, typically, includes the

right to posses, use, and transfer, destroy, manage and exclude other potential users of the resource (Ostrom, 1993; Heltberg, 2001).

Plateau State Fisheries Edict reads in parts;

i. No fisherman shall:

   a. Catch any of the freshwater fish species below the size specified in Schedule I of this Edict.

   b. Fix stationary fishing structures across the river for the purpose of cultivating, culturing or propagating fish.

ii. No person shall take from or destroy any fish within the water bodies by any of the following methods:

   a. The use of any explosive substance or electricity

   b. The use of any poisonous or noxious matter

   c. The use of gillnet or dragnet of less than 2.5 inches or 7.62 cm mesh size

   d. The use of clap net, cast net or any webbing traps of less than 2 inches or 5.1 cm mesh size

   e. Lift net of not less than 1.5 inches or 3.8 cm mesh size.

iii. No person shall:

   a. Preserve fish by use of insecticide or other toxic chemical

b. Transport, display or sell fish under unhygienic conditions.

iv. No person shall fish within the territorial waters of the State unless he obtains a licence so to do.

The Edict goes on to elaborate on the licensing procedures and fees and on penalties for committing any of the offenses stipulated. With the exception of a few omissions, of some factors likely to cause fish depletion such as barriers for capturing migratory species and draining of pools to crop all the fish, the edict could be said to be fairly comprehensive and easy to understand by local fishermen if translated into the local language.

i) Fish size stipulation and mesh size limitation

Schedule I of the Edict outlines ten species with stipulated sizes for capture as follows:

SCHEDULE I

Fish	**Length in cm**
1. Lates niloticus	20 cm and above
2. Gymnarchus niloticus	35
3. Heterobranchus sp.	30
4. Hydrocynus sp.	30
5. Hyperopisus sp.	30
6. Citharinus sp.	23
7. Distichodus sp.	22

8. Tilapia sp.	12
9. Heterotis sp.	30
10. Bagrus sp.	30

In view of the fact that the Edict permits the use of assorted fishing gears with varied mesh sizes ranging from 2.5 inches (3.8 cm) to 3 inches (7.62cm) the listing of the unit sizes of the different species for capture could cause problems during implementation.

2.8 Artisanal Inland Water Fisheries Stock in Plateau State as a Common Pool

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

Where the above critical conditions are not present and collective action needed for resource management is lacking, the motivation of beneficiaries depends on economic costs and benefits, as well as time involved in and social tensions or gratification from participation. And when government supports are lacking in a situation where there are sufficient incentives.

2.9 Description of the Fisheries.

The Pandam lake reserve fishery is the only natural lake reserve inland water body in Nigeria that employs current management programs that includes three major activities; limit entry, mesh size restriction and a close season. The Pandam lake reserve fishery remains an ideal example of how a lake reserve management is carried out after the Californian sea urchin fishery example. Regulatory restrictions include; a closed season, minimum size limits (3.5mm) and a limited entry programme. Current regulation requires that Pandam lake fish be at least 2.5 inches in diameter, a size reached at approximately one years of age for most commercially important species at the lake.

A full closure is in effect from 1st June to 31st October every year; at this period the lake remain totally closed to fishing activities by licensed fishers. In total, the number of days closed to fishing activities is 153 and the number of potential open days per year is approximately 212, the close period or seasons coincides with spawning periods. Furthermore, limited entry programme permits only 30 licensed fishers to fish every day for the period of open season in the fishery. Pandam Lake gives one kilogram of fish every day to government officials and sells the rest for their income. The other natural lakes in the state are being managed by the communities where

they are located. For these lakes; have no direct government control, the number of people going to fish at the lakes are unlimited, mesh size are not regulated, poison fishing and fishing is done throughout the year. The fishers use mostly wooden dugged-out canoes and fishing gears such as gillnets, *malia* traps, *gura* traps and hook lines in both systems.

Chapter 3

METHODOLOGY

3.1 Study Area

Plateau State is located in the middle belt zone of Nigeria and lies between latitude $8^{o}30'$ and $10^{o}30'$N, longitude $7^{o}30'$ and $3^{o}37'$E with a land mass covering 53,585 square metres. The state has an estimated population 3.78 million (NPC, 2012). The Polmakat Lake is located in Langtang South Local Government Area with projected 2012 population figure of 215,300, Shimankar and Deben are located in Shendam LGA with projected 2012 Population figure of 234,210, while Janta and Pandam are located in QuaanPan LGA, with projected 2012 population figure of 225, 175 (NPC, 2012).

The State has a slightly undulating highland, which rises from steep escarpment from the riverine plains of River Benue and descends towards Bauchi State. While hills and rock formation abound in the Northern and upper part of the State, Uninterrupted expanse of plains with dense vegetation are found in the Southern and lower part of the state. The predominant part of the State lies on high altitude of between latitudes $8^{o} - 10^{o}$ N and longitude 7^{o} and 11^{o}E. It share boundaries with Nasarawa to the East, Kaduna to the North, Bauchi to West, Taraba to the South, has a captivating physical features with high lands rising from 1200m to 1820m above sea levels. The major ethnic groups include Taroh, Berom, Ngas, Mwaghavul, Pan etc. The peoples' predominant occupation includes farming, fishing and hunting. They cultivate crops such as maize, Irish potatoes, *acha*, (Hungary rice) sorghum, yam, etc.

Pandam Lake reserve fishery is within the Pandam wildlife park system, located in the South Western end of Plateau State. It was founded in 1972 as part of a nation-wide conservations initiative. It covers an area of 244km^2 of Guinea Savannah, gallery forest and wetland and currently managed for conservation, tourism and fisheries by Plateau State tourism cooperation. The park lies in the lowland of Benue valley at longitude 8^o.08′ – 8^o.15′E and latitude 8^o.35′-8^o.90′N. It is situated in QuaanPan L.G.A of the state. The Park contains a 200 hectare Y-shaped lake of which each arm is about 3km long and between 100-150 metres wide. The Pandam Lake has two major inflow rivers, river Li and river Dep.

3.1.1 Natural resources and fisheries potential of the state

The State is the hydrological centre of Nigeria, in which the major rivers or water channels originate. In addition, there are a number of water bodies in the state such as: Reservoirs and Dams; (over 20 in number), Mining Ponds; (numbering about 1000), which serve as source of water that can be used for fishing, farming and irrigation. Natural lakes: about 15 in number and various sizes which ranges from 3Ha to 200Ha (Pandam Lake). These lakes are used for both fishing and also as tourist sites. Pandam Fish Farm, the largest in West Africa. It is 105 Ha in size and presently heavily silted and Kurra Falls.

Plateau State, being land locked, is however blessed with a large number of inland water bodies from which its fisheries development programme can be anchored. Such water bodies include over 30 seasonal rivers and rivulets all taking their rise from the State, 15 commercially important natural lakes concentrated in the lowland areas (Southern zone). Fishing in these lakes is an all year-round activity with highest intensity of operation occurring during the dry season

(i.e. November- April). Fishing effort is usually reduce during the raining season when fishing operation have to be combined with farming. The fishers at these lakes are artisanal and gears mostly used include hook lines with an average of 1000 hooks, Cast nets (also called Brogi), Gillnets, Gura trap and Malia trap. These fishers used mostly calabash and canoes.

There are also about 10 dams and reservoirs, 20 seasonal flood ponds as well as 50 roadside burrowed pits. There are also more than 500 fish ponds (Earthen and concrete/plastic) all over the urban, semi urban and rural areas. The high water retention capacities of the soils in the Northern and Central zones along with the unfailing and sustaining relief rainfalls offers more opportunities for the construction and managing of more seasonal ponds and growing of crops that can be utilized as fish feeds. The high number of mining activities in the past years that had taken place in the state has left parts of the state littered with mining ponds of variable sizes and depths. In view of their large number (over 1000) many of them could constitute aquaculture potentials for fishing. These ponds are in higher concentrations in B/Ladi, Jos South and Bokkos L.G.As

On the whole, the water bodies in the State have not only continued to attract indigenous fishing, but also migrant fishermen from Sokoto, Kebbi, Kano, Katsina, Bauchi, Nassarawa, Taraba and Benue States. The total fishermen population is estimated at 5,000. The artisanal fisheries dominated the industry and operate in all lakes, rivers, lagoons, flood plains and seasonal streams, using a variety of gears such as gillnets, seines, hook and lines, long lines, mallias, dragnets. The fishing vessels include; canoes, plank boats, dugged-out canoes and calabash. Many of the players in the value chain of fisheries are women and youths. Opportunities for

women include fish processing and marketing. Most of them however, use crude methods of processing.

3.1.2 Weather and climate

On the basis of soils, climate and typical farming system, the state is classified into three distinct agro ecological zones, namely; the lowland moist Savannah which falls within the Southern Guinea and Savannah rain forest, having extensive low lying flat land with high water holding capacity is favourable for the production of rice, yam, cassava, melon and groundnut. The Mid-altitude Zone which falls within 500-1500 meters above sea level, with soils which are sandy clay and heavy rains, while predominantly maize, Irish potato and assorted vegetables are produced; and the Sub-Sudan and Northern Guinea Savannah zones falls within 100-350 metres above sea level, with high concentration of livestock and production of crops like Millet, Groundnuts, Sorghum and Cowpea.

Pandam wildlife Park lies within the Northern Guinea Savannah zone of Nigeria with distinct wet and dry seasons. Annual rainfall ranges between 1.400mm to 2,010mm. It spreads between 6-8 months, and the rain is heavy from late May-September and decreases toward October. The dry season at Pandam lasts between November-April each year. During the dry season around December-February, the Southwest moisture laden wind gives way to cold dry, dusty North-east trade winds (Harmattan).

The temperature at the Park Range from, 29^{o}C- 31^{o}C, but can be as low as 12^{o}C-13^{o}C. Evaporation rate is high during the dry season. In the early rains (April-May), the days remain hot and warmer in the nights. Humidity level ranges from 10-15hmm in the afternoons, but in the

rainy season, the relative humidity rises as temperature climax and evaporation rate falls. Between Augusts to October, the mean temperature is low with maximum relative humidity rising up to 95%.The main vegetation in Pandam Wildlife Park is woodland with an open canopy and continuous grass/shrubs cover between the trees. Dominant trees of the area include: Vitallaria Paradoxa, Khanayaspp.,Lanea spp., Parkia biglosrosa, Burkia Africana, Annona Nigerianessis, elleisguineasis, Danuilla olivexii among others.

Silt soils and slabs of iron stones and rocks are the general formation in the park and lake. Their colours range from black to brown compact silky fine sands or sandy clays in the park and lake-shore with coarse textured soil on the higher altitude (Keay, 1959). There are two important rivers which form the main drainage system of the park and source of inflow of the lake. They are; Dep River and Li River originating from the highland of Jos-Plateau from boundary of the Park. It forms the boundary between the Park, Plateau State and Nasarawa State and enters the Park into the lake from the eastern part. The dominant fishes found in the mixed species lake reserve includes; clarilidae, mochokidae, protopteridae, cidilidae, chanidae and shcilbeidae, families among others.

The Southern agro-ecological zone where the lakes are located lies between latitude $8^{o}30'$E. The area experiences a sub humid tropical climate with about 6 to 7 months of rain and 5-6 months of dry season. The mean annual rainfall is about 110mm falling between April and October; the mean monthly Maximum temperature is 30^{o}C while the mean monthly minimum temperature is 20^{o}c. The area, consist of flood plains dissected by rivers and seasonal streams. Geologically, it

falls within the jepjan, Shendam and Mabudi formations which are predominantly composed of cretaceous shale of tertiary age.

3.2 Sampling Procedures

The regulated and unregulated natural lake fisheries were used as case studies to arrive at a general overview of management of capture fisheries in the study area. The sampling procedures summarised and presented in Table 1 indicated four natural lakes of unregulated fishery were purposively selected in view of their commercial significance and to ensure geographical spread of selected sites to cover the state. Specifically, twenty fishers from each of the chosen natural lakes were randomly selected and interviewed. Furthermore, all the thirty licensed fishers of the regulated Pandam lake fishery were purposively selected for comparison with the unregulated fishers. This gave a total sample size of eighty fishing household heads for unregulated Lakes and thirty for the regulated fishing with a total of one thousand five hundred and forty daily fishing activity observations. The interviews were conducted to fishers actively involved in fulltime fishing only (i.e. fishing throughout the year). The household heads were used as the sampling unit because they represent economic decision-making units.

Table 1 Summary of Sampling Procedures

Lake	Population	Sample Size	Percent	Location (LGA)	Estimated Area
Pandam	30	30	100	Qua`anpan	200*
Polmakat	171	20	11.7	Langtang South	90*
Shimankar	156	20	12.8	Shendam	20*
Deben	143	20	13.98	Shendam	30*

Janta (Tirip)	157	20	12.7	Qua`anpan	40*
Total	**656**	**110**	**16.76**		

* Source: NPFS, 2004

3.3 Data Collection

Primary data were employed for the research and collected using a set of questionnaire and a catch assessment logbook. One of the set was administered to the government regulated fishers of Pandam Lake. The other set was administered to the unregulated fishers at Shimankar, Polmakat, Deben, and Janta lakes. Prior to the administration of the questionnaires, daily fishing observations were conducted on the fishers randomly selected during the pre-study visit and frame survey conducted in April/May 2010. The daily fishing observations of selected fishers were carried out through a Catch Assessment Survey (CAS). The CAS; involved the daily tracking of fishing activities of an individual fisher to collect information regarding; daily catch weights, price, the type and numbers of gears in use.

The CAS was done to capture the lean months (June-September) and peak months (November-February) of unregulated fishing in the study area, while the CAS for regulated fishery were conducted for two weeks each from third week of May to second week of November, 2011. These were followed by the administration of the set of questionnaires to the regulated and unregulated fishers. Total daily fishing observations of one thousand five hundred and forty in four weeks from one hundred and ten fishers were made (1540 observations: 4wks: 110 samples). Information collected include: socioeconomic characteristics, perceptions, effort allocation, types of gears and their activity, prices, costs, returns, self reported violation and compliance and constraints.

3.4 Analytical Frame Work.

The tools of analysis used in achieving the objectives of the study included: Descriptive statistics, logit model, multinomial choice model, ordered probit model, farm business analysis and stochastic frontier analysis (SFA).

3.4.1 Descriptive statistics

Was used in achieving objectives one and seven. Descriptive statistics such as percentage, mean, average range, minimum, maximum and standard deviations were used to describe the general fishing systems in the fisheries and the socioeconomic characteristics of Fishers and the constraint to efficient and sustainable fish exploitation and maintenance of environmental quality.

3.4.2 Logit regression model

Was used to determine the influence of socio-economic characteristics on the fishermen`s decision to participate in the regulated fishery (objectives two). Logit regression model is based on cumulative logistic probability function, where the dependent variable assumes two values (a dichotomous response variable) coded zero and one. The logistic distribution function was specified as follows (Damodar, 1995).

$$\frac{P_i}{1-P_i} = \frac{E(y_I=1/X_i)}{E(y_I=0/X_i)} = \frac{1+e^{z}}{1+e^{-z}} = e^{z} - - - - - - - - - (1)$$

Where; $Z_i = \beta_o + \sum\beta_j x_{ij} + \varepsilon_{ij}$

P_i = Probability that the fisher decides to participate in regulated fishing

$1 - P_i$ = probability of an event not occurring

Taking log of equation (1)

We have; $L_i = \text{In } \frac{P_i}{1-P_i} = Z$ - - - - - - (2)

But $Z = \beta_o + \sum \beta_i x_{ij} + \varepsilon$

Equation (2) can therefore be specified as;

$L_i = \text{In } (P_i / 1\text{-}P_i) = \beta_o + \sum \beta j\ x_{ij} + \varepsilon_i$ - - - (3)

The logistic model was estimated using the maximum likelihood estimator (MLE) as described by (Kmenta, 1986). The estimated model was specified as follows;

$L_i = \ln \frac{P_i}{1-P_i} = \beta_1 X_1 + \ldots + \beta_8 X_8 + e$ - - - - - - - - -- - (4)

Where;

Li = Participation in regulated fishery (1; 0 otherwise)

X_1 = Age of fishers (years)

X_2 = Educational status of the fishers (years of formal schooling)

X_3 = Experience of the fishers (years)

X_4 = Family size (number of people living within household)

X_5 = Extension contact (number of extension visits made to fishers)

X_6 = Catch per unit of effort (CPUE) (kg/day)

X_7 = Technical efficiency from SFA (proxy for Heterogeneous skills)

X_8 = Alternative source of income (exist 1, otherwise, 0)

ε = Error term

CPUE was calculated using FAO (2007); CPUE = C/F = total catch/total gear x number of fishing days.

In this study it was hypothesized that *Age* of the household head has both positive and negative impacts on regulated fishing measures. It is assume that old age is associated with more experience and expect older farmers to participate in new fishing innovation maybe considering a previous fail attempt. However, we also expect young farmers to have a longer planning horizon and to take up long-term adoption of sustainable fishing measures such as regulated fishing.

The study also hypothesizes family size to have both positive and negative impact on regulated fishing. Larger family size is expected to enable fishers to take up labour intensive adoption measures at regulated fishery. Alternatively, a large family might be forced to divert part of its labour force into non-fishing activities to generate more income and reduce consumption demands. Also, the existence of alternative source of income outside the regulated fishing area will have a negative impact on regulated fishing and make fishers to move away from regulated fishing. The regulated fishery located in the Wildlife Park which make other sources of income common in rural areas very rare because of restrictions within and around Park. This may make the opportunity cost of labour higher in most smallholder unregulated fishing areas as off-fishing opportunities such as farming and hunting are possible and more in areas outside the Pandam Wildlife Park.

The variables of Education, fishing experience and extension are important factors influencing innovations adoption decisions and assume to have a positive impact on regulated fishing. This is because improving education and extension education by way of disseminating knowledge is an important policy measure for stimulating local participation in various development and natural

resource management initiatives. Furthermore, it is assume here that better education and more fishing experience improve awareness of potential benefits and willingness to participate in local natural resource management and conservation activities of regulated fishing. Educated and experienced fishers are expected to have more knowledge and information about sustainability issues. It is therefore expected that improved knowledge, farming experience and improve awareness in the form of extension contact will positively influence fishers' decisions to participate in a regulated fishing measures.

The variables of CPUE and Heterogeneous fishing skills are assumed to have a positive influence on regulated fishing. This is because CPUE which is a measure of stock abundance or catch ability coefficient is expected to make fishers to move to areas where there is a higher CPUE and more sustaining regulated fisheries as they may see it as a more secure source of income and employment. Furthermore, because regulated fisheries is more professionalise than the conventional system. The fishers that have better fishing skills are expected to do well in a regulated fishery.

3.4.3 Multinomial choice model

This was used to evaluate determinants of lake choices among fishers of unregulated fishery (objective 3). The model used is generally effective where the dependent variable is composed of a polychromous category having multiples choices. The study used the model to estimate the effects of individual variables on the probability of choosing a type of alternative fishery resource location in the unregulated fishing activities. The multinomial logistic model for fishery

choice specifies the following relationship between the probabilities of choosing option A_i and the set of explanatory variable x as (Greene, 2003);

$$\text{Prob } (A_i = j) = \frac{e^{\beta j x_i}}{\sum_{k=o}^{j} e^{\beta j x_i}} \qquad j = O, 1 \ldots J \text{ - - - -} \qquad (6)$$

Where; β_j is a vector of Coefficient on each of the independent variable X. Assuming that $\beta_o = o$ and the probabilities can be estimated as;

$$\text{Prob } (A_i = j) = \frac{e^{\beta k x_i}}{1 + \sum_{k=1}^{j} e^{\beta k x_i}} \qquad j = O, 1, 2 \ldots J, \quad \beta_o = O \text{ - - - -} \qquad (7)$$

Estimating equation (7) yields the J log-odds ratios

$$\text{In } \frac{P_{ij}}{P_{jk}} = xi\ (\beta_j - \beta_k) = X_i\ \beta_j, \text{ if } K = O \text{ - - - - - - - - - - - -} \qquad (8)$$

Where; A_i = fishers of Pandam (0), Polmakat(1), Shimakar(2), Deben(3) and Janta(4).

X_1 = Age of fishers (number of years)

X_2 = Educational status (Number of years)

X_3 = Experience in fishing (Number of years)

X_4 = Family size (number of people)

X_5 = Alternative source of Income (exist = 1, does not exist = 1)

X_6 = Heterogeneous fishing skills proxy by technical efficiency (ested. from SFA)

X_7 = Catch- per-unit- of – effort (CPUE) (kg/day)

X_8 = Extension contact (number of visits)

ε = Error term

To interpret the effects of explanatory variable on the probabilities, marginal effects are usually driven as (Greene, 2003);

$$\delta j = \frac{\partial P_j}{\partial x_{ij}} = P_j\ [\beta_j - \textstyle\sum_{k=o} P_k \beta_k] = P_j\ (\beta_j - \beta) \quad - - - - - - - - - - (9)$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (long, 1997).

It was hypothesize that *A*ge of the household head has negative impacts on unregulated fisheries. It is assume that old age is associated with more experience and expect older farmers to participate in new fishing innovation maybe considering a previous fail experiences. Furthermore, young farmers may have a longer planning horizon and to take up long-term adoption of sustainable fishing measures such as regulated fishing.

The study also hypothesizes family size to have positive impact on unregulated fishing site choice. Larger family size might be forced to divert part of its labour force into non-fishing activities which are more common in unregulated site to generate more income and reduce consumption demands rather than stay in regulated fisheries where there may be no income during the close seasons. Also, the existence of alternative source of income will have a positive impact on unregulated fishing. The regulated fishery located in the Wildlife Park which make other sources of income common to rural areas very rare because of restrictions within and around Park. Therefore, the high opportunity cost of labour in most smallholders' fishers may prefer diversification into off-fishing opportunities such as farming and hunting for extra sources of income.

The variables of education, fishing experience and extension are important factors influencing innovations adoption decisions and assume to have a negative impact on unregulated fishing choice. This is because improving education and extension education is an important policy

measure for stimulating participation in new technology adoption such as regulated fisheries. Educated and experienced fishers are expected to have more knowledge and information about sustainability issues. Furthermore, it is assume here that better education and more fishing experience improve awareness of potential benefits and enhance fishers willingness to choose a sustainable natural resource management and conservation activities of regulated fisheries. It is therefore expected that improved knowledge, farming experience and improve awareness in the form of extension contact will positively influence fishers' decisions to quit unregulated fishing measures.

The variables of CPUE and Heterogeneous fishing skills are assumed to have a negative influence on unregulated fishing. This is because fishers will prefer fishing areas where there is a higher CPUE and more sustaining regulated fisheries for better source of income and employment. Also, fishers that have better fishing skills are expected to do well in a regulated fishery, where efficiency levels are more than the unregulated fisheries.

3.4.4 Ordered probit model

This was used to determine the violation behavior of fishermen of regulated fishery (Objective 4). The analysis of factors affecting compliance of close season using two step Heckman procedures was employed. In the first step ordered probit model utilizes a form of discrete choice models was used, The socioeconomic variables were continuous variables, while the deterrence, legitimacy and social variables were all measured by a four-digit scale. However, in the final analysis, these answers were re-coded as dummy variable with levels three and four being one, while, one and two being zero, where one represents fishermen who agreed with the statement

and zero otherwise. The second step involved a least square regression on the subsample of occasional violators. The data were corrected by estimating the models using Limdep AR (1) and Prais-winsten method of correction for heteroscecadasticity and autocorrelation respectively.

The ordered probit model was specified as follows:

$VL = x' \beta + bi \beta + pi \beta + si \beta + \mu$ - - - - - - - - - - (10)

Where; VL = $\begin{cases} 0 \text{ If } v^* \leq \mu 1 \\ 1 \text{ If } \mu < v^* < \mu 2 \\ 2 \text{ If } v^* \geq \mu 2 \end{cases}$

X_1 = Age of fishermen (number of years)

X_2 = Educational status (number of years)

X_3 = Experience in fishing (number of years)

X_4 = Family size (number of dependence)

B_1 = Expected gain from catch from illegal fishing (high =1, low = 0)

B_4 = Close season regulations is not effective (yes = 1, N0 = 0)

P_2 = Number of past arrest of fisher (number)

P_3 = Subjective probability of being detected and caught (low = 0, high = 1)

P_4 = Subjective probability of being detained if arrested (low = 1, high= 0)

P_5 = Probability of being taken to court and convicted (low = 1, high = 0)

S_2 = Number of others you think are violating regulations (number)

S_3 = Do your peer /friends think violation is right or wrong? (Right = 1, wrong = 0)

S_4 = Do they seek your opinion during the design of regulation (No = 1, yes = 0)

S_5 = Close season regulation is not enforced consistently (yes = 1, No = 0)

S_6 = Close season regulation improves the well-being of a few? (Yes = 1, No = 0)

S_7 = Penalty given to offenders or violators fit the offense (Yes = 0, No = 1)

S_8 = Enforcement at lake is not adequate (Yes = 1, No = 0)

S_9 = Many offender are not detected (Yes = 1, No = 0)

S_{11} = Close season regulation is not fair (Yes = 1, No = 0)

v* is not observed and v is its observed counterpart, $X_{i,,}b_i$, pi and s_i are vectors of explanatory variables, μ_1 and μ_2 are threshold parameter to be estimated with the β's, the subscript i is index of the individual and the error term μ is distributed as standard normal (Greene, 2003);

3.4.5 Farm business analysis

This was used to show the level of costs, returns, Net farm Income and profitability index for both regulated and unregulated fisheries under the existing management systems and used to achieve objective five. The farm business analysis measures the strength and weakness of the farm (Olukosi and Erhabor, 1987). The indicators used in this work were the Net farm Income (NFI) and Profitability Index. The item of revenue - sales of total daily catch for the period of catch assessment survey. The cost items considered were variable costs; fishing gears; gillnets, hook line, gura traps, mallia trap, repairs/maintenance and labour, while fixed costs were; depreciation on canoes and calabashes. The total return was estimated by multiplying the total weight of catch by the prevailing market prices.

The final output value was standardised using the "statistical sampling method for improving the catch assessments" formula by FAO (2007). The formula as given:

$$z = 26/4\sum xi$$

Where; z = output (kg)

x_i = individual sample

26/4 = four sampling days a week, assuming a twenty six day fishing in a month.

$\sum$ = summation sign

The model used was represented by the equation;

$$NF1 = \sum_{i=1} P_i Y_i - \sum_{j=1} P_{xj} X_j - \sum_{k=1} F_k \quad \text{- - - - - - - - - - - (11)}$$

Where;

NFI = Net farm Income (₦ per month of fishing)

Y_i = Fish output (kg/month)

P_i = Unit price of the fish (₦ / kg)

X_j = Quantity of variable input (where j=1, 2, 3 . . . m)

Px_j = Price/Unit of variable input (₦)

F_k = Cost of fixed inputs (Where k = 1, 2, 3…k fixed input)

$\sum$ = Summation (addition) sign.

The Net farm Income (NF1) is gross receipt less total cost. Fixed cost was cost of calabashes and canoes depreciated using straight line method. While variable cost items include cost of fishing effort allocation such as; labour, gillnets, mallia traps, gura traps and hook lines. Profitability index (rate of return on an investment) was employed to explain the extent to which a Naira invested into regulated or unregulated fishing will contribute to total value of output. The rate of return on investment into an enterprise is the ratio of net income to total cost of fish captured.

3.5.6 Stochastic frontier production function analysis (SFA)

This was used to estimate the technical efficiencies of the fish capture function (objective six). Stochastic frontier model was simultaneously used to estimate the technical efficiencies and inefficiencies of individual fishers using the maximum-likelihood estimation (MLE) program in a FRONTIER 4.1c (Coelli, 1993). The study assumed the translog function to be the appropriate specification for the capture fish technology structure, therefore, testing the inadequacy of Cob-Douglass was required (Coelli *et al.*, 1998) relative to the less restrictive translog form. The use of SFA will enable managers to understand individual fishers level of technical efficiency in the fish capture function where the maximum attainable catch of individual at a certain time is a function of two productive inputs, fishing effort (E_i) and exploited stock Si represented by;

$Y_i = f(E_i, S_i)$ - - - - - - - - - - (12)

Where; Y_i = catch of individual i at the specified period, S_i is exploited stock, (higher stock densities lead to higher yields), E_i is Fishing effort and has a more difficult interpretation (Garcia et al, 2004) and is generally thought (Benerton and Holt, 1957) to be a function of fishing Power and fishing activity, therefore, can be written as;

$Y_i = g(E_1, E_2, E_{3,})$ - - - - - - - - - - (13)

Where;

E_1 = is the length of fishing gears measured in meters.

E_2 = represents the time taken for passive gears to remain active in water (hours) per fishing trip as a proxy for hours fished (Kirkley et al, 1998).

E_3 = represents the number of fishing gears owned by the individual fisher that were in activity during survey period.

To estimate Equation (13), the first best option was to consider a translog flexible functional form, because it represents a second-order approximation of any arbitrarily chosen function as well as being theoretically pausible (Berodt and christenseo 1973); it's specified as follows:

$$In\ Y_j = \beta_o + \beta_1 InE_1 + \beta_2 InE_2 + \beta_3 InE_3 + \beta_{12} InE_1 InE_2 + \beta 13InE1InE3 + \beta_{23} InE_2 InE_3 + ½ (\beta_{11} InE_1 + \beta_{22} InE_2 + \beta_{33} InE_3)^2 + (V_i - \mu_i) \quad (14)$$

Where; subscript j refers to the jth fisher in the sample. In denotes the natural logarithm (base e). A logarithmic transformation provides a model which is linear in the logarithmic of the inputs. In equation (14), the symmetry restriction has imposed a priori to identify the coefficients ($\beta_{ij} = \beta_{ij}$). Consequently, different restriction on the translog function was tested to establish the most appropriate final form for the fish capture function. The deviations ε_i in equation (12) from the catch frontier [$f(E_i\ S_i)$] are represented by an asymmetric two-sided error composed of a two-sided random (v_i) and a consider error term ($\mu_i \geq O$);

$$E_i = v_i - \mu_i \quad (15)$$

The stochastic error V_i is usually assume to be normally distributed, with Zero mean and constant variance. The μ_i in equation (v) is the technical inefficiency effects, assumed to depend on some selected fishing-specific variables which were included to indicate their possible influence on the technical inefficiencies of the fishermen.

Where;

μ_i = $b_o + b_1 D_1 + b_2 D_2 + b_3 D_3 + b_4 D_4$ . . . . . . (16)

D_1 = Age of fishers (number of years)

D_2 = Education status (number of years)

D_3 = Experiences of fishers (number of years)

D_4 = Family size of fishers (number of people)

3.5.7 *A priori* expectations for variables used in models

It was hypothesize that Age of the fishing household head has both positive impacts on fishing efficiency. It is assumed that old age is associated with more experience and by extension higher fishing skills. It is expected than older fishers might have learned from experience the best improved ways to catch fishes. This study also hypothesizes family size to have positive influence on fishing efficiency. Larger family size is expected to enable fishers use labour intensively for high efficiency. Large family might be forced to divert part of its labour force into non-fishing activities to generate more income and reduce consumption demands. However, the opportunity cost of labor might be low in most smallholder farming systems as off-fishing opportunities are rare. Therefore, the available labour can be focus into intensive labor use for high efficiency.

The research also hypotheses factors such as formal education and fishing experience to positively contribute to efficiency levels. This is because improving education is an important policy measure for stimulating adoption of new technology in various development and livelihood improvements. Better education and more fishing experience improve awareness of potential benefits and willingness to adopt best practice and activities that can result to higher efficiency. Test for the presence of technical inefficiency effects using generalized likelihood ratio, is defined by chi-square (χ^2) test statistics (Greene, 2000). The test statistics, $\chi^2 = -2\text{In}(H_o/H_a)$

H_o: Total variation in output is not due to technical inefficiency

H_a: Total variation in output due to technical inefficiency effects.

When inefficiency was estimated, Technical Efficiency (TE) was computed using,

$$TE = E [\exp (- \mu i)/ (v - \mu i)] \quad (17)$$

Chapter 4

RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Fishers of Regulated and Unregulated Fisheries.

A study of the socioeconomic profile of small-scale fishers is a prerequisite to the design and implementation of effective support programs. This evaluation was to provide an overall picture of the structure and activities of households as a background to more in-depth analysis. Furthermore, the comparative evaluation of socio-economic status of fishers of Regulated Natural Lake Fishery (RENLAF) and Unregulated Natural Lake Fishery (URENLAF) will help compare to those of other socioeconomic groups (e.g. farmers) and to the national average. The study evaluated socioeconomic factors such as age, household size, educational status, experiences, and types of gears used as well as perception of fishers about fish stock.

4.1.1 Age

The age structure of the respondents in the study area is presented in Table 2. The mean age of fishers for URENLAF was 35.90 years and 45.17 years for RENLAF. This results show that the mean age of RENLAF fishers was significantly ($t = 2.37$, 5%, level of significant) higher than the URENLAF fishers. This means that RENLAF fishers were older compared to other URENLAF fishers. This may suggest that officials at RENLAF prefer to grant license request for fishers who attained some certain age limit. The standard deviation of RENLAF fishers was 38.9; the large variation in age of fishers implies that the fishers were of different age group.

Table 2: Age Structure of Fishers in the Study Area

	Polmakat		Shimankar		Deben		Janta		Urenlaf Pooled		Pandam Renlaf	
Age group	**Freq**	**%**	**freq**	**%**	**freq**	**%**	**freq**	**%**	**Freq**	**%**	**Freq**	**%**
≤ 20											3	10
21-30	2	10	9	45	7	35	5	25	23	28.75	10	33
31-40	12	60	7	35	10	50	7	35	36	45	9	30
41-50	3	15	4	20	3	15	8	40	18	22.50	2	09
51-60	3	15	-		-		-		3	3.75	6	20
Total	20	100	20	100	20	100	20	100	80	100	30	100
means	**39.90**		**33.5**		**33.5**		**36.80**					
S.D	10.5		6.9		8.5		9.3				39.8	
MEAN									**35.90**		**45.9**	

4.1.2 Educational status

The distribution of educational status among fishers is presented in Table 3. The average year of schooling of URENLAF fishers was 7.0, while 6.2 years for RENLAF fishers. This means that for all categories of fishers the average year of educational attainment was at primary school level. This result reveals that professional fishers in the study area generally had low level of educational attainment. This finding agrees with the finding of Inoni *et al.* (2007) on socio-economic analysis of artisanal fishing in the South Agro-ecological Zone of Delta State, Nigeria, in which they observed that 69% of the small-scale fishers went through primary school. This may be a pointer to the fact that fishing profession in the study area may be considered as a job for the less educated in the society.

Table 3: Educational Status of Respondents in the Study Area

Year of school	Polmakat freq	%	Shimankar freq	%	Deben freq	%	Janta freq	%	URENLAF pooled Freq	%	RENLAF freq	%
None.	0	-	2	10	2	10	6	30	10	12.50	8	26.67
1-6	7	35	6	30	7	35	13	65	33	41.25	12	40
7-12	10	50	5	25	6	30	1	5	22	27.50		
13-14	3	15	7	35	4	20	0	-	14	17.50	8	26.67
15≥	-	-	-	-	1	05	-	-	1	1.25	2	06.67
Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**80**	**100**	**30**	**100**
Means	7.95		7.85		7.2		3.55					
S.D	3.6		4.2		4.2		2.7		**6.6**		4.7	
MEAN							**6.66**				**6.2**	

4.1.3 Years of experience

The analysis of years of experience in fishing presented in Table 4 shows the mean for URENLAF fishers was 15.33 years. The RENLAF fishers had a mean of 27.20 years of experience. This result shows that fishers of RENLAF were more experienced than the URENLAF fishers at (t =2.98, 5% LOS).

Table 4: Distribution of Fishers according to Years of Fishing Experience

					URENLAF pooled		RENLAF Pandam	
Experience	**Polmakat**	**Shimankar**	**Deben**	**Janta**	**Freq**	**%**	**Freq**	**%**
1-10	4	8	6	11	29	36.25	2	6.67
11-20	10	10	8	5	32	40	7	23.33
21-30	4	1	5	1	11	13.75	7	23.33
31-40	1	1	1	3	6	7.50	10	33.34
41≥	1		1		2	2.50	4	13.33
Total	**20**	**20**	**20**	**20**	**80**	**100**	**30**	**100**
Means	18.90	14.2	16.8	11.45				-
S.D	9.5	8.1	9	10	**15.3**		12.8	
Mean					**3**		**27.20**	

4.1.4 Household size

The result of analysis of number of people living within the household is presented in Table 5. This result reveals that the average family size for URENLAF fishers was 7.2 people, while the RENLAF fishers had a mean of 9.9 people. The study agrees with the findings of Akpalu (2002) on Compliance to mesh size regulations in artisanal marine fishery in Komenda-Edina-Equafr-Abrew District of central region of Ghana, in which he found that fishers had an average of about eight people per household.

Table 5 Distribution of Fishers according to Household Size

Household size					Urenlaf		Renlaf Pandam	
	Polmakat	Shimankar	Deben	Janta	Freq	%	Freq	%
0-5	7	7	7	11	32	40	14	46.67
6-10	13	10	8	6	37	46.25	8	26.67
11-20	0	3	4	3	10	12.50	4	13.33
21-30	-	-	1	-	1	1.25	1	3.33
31≥	-	-	-	-			3	10
Total	**20**	**20**	**20**	**20**	**80**	**100**	**30**	**100**
Means	6.8	8	7.5	7.3				-
S.D	2.5	4.1	5.9	5				9.43
MEAN					**7.2**			**9.77**

4.1.5 Fishing Gears Ownership

The evaluation of fishing gears that are operational in the study areas is important in understanding fishing structure and level of economic activities at the lakes. Researchers usually classify fishery based on the type of gears in use at the site. The results presented in Table 6 revealed that fishing craft in use were paddle wooden dugout canoes and "Gora" calabash found under both RENLAF and URENLAF.

Specifically, the fishing gears used at the URENLAF were; gillnets, malia traps, gura traps and Hook lines. The most commonly used type of fishing gears at the URENLAF and RENLAF were; malia traps and gillnets. malia traps constitute 81% of all fishing gear activities at Polmakat Lake. It also constituted 90.2% of total gear activities at Shimankar Lake. Furthermore, malia traps were the dominant gears used at Deben with 58.32%. At the Janta

Lake, gillnet was the dominant gear in use with about 44.44%. At the RENLAF, the average numbers of each gear owned per fisher were 4.6, 30, 16 and 68.8 for Gillnets, malia traps, gura traps and hook lines respectively. There were a total of 1702 gears in operation at the RENLAF during the survey period. These consisted of gillnets 17%, malia traps 39%, gura traps 23% and hook lines 21%.

Table 6 Distribution of Fishers according to Gears used

									Urenlaf		**Renlaf**	
Type of Gears	**Polmakat**		**Shimankar**		**Deben**		**Janta**		**Pooled**		**Pandam**	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**freq**	**%**	**Freq**	**%**
Gillnet	45	4	72	8	8	4	240	44	363	10.44	294	16
Malia trap	940	82	845	90	515	58	133	25	2433	69.97	662	39
Gura trap	-		-		130	5.4	-		130	3.73	382	23
Hook line	164	14	20	2	200	22.6	167	31	551	15.84	364	22
Total	**1148**	**100**	**937**	**100**	**883**	**100**	**540**	**100**	**3477**	**100**	**1702**	**100**
Mean	57.4		47		44		27		**43.85**		**57**	

4.1.6 Gilnet mesh size assessment

The type of gillnet mesh size used at the fisheries presented in Table 7 also revealed that the fishers used gillnets of various sizes, ranging from ¾ – 3½ inches. The analysis show that, Gillnets constituted 10.4% of all gears at URENLAF sites. Out of the 45 number of Gillnets at Polmakat, 20 were 2 ½ inches mesh size nets, while 25 were 3 ½ inches mesh sizes. At Janta, 99 of the 240 Gillnets were 2 ½ mesh size Gillnets and 141 were 3 inch mesh size Gillnets. The

results also show that 6 of the 8 Gillnets at Deben were 3 inches mesh size nets, while two were ¾ inch mesh size.

In Shimankar Lake, 72 Gillnets use by the fishers were 3 ½ inches, while eight were 2 ½ inches mesh size Gillnets. While Twenty-two Gillnets was ¾" and another thirty were 1" mesh size nets. The Plateau State fisheries edicts of 1973 forbid fishers from using Gillnets of less than 2½ inches mesh size to fish in its rivers and lakes. When fishers were questioned on the use of ¾" and 1" mesh sizes at Deben and Shimankar, they admitted knowledge of the edict, but stated that some fishes cannot grow beyond 1" diameter and indicated they were interested in catching those types of species. This finding agrees with the study of Eggart (2004) on regulatory compliance in Lake Victoria, in which fishers admitted knowledge of rules, but reported they violated for economic reasons.

At the RENLAF site, the results indicated that 29 of the 294 Gillnets had 2½" mesh size, while, 201 were 3" inches mesh size of nets. The remaining 64 were 3½ inches mesh size. The results also revealed that the Pandam Lake Fishery recorded a 100% compliance with recommended minimum of 2 ½ inches as mesh size specified in Schedule 1 of Plateau State fisheries edict of 1973.

Gillnets are placed in the late afternoons and retrieved in the morning of the following day. Fishers often stay out with gears, leaving the lake at evenings and returning very early the next morning. Gillnets are about 100yards long in length (91metres) and between four-five meters width. The other gears are hook lines, mallia traps and Gura traps, when these gears are set they

can remain in water for weeks and even months, as fishers only return to check every morning. The malia traps are made up of spherical shape sticks covered by nets with about three or four deceptive openings at the base. The Gura traps are also made of spherical shape wood work covered with net, but has a deceptive opening at both ends that lead to the inside. The fishing units at both RENLAF and URENLAF fisheries were all passive (i.e. they are set and allowed active in water to catch fish and not driven in water to catch fish).

Table 7: Distribution of Fishers according to Gillnet Mesh Sizes

Mesh size	Polmakat	Shimankar	Deben	Janta	Urenlaf pooled Freq	Urenlaf %	Renlaf Pandam
3 ½"	940	12	-	-	752	68.05	64
3"	25	-	6	141	172	15.56	201
2 ½"	20	8	-	99	127	11.49	29
¾" and 1"	-	52	2	-	54	4.90	-
Total	**985**	**72**	**8**	**240**	**1105**	**-**	**294**

4.1.7 Perception of fishers about stock abundance.

Fishers were asked to comment on their perception of stock abundance, and result presented in Table 8. For the URENLAF sites, fishers generally believed stocks were declining in the past 15 years. The result show that about 50%, 75%, 80% and 55% of fishers at Polmakat, Shimankar, Deben, Janta respectively believed stocks were decreasing. About 30% at Polmakat and 5% at Janta perceived stock to be increasing. Furthermore, about 20%, 25%, 15% and 30% of fishers

at Polmakat, Shimankar, Deben and Janta respectively reported they believed stocks are constant. At Deben 5% and Janta 10% confessed they don't know what is happening to stock levels.

At the RENLAF site, most fishers (53%) believed stock level has not changed, while 20% said stock level was decreasing. About 14% believed there was an increase in stock level. The perception of fishers in fishery management is important for the success or failure of management tools used. This finding confirms the findings of Akpalu (2002) on regulatory compliance of fishers at Central Region of Ghana. He found that 60% of the fishers truly believed fish stocks were decreasing, yet they preferred to break rules of safe fishing.

The study also revealed that catch- per- unit- of- effort (CPUE) (which is a measure of resource abundance as well as a catch ability) of fishers were 6.45kg and 5.3kg respectively for RENLAF and URENLAF. This may suggest that there could be a change of apathy about fishing where management regulations are impose.

Table 8: Fishers Perception of Stock Abundance

									Urenlaf		**Renlaf**	
Perceptions	**Polmakat**		**Shimankat**		**Deben**		**Janta**		**Pooled**		**Pandam**	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**			**Freq**	**%**
Decreasing	10	50	15	75	16	80	11	55	52	65	6	21
Increasing	6	30	-	-	-	-	1	5	7	8.75	4	13
Constant	4	20	5	25	3	15	6	30	18	22.50	16	53
Don't know	-	-	-	-	1	5	2	10	3	3.75	4	13
CPUE((kg)	**6.26**		**5.02**		**4.23**		**5.69**				**-**	
Mean CPUE	-		-		-		-		**5.3**		**6.45**	

Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**80**	**100**	**30**	**100**

4.2. Factors Influencing Fisher's Participation in RENLAF

Results of estimate of factors influencing fishers' participation in the RENLAF fishers are presented in Table 9. The correlation coefficient results show that education status, experience and family size were highly correlated; therefore, excluded from further analysis. The logit and probit results show similarity and were fitted at $R^2 = 0.63$. This implies that the explanatory variables were able to explain 63% of the decisions of fishers to participate in RENLAF. The chi-squared statistic value was 18.58; the critical value from the chi-squared distribution with 3 degrees of freedom was 7.81, so the hypothesis of misspecification of the logit model was rejected.

The variable, extension Contact (ext.con) was positive and statistically significant at 5% level of significance (LOS). This indicated that the probability of fishers' participation in a regulated fishing will increase for a unit increase in extension contact. As fishers interact with extension workers and fisheries officers at the office by the Lake, it gives them a higher probability to fish under regulation. This may be because as the fishers interact; they learn and understand safe fishing (fishing using the required minimum mesh size, avoidance over exploitation and poisonous fishing). The result shows that for a unit increase in extension contact, the probability of fishers showing willingness to participate in regulated fishery will increase by 11.4%. This result also indicates the need and importance for extension education at the URENLAF. Interaction between extension staff and fishers could help them to adopt safe fishing methods such as use of higher mesh size and non-poison fishing techniques.

Catch-per-unit-of-effort (CPUE) is a measure of resource abundance as well as catch ability. The analysis shows that CPUE was significant at 5% LOS and negative. This means that the variable was inversely proportional to the fisher's willingness to participate. This implies that as CPUE increases at the RENLAF, the fishers will show willingness or higher probability to exit the fishery. Putting it differently, for a unit increase in CPUE at regulated Pandam fishery, 25% of fishers will prefer fishing at unregulated fishery. The result was against a priori expectation. However, this could be because fishers assume increase at RENLAF was also an increase at the URENLAF, so they would prefer fishing outside the RENLAF sites.

Heterogeneous fishing skill which shows the technical ability of fishers was significant at 20%. Fishing at Pandam Lake required great skills because of the large body of water in addition to wildlife at the lake, high skills and competence are required. As the skills of fishers increase, they are influenced to participate in the RENLAF. The nature of influence of age on farmers' participation on adoption of an innovation is indeterminate. It is believed that younger fishers are likely to adopt innovation than older fishers because of better education and more exposure to new ideas. On the other hand, it may be that older fishers may have more resources that make it more likely for them to try new technologies. The result indicated that the probability of participation of fishers at regulated fishing decrease with increase in age. This finding agrees with the findings of Dawang (2006) for farmer participation in local chicken innovation, in which he found age to be negative and insignificant in adoption of local chicken management innovation in Plateau State. This may be because as the fishers became older, dependants become more in number, therefore responsibility increase for the fishers. They may prefer

fishing at the URENLAF where they used smaller mesh size and other indiscriminate fishing methods to catch more fish all year round to feed their families and pay their bills.

The most important socioeconomic variables influencing fishers` decision to participate in a RENLAF site in Plateau state was; extension contact and catch-per-unit-of-effort (CPUE). Thus, structural transformation to capture fish harvest through regulatory mechanism will need to take these variables into consideration.

Table 9 Estimate of Fishers' Participation in RENLAF

Variable	**logit Coef**	**t-ratio**
Age	-0.022*	1.5
Extension contact	1.90***	2.75
Heterogenous Fishing Skills	1.67**	2.28
Catch Per Unit of Effort	-0.25**	-2.21
LR $\chi 2$	18.45	
PV	P<.003	
R_{BL}^2 =	.63	
Critical χ^2 (df 3, 95)	= 7.81	

*** P<0.01, ** P<0.05, * P<0.20.

4.3 Factors Influencing the Choice of Lake at Unregulated Fishery

The multinomial logit (MNL) model was employed to identify factors that influence fisher's location choices using Maximum likelihood estimation in Limdep econometric software (Greene, 2003). The results show that most of the explanatory variables had expected signs. The likelihood ratio (LR) test statistic rejects the Ho: (β = O) in the model, indicating that the

variables contributed to explaining the difference in lake choices for fishing. The likelihood ratio statistic was highly significant at 1% LOS, indicating that the model has a strong explanatory power. The sample was corrected for choice base sampling. The restricted log likelihood function confirms the Independent of Irrelevant Alternative (IIA) assumption. This means there was no independence of the choice measures under considerations. The results implied that the application of the MNL specification to model the determinants of lake choices was justified. Descriptive statistics of explanatory variables used in further analysis presented on Table 10 initially included experience of fishers and educational status, but the data was further fitted using the ordinary least square regression and indicated high correlation between educational status and experience as presented in Table 11, therefore, excepted from further analysis.

Table 10 Descriptive Statistics of the Socio-economic Characteristics of Fishers

Variable	Min	Max	Mean	Std. Dev	Coff. Var
Age	20	75	40.35	12.90	0.32
Farm size	0.0	13	6.23	4.3	0.69
Edu Status	2.0	55	21.30	12.57	0.59
Exp	1.0	35	0.46	7.36	15.3
Ext.con	0.0	1.0	0.61	0.49	0.80
HFS	0.35	0.97	0.71	0.19	0.27
CPUE	0.60	46	5.77	6.49	1.12

Table 11 Correlation Matrix of Socio-economic Variables of Fishers

	Age	**FM. S**	**Edu**	**Exp**	**Ext.con**	**HFS**	**CPUE**
Age	1.0000						
FMS	0.170	1.000					
Edu	0.313	-0.181	1.000				
Exp.	0.31	-0.428	0.955	1.000			
Ext Con.	0.26	-0.019	0.336	0.116	1.000		
HFS	0.13	0.115	0.275	0.160	0.348	1.000	
CPUE	0.03	-0.177	0.152	0.119	-0.178	-0.112	1.000

The second column of Table 12 compares the choice of Polmakat Lake with no choice (RENLAF) and it reflects the expected change in probability of preferring to fish at URENLAF than fishing at RENLAF (the base category) per unit change in an explanatory variable. The same applies to the remaining choice in the Table. The marginal effects results which are the most reliable estimates from average probabilities were presented in Table 13 and suggested that increase in Age of fishers promote switching from Polmakat and Shimankar lakes. Age increase also tends to be associated with switching to Janta Lake. Fishers increase in family size at Polmakar and Deben tends to lead them away from RENLAF sites. This may be so, because the RENLAF is located within the government reserve area with limited opportunities for absorption of excess family labour compared to Polmakat and Deben which are located at farm settlements.

Alternative source of income is strongly associated with URENLAF. This could be because fishers may wish to be involved in farming opportunities which exist at the URENLAF sites. In other words, a large family size and low income from fishing may force fishers to make choices where alternative sources of income existed e.g. hunting, farming and craft. This is to generate income that could supplement the major source of income. These features were visible during the survey. This result also indicates that 16.5% of fishers at Polmakat will prefer staying away from Pandam Lake for a unit change/increase in alternative sources of income, while about 5% of fishers at Shimankar would prefer to remain with a unit increase in their alternative sources of income.

Heterogeneous fishing skills of fishers at Polmakat and Deben were negatively associated with RENLAF sites. This means that as the fishers become more skilful, it tends to lead them away from RENLAF fishing and restrictions. The fishers of Shimankar and Janta would prefer coming to RENLAF as they become more skilful. Specifically, 85% of fishers of Polmakat Lake show probability of remaining at the lake than to choose Pandam Lake for a unit increase in their fishing skill, while about 3.02% of fishers of Shimankar would prefer moving to RENLAF sites for a unit change in the fishing skills. CPUE was relevant in the choice of fishing at Polmakat, Shimankar and Deben. For a unit change in CPUE, 1.1% of fishers at Polmakat will prefer to move to RENLAF site, while 0.9% of fishers at Shimankar would prefer to move to RENLAF site. The fishers of Deben have shown negative response to RENLAF for a unit increase in their CPUE.

The result indicates that for a unit change in extension contact, 18.11% of fishers at Shimankar would prefer to move to Pandam Lake. This finding confirms our earlier result that more than 1/3 of fishers at Shimankar had nets of Mesh size 3/4" and 1". These mesh sizes were against Plateau State Fishery Edict Schedule 1 of 1973. About 10.37% of fishers at Deben would tend to stay at the Lake for a unit change in extension contact, while about 3% of the fishers at Polmakat Lake would show preference for Pandam Lake. About 2.21% of fishers at Janta would prefer staying for unit change in extension contact. Extension contact usually creates awareness against minimum mesh size regulations and poison fishing.

The result suggest that age, family size, alternative sources of income, heterogeneous fishing skills, CPUE and extension contacts serve as important factors/determinant of location choices among URENLAF fishers in Plateau state. The multinomial logistic regression model provided sufficient evidence that lake choice of fishers were closely associated with individual's willingness to substitute other locations. This finding is expected create understanding among managers and extensionists` about the future pattern of fishers' choice behaviour at URENLAF sites.

Table 12 Estimates of Multinomial Logit to Determine Site Choices among URENLAF fishers

Variables	Pol	Shim	Deben	Janta
Constant	12.11 ***	4.48	5.22 **	6.43***
	(0.002)	(0.11)	(0.020)	(0.0041)
Age	-0.069	-0.094**	0.022	0.11***
	(0.05)*	(0.04)	(0.49)	(0.006)
Family size	-0.073	0.094	0.222	0.048
	(0.43)	(0.63)	(0.82)	(0.47)
Alternative source of income	-4.32***	2.67 ***	0.71	2/57***
	(0.001)	(0.003)	(0.40)	(0.002)
Heterogenous fishing skills	-15.60***	-3.24	5.66 ***	3.66x
	(0.000)	(0.212)	(0.004)	(0.07)
Catch per unit effort	0.33 ***	0.26**	0.050	0.218**
	(0.002)	(0.010)	(0.65)	(0.03)
Extension contact	1.63*	2.42***	0.062	1.00
	(0.065)	(0.003)	(0.929)	(0.217)

Prob correct prediction 52.72, Prob [Chisd > valve] = 0.000 Sample corrected for choice base sampling. Restricted Log likelihood function = -175.30 LR statistic = 120.96 (P<0.000) note; P. values in parenthesis.

Table 13 Marginal Effects of Significant Variables

Variables	Pol	Shim	Deben	Janta
Constant	0.505***	0.20	0.196	0.180
Age	0.005**	0.0032	0.0030*	0.0076**
Family size	0.0070	0.031	0.0020	0.0070
Alternative source income	0.165***	0.0503*	0.0978**	0.0824*
Heterogenous Fishing Skills	0.850***	0.3027	0.2874	0.2205
Catch per unit effort	0.011**	0.0097**	0.0096	0.0064
Extension contact	0.0316*	0.1811***	0.1037**	0.0221

*** P<0.01, **P<0.05, *P<0.10. Log likelihood = -114.82. Prob [chisqd < value] = 0.0009) Estimates corrected for choice based sampling.

4.4 Determinations of Factors Influencing Regulatory Compliance of Fishers at RENLAF

The descriptive statistics of variables used and the estimates of violation category for regulated fishermen are reported in Tables 14 to 16. The results also indicated that 47% of the respondents are non-violators, 40 % are occasional violators and 13 %, are persistent violators. These results suggest that less than half of the fishers at RENLAF show absolute compliance to management regulations.

Table 14 Descriptive Statistics of Variables included in the Estimation:

Variable description		Min	Max	St.Dv	Mean	Coef. Var.
Socioeconomic variables						
Age of fishers	(X_1)	23	75	14.66	45.67	0.32
Educational status	(X_2)	0.0	12	4.73	6.16	0.77
Experience in fisher	(X_3)	10	55	12.80	27.20	0.47
Family size	(X_4)	1.0	35	9.43	9.76	0.18
Deterrence variables						
Expected gain from catch of illegal fishing	(B_1)	0.0	1.0	1.02	1.70	0.21
Close season regulations is not effective	(B_4)	0.0	1.0	1.06	1.10	0.12
Number of past arrest of fisher	(P_2)	0.0	7.0	2.19	1.70	1.2
Subjective probability of being detected and caught	(P_3)	0.0	1.0	0.97	1.76	0.55
Subjective probability of being detained if arrested	(P_4)	0.0	4.0	1.06	1.90	0.55
Subjective probability of being taken to court/ convicted	(P_5)	0.0	1.0	1.02	1.70	0.34
Social and legitimate variables						
Number of others you think are violating regulations	(S_2)	0.0	1.0	6.42	6.36	1.01
Do your peer /friends think violation is right or wrong?	(S_3)	0.0	1.0	1.10	1.43	1.13
Do they seek your opinion during the design of regulations	S_4)	0.0	1.0	0.91	1.93	0.47
Close season regulation is not enforced consistently	(S_5)	0.0	1.0	0.95	1.83	0.42
Close season regulation improves the well-being of a few?	S_6)	0.0	1.0	1.05	1.27	0.83
Penalty given to offenders fit the offence	(S_7)	0.0	1.0	0.97	1.40	0.69
Enforcement at lake is not adequate	(S_8)	0.0	1.0	1.01	1.06	0.59
Many offenders are not detected	(S_9)	0.0	1.0	0.96	1.63	0.36
Close season regulation is fair	(S_{11})	0.0	1.0	0.41	0.20	2.0

4.4.1 Ordered probit model

Estimated using the LIMDEP econometric software and presented in Table 15. The results shows the threshold parameter (μ) was highly significant at 1% LOS, indicating that the three categories in the responses were indeed ordered (Liao, 1994). The result indicates that many variables are statistically significant across all of the subgroups of deterrence, socioeconomic, social and legitimacy variables.

Table 15: Estimate of Ordered Probit Model Probability of Violation Rate
(0= non- violator, 1=occasional violator, 2= persistent violator)

Variables description	Coef	P (Zi>z)
Age of fishers	-0.42**	0.043
Educational status	-0.056*	0.068
Experience in fisher	0.49**	0.032
Family size	-0.13	0.134
Expected gain from catch of illegal fishing	1.64**	0.022
Close season regulations is not effective	0.57	0.239
Number of past arrest of fisher	0.58	0.140
Subjective probability of being detected and caught	1.51	0.118
Subjective probability of being detained if arrested	0.37	0.359
Subjective probability of being taken to court/ convicted	1.50*	0.095
Number of others you think are violating regulations	0.08	0.440
Do your peer /friends think violation is right or wrong?	-0.17	0.699
Do they seek your opinion during the design of regulations	-3.30**	0.054
Close season regulation is not enforced consistently	-2.55*	0.065
Close season regulation improves the well-being of a few?	-0.41	0.431
Penalty given to offenders fit the offence	-0.41	0.332
Enforcement at lake is not adequate	4.07**	0.023
Many offenders are not detected	-0.044	0.401
μ = Rho statistics	0.438***	0.0010

Log likelihood functions =-15.797
Chi-squared = 33.74
Degrees of freedom χ^2 ,17,095 = 27.58
Prob [chi sqd > value = 0.0029

***P<0.01,**P<0.05,*P<0.10

The marginal effects of the statistically significant variables are presented in Table 16 and these measures the decreased (increased) in probability that the fisherman would be in the violation category, given a unit change in the particular independent variable with other variables held at their means. If the independent variable is a dummy, its' interpreted to mean the increase (decrease) in probability if the binary variable is equal to one. The result indicated that the marginal effect for a fisherman being a close season non-violator for education was 0.182. This suggests that the probability for a fisherman being a non-violator will increase by 18% for every extra year of formal schooling he/she gets. Education was not particularly significant for persistent violators, but marginal effect shows an interesting sign. This reveals that for an extra year in formal schooling, the probability of a fisherman being a persistent close season violator will decrease by 11%. Furthermore, the results show that the probability of fisherman being in the non- violation category will decrease by 15% with an increase in a year of experience.

This finding confirms Lokina (2008) for Lake Victoria fisheries, in which they found that experienced fishermen tend to violate mesh size regulations more. Expected gain from violation was the only significant deterrent factor. This may mean if expected gain from illegal fishing (b_1) is high or increasing, then non-violators are likely to become occasional violators. The result also reveals that some variables from the social and legitimate subgroups were statistically significant, factors relating to perception of legitimacy and social influence impact on the decision to be a non-violator of the close season regulation or to contemplate breaking the rule.

The statistical significance of fishermen views considered in design of regulations (S4), indicates that the higher the fishermen perceived that their opinion were sought during the design of regulations, the higher the probability of fisherman to remain a non-violator. Also the higher the fishermen perceived their opinion were sought during the design of rule, the lower the probability of occasional and persistent violators to remain.

The result also shows that if fishermen perception of the government imposition of regulation (S_5) was wrong, then the probability of being an occasional violator or persistent violator will also increase, while the probability of remaining a non-violator decreases. The result further suggested that if the close season is seen to improve the well being of few (S_8), then there will be a higher probability of non-violators to move to occasional violators, while the probability of being occasional and persistent violators will increase. This result may confirm our face-to-face interview with the fishermen who believed the government was not sensitive to their suggestions, that management of the lake should reduce the close period to two or three months, But there was no response from government yet.

Table 16: Marginal Effects of Significant Variables

Variables	**Non-violators**	**Occasional violators**	**Persistent Violators**
Socio-Economic Characteristic Variables		**Coefficients**	
Age of fishers	0.137**	-0.053*	-0.084
Educational status	0.182**	-0.070	-0.112
Experience in fisher	-0.158**	0.061*	0.97
Deterrence Variables			
Expected gain from catch of illegal fishing	-0.529**	0.203*	-0.325
Subjective probability of being taken to court/ convicted	-0.483**	0.185	0.297
Social And Legitimacy Variables			
Do they seek your opinion in the design of	1.06**	-0.408*	-0.654

regulations			
Close season regulation is not enforced consistently	-0.822**	0.316*	0.505
Enforcement at lake is not adequate	-1.311**	0.50**	0.806

*P<0.01, **P<0.05

4.4.2 Least square estimate

The results of the least square estimation of subsample on occasional violators are reported in Tables 17 and 18. Using the corrected least squares, two separate models were fitted because of the problem of degree of freedom on the combined data. In the first corrected OLS regression (Table 17), the socio-economic and deterrence variables were regressed on occasional violation rate. The adjusted R-Square was found to be 0.619. This suggests that the variables included in the model explain at least 62% of variation in violation of regulations. The rho(ρ) statistics was -0.77 and whites test value of 7.44 at 3 degrees of freedom and 5% LOS, confirms our normality assumption of OLS. The result also show that all socio-economic variables were statistically significant with Age (X_1) and family size (X_4) showing negative signs. This implies that as the fishermen increase in both age and number of dependence, there is a high probability of moving from occasional violator to non-violator.

For the deterrence variables, four subjective probabilities have the expected negative sign with the exception of the subjective probability of being detected (P_3). They were also statistically significant with the exception of subjective probability of being detained if arrested (P_4). The insignificance of this variable could reflect the level of commitment of managers to enforcement. This may suggest and point to the fact that bribes or other forms of gratifications would have been offered to avoid punishment for violation.

c

Table 17: Corrected Least Square Estimate of Socioeconomic and Deterrence Variables

Variables description	**Coef**	**t-ratio**
Constant	6.84**	7.203
Age of fishers	6.84*	7.203
Educational status	-3.30*	0.054
Experience in fisher	-0.176*	-3.88
Expected gain from catch of illegal fishing	0.269*	2.17
Close season regulations is not effective	0.509	-1.52
Number of past arrest of fisher	0.546*	-3.57
Subjective probability of being detected and caught	1.298**	5.03
Subjective probability of being detained if arrested	0.307	-0.93
Subjective probability of being taken to court/convicted	-0.904**	-3.40
Rho statistics	-0.77	-0.670

Adjusted R – square = 0.61
White test chi-square = 7.45
Lagragain statistics (LM) = -44
Degrees of freedom. χ^2 = 7.81

*P<0.01,**P<0.05

The second corrected OLS regression estimate uses legitimacy and social variables on the occasional decision of fishermen to comply or to break the rules presented on Table 18. The adjusted R-Square was found to be 0.625. This suggests that the variables included in the model explain at least 63% of variation in violation of regulations. The rho (ρ) statistics was -0.025 and White`s test value of 7.68 at 4 degrees of freedom and 5% LOS, confirms also the normality assumption of OLS. The result presented in Table 18 shows strong evidence that the participation was positive (P<.000) and most variables of the subgroups show strong statistical significance.

The social variables; number of others believed to be violating the regulations (S_2), number of times you were arrested in the past year (B_4) and does your peers/friends think that regulation is right or wrong (S_3)), all show statistical significance. The negative sign of B_4 means fisherman tend to stop violating as rate of past arrest increases, furthermore, if fishermen perceived that others are violating the close season regulations, there is a higher probability for them to violate too(S_3). The variables government was right to impose regulation (S_5), close season regulation is adequately enforced (S_9) and Close season regulation is fair (S_{11}) were all negative and statistically significant. This result means that government imposition of regulation, perception of fair regulation by fishers and an adequate enforcement of close season can reduce the probability of violations by occasional violators.

Generally, the results of social and legitimacy variables point to fact that their influence on the violation rate were high confirming their influence on decision of fishers on whether to be a non-violator or to violate the regulation. This is so because those who do violate are still influenced by the perceived compliance rate among their colleagues. If they think many others violate the close season then the probability to comply will be low. Furthermore, they tend to comply if their perception is that fishers` opinion was considered in the regulation designing; and if they believed the regulation is fair.

Fundamentally, socioeconomic, deterrence, social and legitimate variables in first and second corrected OLS regressions show adjusted R- squares of 0.619 and 0.625 respectively. Also the whites' test statistics in both regressions confirms the homoscedasticity and non autocorrelation assumptions. It therefore, means that we can conclude variables relating to socioeconomic,

deterrence, social and legitimacy were vital in explaining the behaviour of the alternating violators.

Table 18 Least Square Estimate of Social and Legitimate Variables

Variables	**Coeff**	**t-ratio**
Constant	-0.950	-1.042
Close season regulations is not effective	1.975**	-5.78
Number of others you think are violating regulations	0.153*	7.88
Do your peer /friends think violation is right or wrong?	3.42*	9.09
Do they seek your opinion during the design of regulations	8.34*	7.54
Close season regulation is not enforced consistently	-4.48*	-6.99
Close season regulation improves the well-being of a few?	2.34*	6.57
Penalty given to offenders fit the offence	2.18**	4.87
Enforcement at lake is not adequate	6.68*	7.80
Many offenders are not detected	-7.34*	-9.80
Close season regulation is fair	-5.81*	-10.90
Rho Statistic	-0.025	-0.136
Adjusted R-squared	= 0.625	
Whites test chi-square	= 7.60	
Lagragian statistics (LM)	= -22	
degrees of freedom χ^2	= 9.48	

*P<0.01,**P<0.05

4.5 Costs, Returns and Profitability Analysis

The Costs, returns and profitability analysis of both RENLAF and URENLAF fishers were calculated as indicated in Tables 19 and 20. The daily prevailing average wage rate at URENLAF was ₦175, while RENLAF wage rate was ₦250. This result further shows that labour represents about 30% of total cost, a figure lower compare to URENLAF figure of about 39%, this may be an indication that fishing at RENLAF requires less labour as a result of their

more specialised fishing gears. Furthermore, the RENLAF cost of fishing gears was about 61%, quite higher than URENLAF`s. the result shows that RENLAF cost more than URENLAF by 46%. This may suggest that fishers do increase fishing effort during open season to achieved profit maximisation to make up for the closed season, thereby incurring more cost. Labour was higher in URENLAF, but less than the percentage reported in peasant agriculture, where the proportion of labour was found to make up to 80% of total cost (Sanaiya, 2001). The URENLAF cost of fishing gear result contradict, while RENLAF result confirms CBN (2004) findings on problems of artisanal fishing of inland fisheries in Nigeria, which they found that cost of gears forms over 60% of total cost of fishing.

Table 19: Costs, Returns and Profit Analysis for URENLAF Sites

	Items	**Polmakat**	**Shimankar**	**Deben**	**Janta**	**URENLAF** Pooled	**%**
A	**Returns /month**						
i.	Catch (Kg)	424.128	321.76	326.20	281.42	338.33	
ii.	Sales (₦)	55,136.25	41.828.80	42,406	36584.60	43,985.91	
B	**Cost/month**						
i.	Labour	3640	3380	2600	2860	3120	**52.24**
ii.	Gillnet	527.91	724.58	460	2320.83	1008.33	16.88
iii.	Malia trap	973.95	1041.25	543	171.90	682.53	11.43
iv	Gura trap			40.63		40.63	0.68
v.	Hook line	775.	119.58	1186.67	904.167	746.36	12.49
vi.	Repair/ maintenance	39.33	22.29	25/25	44.58	32.86	0.55
vii.	Dep. on Crafts	445.49	465.10	136.11	318.12	341/21	5.71
C	**Total cost**	**6,401.68**	**5752.80**	**5113.53**	**6619.59**	**5971.90**	**100**
D	**Net Farm Income**	**48,734.57**	**36,076**	**37,292.47**	**29,965.01**	**38,017.01**	
E	**Profitability Index**	**7.67**	**6.27**	**7.29**	**4.53**	**6.36**	

Table 20 Costs, Return and Profit Analysis for RENLAF Site

	Items	Amount/month	Open season Est.	percentage
A	**Returns**			
i.	Catch (Kg)	405.93		
ii.	Sales (₦)	60,889.49		
B	**Cost**			
i.	Labour (hr)	2600	18200	**29.9**
ii.	Gillnet	2739.57	19176.67	31.50
iii.	Malia trap	368.57	3980	6.64
iv.	Gura trap	396.67	2776.67	4.56
v.	Hook line	1602.86	11220	18.43
vi.	Repair/maintenance	67.14	470	0.77
vii.	Depreciation on crafts	720.27	5041.90	8.28
C	**Total cost**	**8695.03**	60,865.21	100
D	**Net Farm Income**	**52,194.46**	365,361.22	
E	**Profitability Index**	**6.0**		

4.5.1 Net farm income and profitability index

The revenues of fishers were estimated from the total output (catch) of individuals realise during the period of Catch Assessment Survey. The estimates of profitability of RENLAF and URENLAF fisheries made using the Net Farm Income (NFI) and Profitability Index (PI) and are

presented in Tables 19 and 20 above. The monthly estimates of revenues were ₦38, 017.01 and ₦52, 194.46 for URENLAF and RENLAF fisheries respectively, suggesting that RENLAF is more profitable than URENLAF by 37%. The PI for fishers at RENLAF was 6.0, while the PI for combined URENLAF fishers was 6.3. This result means that every naira invested in fishing business at the RENLAF is expected to bring a five Naira return, while a return of five Naira Three kobo was expected for fishers at the URENLAF. This result is unexpected and may be because RENLAF fishers spend more on fishing gears in view of the fact that gears were more specialise than the URENLAF fishers. The statistical test of significance presented in Table 21 shows both enterprises were profitable, however, RENLAF was more profitable than the URENLAF fishers. This is a very important parameter for investment decision as fishers will wish to know the profit that they can possibly generate from their limited financial resource.

Table 21: Test of Significance for Revenues and Costs of URENLAF and RENLAF Fishers

Estimates	**Revenues (₦)**	**Total Cost (₦)**
Maximum	1313280	120225
Minimum	113760	131280
Mean	586222.46	51433.23
Std Dev	251951.26	22213.35
Coeff. Variation	0.430	0.432
Profit	38,017.01	
Std. Error Mean	28169.007	
t- Ratio Value	19.007*	
Renlaf Fishers	**Revenue**	**Cost**
Maximum	1497600	120225
Minimum	199680	22340
Mean	714015.80	56641.90
Std. Dev.	290672.339	26545.75
Coefficient Of Variation	0.41	0.47
Profit	52,194.46	
Std. Error	53069.27	
T- Ratio	12.288*	

*P<0.01

4.6.0 Stochastic frontier production function analysis

The parameters of the stochastic frontier production model and those of the technical inefficiency model are estimated simultaneously using the maximum likelihood estimation (MLE) program, FRONTIER 4.1C (Coelli, 1993). To confirm the choice of the functional form of stochastic frontier, a test of the adequacy of Cob-Douglass relative to the less restrictive Translog form. Several hypotheses concerning model specifications are presented in Table 22.

Table 22 Test of Hypotheses

Null hypothesis	**Log likelihood**	**χ2statistics**	**Critical χ2 v, 95**	**Decision making**
Ho:$\beta ij = 0$ For all $1 \leq j =$ 1,2,3 (Cob-Douglas)				
Polmakar	-1.927	14.83	X^2,6,0.95= 12.59	Reject Ho
Shimankar	-3.401	23.45	X^2,6,0.95=12.59	Reject Ho
Deben	-0.601	7.64	X^2,6,0.95=12.59	Accept Ho
Janta	-3.28	10.40	X^2,6,0.95= 12.59	Accept Ho
URENLAF (Comb.)	-35.17	17.50	X^2,6,0.95= 12.59	Reject Ho
RENLAF	-7.84	7.07	X^2,6,0.95= 12.59	Accept H_0
$\gamma=\delta 1=...=\delta j =0$ (no tech. ineff.)				Accept H_O Reject H_O
Polmakat	1.95	10.40	X^2,6,0.95= 12.59	Accept H_O
Shimankar	-1.92	23.50	X^2,6,0.95= 12.59	Accept H_O
Deben	-0.60	7.64	X^2,6,0.95= 12.59	Reject H_O
Janta	3.26	10.41	X^2,6,0.95= 12.59	Accept H_O
URENLAF	-34.55	16.84	X^2,6,0.95= 12.59	
RENLAF	7.84	7.07	X^2,6,0.95= 12.59	

4.6.1 Stochastic frontier estimate, POLMAKAT site

The results of estimates for Polmakat using the translog specification are presented in Tables 23 and 24. The gamma (γ) parameter which measures presence of technical inefficiency was statistically significant at 1%, indicating that there was 33.05% deviation from frontier. The LR test fails to reject the hypotheses that there were no technical inefficiency effects. This then means that Maximum Likelihood Estimates (MLE) model was the adequate representation of data. The Return to Scale (RTS) was 0.09, implying a decreasing RTS. These results suggest the capacity at the fishery was not getting a proportionate return at the lake and that fishers at Polmakat cannot increase their catch by increasing more gears per fisher.

The inefficiency model shows that experience to be negative and statistically significant. This means that for a one year increase in experience of a fisher there will decrease inefficiency by 5%. The distribution and quartile range of Polmakat lake fishery indicate that about 45% of fishers have efficiency scores of 70% and above, while 20% of fishers had efficiency scores of less than 50%, implying that they were operating below the 50% efficiency level. Furthermore, the result indicated that about 15% of the fishers at Polmakat were operating at 90% or more efficiency level. The mean technical efficiency of fishers at Polmakat was 66.95%.

Table 23: Stochastic Frontier Estimate of Polmakat Fishers (translog function)

Variables Description	Maximum Likelihood Estimate		
	Coefficient	Standard Error	t-ratio
Efficiency			
Intercept	4.3*	0.98	4.3
Length of fishing gears (m)	0.79*	0.24	3.2
Hours fished (hours)	0.09	0.29	0.43
Number of fishing gears owned by the fisher	0.49	0.46	1.0
Length of fishing gears X Hours fished	-0.05	0.87	-0.05
Hours fished X Number of fishing gears owned by the fisher	-0.12	0.10	-1.12
Number of fishing gears owned by the fisher X Length of fishing gears	-0.11	0.43	0.025
Square of Length of fishing gears	-0.03	0.32	-0.11
Square of Hours fished	0.09	0.29	0.32
Square of Number of fishing gears owned by the fisher	.14	0.44	0.33
Inefficiency			
Constant	0.23	0.99	-0.23
Age of fishers (number of years)	0.046**	00.027	1.9
Education status (number of years)	0.0007	0.043	-0.018
Experiences of fishers (number of years)	0.0007**	0.043	-2.40
Family size of fishers (number of people)	-0.05	0.021	0.36
δ^2 sigma square	0.11	0.080	1.41
γ gamma	0.99*	0.0038	257
Log likelihood	1.95		
LR test	20.402		

*P<0.01, **P<0.05

Table 24: Decile Range of Freq. Distribution for TE Polmakat Fishers

Technical Efficiency	frequency	Percentage
0.20 – 0.29	0	0
0.30 – 0.39	2	10
0.40 – 0.49	2	10
0.50 – 0.59	3	15
0.60 – 0.69	4	20
0.70 – 0.79	3	15
0.80 – 0.89	3	15
0.90 – 0.99	3	15
Total	**20**	**100**

Mean TE = 66.95 percent

4.6.2 Stochastic frontier estimate, SHIMANKAR site

The results of estimates for Shimankar using the translog specification are presented in Tables 25 and 26. The data show that gamma (γ) parameter which measures presence of technical inefficiency was also statistically significant at 1%, indicating that there was 28.55% deviation from frontier. The LR test fails to reject the hypothesis that there were no technical inefficiency effects, suggesting the existence of technical inefficiency effects in the fishery. This then mean that MLE model was the adequate representation of data. The Return to Scale (RTS) was 2.49 implying an increasing RTS. This means that investing in fishing at Shimankar will yield a more than proportionate return, suggesting that fishers can increase input factors to expand their catch per fishing trip. The distribution and quartile range for Shimankar Lake presented in Table 27 shows that about 40% of fishers are operating at 90% or more efficiency level. And about 85% were operating at efficiency level at 50% and above. The mean technical efficiency of fishers was 71.45%.

Table 25: Stochastic Frontier Production Estimate of Shimankar Fishers (translog function)

Variable description	Maximum Likelihood Estimate		
	Coefficient	Standard Error	t-ratio
Efficiency			
intercept	0.82	0.94	0.87
Length of fishing gears (m)	1.3*	0.26	4.9
Hours fished	0.52	0.37	1.3
Number of fishing gears owned by the fisher	0.82	0.96	0.84
Length of fishing gears X Hours fished	-0.098*	1.3	-7.2
Hours fished X Number of fishing gears owned by the fisher	-0.27	0.23	-1.1
Number of fishing gears owned by the fisher X Length of fishing gears	0.016	4.41	0.39
Square of Length of fishing gears	0.089	0.29	0.32
Square of Hours fished	0.12	0.20	0.599
Square of Number of fishing gears owned by the fisher	-0.0003	0.20	-0.0014
Inefficiency			
Constant	-0.22	2.2	-0.97
Age of fishers (number of years)	0.05	0.11	-0.48
Education status (number of years)	-0.0023	0.06	-0.48
Experiences of fishers (number of years)	0.058	0.048	-1.33
Family size of fishers (number of people)	-0.22	0.24	0.91
δ^2 sigma square	0.84	0.59	1.41
γ gamma	0.99*	0.00000	3962
Log likehood		-1.92	
LR test		23.50	

*P<0.01, **P<0.05

Table 26: Decile range of freq. distribution for TE Shimankar fishers

Technical Efficiency	Frequency	Percentage
0.40 – 0.49	3	15
0.50 – 0.59	4	20
0.60 – 0.69	1	5
0.70 – 0.79	3	15
0.80 – 0.89	1	5
0.90 – 0.99	8	40
Total	**20**	**100**

Mean TE = 71.45 percent

4.6.3 Stochastic frontier estimate, DEBEN site

The results of the estimates for Deben using the Cob-Douglass specification are presented in Table 27 and 28. The gamma (γ) parameter which measures technical inefficiency was statistically significant at 1%, indicating that there was deviation from frontier. The LR test shows that there were no technical inefficiency effects, suggesting that deviation from frontier was not as a result of technical inefficiency effects. This then mean that OLS model was the adequate representation of data. The Return to Scale (RTS) was 0.601 implying a decreasing RTS. This signifies that fishers were getting a less than a proportionate return for fishing at Deben Lake. The distribution of efficiency scores of fishers shows that 75% of fishers were operating at efficiency level of less than 50%, while about 5% of fishers were operating at 90%

or more efficiency level. The result indicated that only about 25% of fishers were operating at 50% or more efficiency level. The mean technical efficiency level was 48.31%.

Table 27: Stochastic Frontier Production Estimate of Deben fishers (Cob-Douglass)

	Maximum Likelihood Estimate		
Variable description	**Coefficient**	**Standard Error**	**t-ratio**
Efficiency			
Intercept	8.69*	0.91	9.5
Length of fishing gears (m)	0.13**	0.05	2.6
Hours fished	-0.58**	0.26	-2.4
Number of fishing gears owned by the fisher	0.93*	0.28	3.2
Inefficiency			
Constant	1.3**	0.59	2.2
Age of fishers (number of years)	-0.02**	0.012	-2.2
Education status (number of years)	0.035*	0.008	4.1
Experiences of fishers (number of years)	-0.007*	0.011	-6.8
Family size of fishers (number of people)	0.03*	0.012	2.8
δ^2 sigma square	0.064*	0.017	3.6
γ gamma	0.99*	0.123	8.0
Log likehood	-0.601		
LR test	17.64		

*P<0.01, **P<0.05

Table 28: Decile range of frequency distribution for technical efficiency of Deben fishers

Technical efficiency	Frequency	Percentage
0.30 - 0.39	7	35
0.40 – 0.49	8	40
0.50 – 0.59	2	10
0.60 – 069	0	0
0.70 – 079	1	5
0.80 – 0.89	1	5
0.90 – 0.99	1	5
Total	**20**	**100**

MEAN TE = 48 Percent

4.6.4 Stochastic frontier estimate, JANTA site

The results of estimates for Janta fishery using the Cob-Douglass specification are presented in Tables 29 and 30. The gamma (γ) parameter which measures technical inefficiency was statistically significant at $p<0.00$ indicating that there was deviation from frontier. The LR test shows that there were no technical inefficiency effects, suggesting that deviation from frontier was not as a result of technical inefficiency effects in the fishery.

The value of gamma parameter was 0.67, suggesting that 67% of variation in catch was due to random factors. This then means that OLS model was the adequate representation of data. The Return to Scale (RTS) was 0.063 implying a decreasing RTS. This signifies that fishing at Janta was experiencing a decreasing return to scale, meaning that capture function is in stage 11 of the production. The variable “number of gears” was negative implying it’s in excess use. The efficiency scores of fishers for Janta fishery shows that 85% of the fishers are operating at 90%

or more efficiency level. All the fishers were operating at an efficiency level of 50% or more. The mean efficiency level was 91.29%.

Table 29: Stochastic Frontier Estimate of Janta Fishery (Cob-Douglass)

	Ordinary Least Square			Maximum Likelihood Estimate		
Variables Description	**Coeff.**	**S.E**	**t-ratio**	**Coeff.**	**S.E**	**t-ratio**
Efficiency						
Intercept	5.9	1.2	4.58	6.29	0.68	-9.13
Length of fishing gears (m)	0.33*	0.09	3.70	0.34	0.08	4.32
Hours fished	0.25	0.36	0.71	0.14	0.23	0.62
Number of fishing gears owned by the fisher	-0.53*	0.44	-4.19	-0.48	0.30	-1.59
Inefficiency						
Constant				0.89	0.83	-1.07
Age of fishers (number of years)				0.010	0.018	-5.44
Education status (number of years)				0.023	0.048	0.47
Experiences of fishers (number of years)				0.30**	0.015	1.9
Family size of fishers (number of people)				0.71	0.029	2.36
δ^2 sigma square		0.12		0.051	0.047	1.08
γ gamma		0.67		0.27	0.44	0.61
Log likehood		1.91		3.285		
LR test				10.408		

*P<0.01, **P<0.05

Table 30: Deciles Range of Frequency Distribution for TE of Janta Fishers

Technical Efficiency	Frequency	Percentage
0.50 - 0.59	1	5
0.60 – 0.69	2	10
0.70 – 0.79	0	0
0.80 – 0.89	0	0
0.90 – 0.99	17	85
Total	**20**	**100**

Mean TE = 91.29 percent

4.6.5 Stochastic frontier estimate, pooled URENLAF sites

Estimates for Pooled URENLAF fishers using the translog specification are presented in Tables 31 and 32. The data revealed that there was presence of technical inefficiency effects. The chi-square value was 17.51, while the critical value of the chi-square at 5% level of significance with 6 degree of freedom (5%, 6) was 12.60 Thus, suggesting that the OLS model for capture function was not an adequate representation of the data; hence the MLE model was preferred model for further technical efficiency analysis. The estimated gamma parameter of MLE model was statistically significant at 1% LOS with value 0.682, indicating that about 68% of the variation in the output of fish capture among the fishers was due to differences in their technical efficiencies.

Technical inefficiency model indicated that the family size and experience of the fisher show statistical significance, with experience having a negative sign. This implies that an increase in experience will results in a decrease in inefficiency. This is consistent with Lokina (2008) for Lake Victoria fisheries, where he found that experience was negatively significant in

determining technical inefficiency of fishers. The URENLAF fishers' technical efficiency estimate shows that 30% of the fishers were operating at 90% or more efficiency level, while 3.75% are operating at efficiency level below 50%. The result further indicated that about 80% of fishers were operating at 80% or more. Similarly, 96.25% of the sample fishers were operating at 50% or more and mean technical efficiency level score of fishers was 84.16%.

Table 31: Stochastic Frontier Estimate of TE Pooled URENLAF Fishers (translog specification)

Variables Description	Maximum Likelihood Estimate		
	Coefficient	Standard Error	t-ratio
Efficiency			
intercept	5.56*	1.05	5.27
Length of fishing gears (m)	0.29**	0.17	1.72
Hours fished	0.47	0.39	1.21
Number of fishing gears owned by the fisher	-0.15	0.63	-0.23
Length of fishing gears X Hours fished	-0.022	0.095	-0.23
Hours fished X Number of fishing gears owned by the fisher	-0.034	0.15	-0.22
Number of fishing gears owned by the fisher X Length of fishing gears	0.057	0.087	0.65
Square of Length of fishing gears	-0.047	0.15	-0.31
Square of Hours fished	0.10	0.18	0.55
Square of Number of fishing gears owned by the fisher	-0.12	0.16	-0.75
Inefficiency			
Constant	1.85	1.82	-1.01
Age of fishers (number of years)	0.0097	0.0027	0.35
Education status (number of years)	0.083	0.065	1.27
Experiences of fishers (number of years)	0.092*	0.05	-1.73
Family size of fishers (number of people)	0.144**	0.07	2.05
δ^2 sigma square	0.34*	0.12	2.81
γ gamma	0.68*	0.15	4.48
Log likehood	-34.55		
LR test	16.84		

*P<0.01, **P<0.05

Table 32: Deciles Range of Freq. Distribution of TE combined URENLAF Fishers

Technical Efficiency	Frequency	Percent
0.20-0.29	-	
0.30 - 0.39	1	1.25
0.40 – 0.49	1	1.25
0.50 – 059	1	1.25
0.60 – 069	10	12.5
0.70 – 0.79	10	12.5
0.80 – 0.89	40	50
0.90 – 0.99	23	28.75
Total	**80**	**100**

Mean TE = 84 percent

4.6.6 Stochastic frontier estimate, RENLAF site

The results of estimates of RENLAF fishers are presented in Tables 33 and 34. The data revealed that there was no significant presence of technical inefficiency effects in fish capture as confirmed by the result of test using the generalized likelihood ratio test (LR). The chi-square computed for the presence of technical inefficiency effect is 7.07, while the critical value of the chi-square at 5% level of significance with 6 degree of freedom (5%, 6) was 12.60 The null hypothesis of no technical inefficiency effects in the course of the fishers fish Capture $\gamma = 0$, was not rejected. This suggests that the regulated fish capture function was the average response function. Thus, OLS model was an adequate representation of the data.

The estimated gamma parameter for production function was 0.50, indicating that about 50% of the variation in the fish capture not accounted for by technical efficiency; other factor like weather, measurement error might be responsible. The sum of partial elasticity was 0.132, implying a decreasing return to scale. This signifies that fishing at RENLAF, inputs would return a less than proportionate output. However, exploitation was at stage of profit maximisation. The distribution of fishers of RENLAF shows that there was no fisher operating below 50% efficiency level. Similarly, all the fishers were operating at 60% or more efficiency levels. The result indicated that 76.67% of fishers were operating at 90% or more efficiency level. The mean technical efficiency score of fishers of regulated Pandam lake fishery was 92.50%.

Generally, limited number of fishers displays substantially lower levels of technical efficiencies in URENLAF, while most fishers of RENLAF were operating at higher efficiency. The arithmetic means of the individual efficiency scores of 0.84 for URENLAF and 0.92 for RENLAF can compare well with Lokina (2008) for Lake Victoria artisanal fisheries and Squires et al (2003) also found similar result, for the Malaysian gillnet fleets of artisan fishers. But these figures are comparatively higher than those found in Kuperan et al (2001) in Malaysian trawl fishery. These comparatively high efficiency scores are consistent with Schultz's (1964) thesis of "Poor and efficient" smallholders and peasant farmers in developing country agriculture.

Table 33: Stochastic Frontier Production Estimate of RENLAF Fishers (Cob-Douglass)

Variable description	Ordinary Least Square			Maximum Likelihood Estimate		
	Coeff.	S.E	t-ratio	Coeff.	S.E	t-ratio
Efficiency						
Intercept	7.3	0.45	16.17	7.08	0.50	13.99
Length of fishing gears (m)	0.05*	0.06	1.89	0.06	0.06	0.92
Hours fished	0.013	0.10	0.12	0.066	0.122	0.54
Number of fishing gears owned by the fisher	0.043	0.12	0.34	0.006	0.122	0.054
Inefficiency						
Constant		0		0.77	0.46	1.66
Age of fishers (number of years)		0		0.044	0.017	-2.57
Education status (number of years)		0		0.018	0.049	-0.37
Experiences of fishers (number of years)		0		0.040	0.0`7	2.24
Family size of fishers (number of people)		0		0.013	0.013	1.01
δ^2 sigma square		0.35		0.040	0.023	1.73
γ gamma		0.05		0.15	0.73	0.206
Log likehood		7.8				
LR test		3.5				

*P<0.01, **P<0.05

Table 34: Deciles Range of Freq. Distribution for TE of RENLAF Fishers

Technical Efficiency	Frequency	Percentage
0.60 – 0.69	2	6.67
0.70 – 0.79	2	6.67
0.80 – 0.89	3	10
0.90 – 0.99	23	76.67

Total	**30**	**100**

Mean TE = 91.5 percent

4.7 Constraints faced by fishers

The constraints faced by fishers at the lakes are presented in Table 35. At the RENLAF site, about 100% of the fishers mention threat to lives and destruction of fishing gears by hippopotamus at the lakes. The hippopotamus can destroy fishing gear once the gears are set on their way. Also, 83% of fishers cited high cost of fishing gears, while 50% also stated that cold /wind was a serious problem in fishing at the lake.

At the URENLAF fishing sites, the analysis reveals that at Polmakat Lake, 100% of the fishers stated that fishing gears were very expensive. Some suggested that government should allow them to reduce the number of hippopotamus in the Lake so as to reduce their level of destructions to their fishing gears. The fishers of Polmakat also mention cold/wind as another impediment to fishing. During the early morning fishing trips fishers are usually faced with problem of cold water and avoiding morning fishing may in turn affect price of fresh fish caught that day as demand is always lower at the lakes by late hours of the day. This is because buyers usually come from distant towns to buy the fish. At Shimankar, fishers show that hippopotamus remains a major threat to lives and destruction of fishing gears. Stealing of fish from each other's gears was reported among the fishers, as it was revealed that some fishers who get to the lake early to remove fish caught by the gears of their colleagues. This problem was mentioned by 90% of fishers at Shimankar.

The constraints of fishers report from Deben and Janta lakes also indicate that stealing and high cost of fishing gears were the most frequently mentioned problems. The problem of

Hippopotamus' was also mentioned in RENLAF as well as at URENLAF sites of Polmakat and Shimankar lakes. But hippopotamus was not mentioned by fishers at Janta and Deben. The face to face interviews with fishers' at these lakes revealed that there are no longer hippopotamus in these lakes. As to whether they were killed by fishers or hunters they did not confide. The fishers indicated a higher possibility that the wild animals may have exited the lakes to river Benue. They also indicated that there was a possibility the animals may reappear someday since that was what was usually experienced.

The reports of stealing of fish by fellow fishers were mentioned in all URENLAF. This may be as a result of unlimited number of fishers at these lakes, furthermore, as it may indicate overcapacity at the URENLAF sites. The fishers of URENLAF also mentioned that water weed being driven by strong wind on the water surface also affect gears mostly hook lines and gillnets. Finally, stealing, high cost of gears, water weeds, hippopotamus were the most common constraints of fishing at URENLAF sites. The most common constraints to fishing at Pandam Lake, however, were hippopotamus, high cost of gears and cold/wind. There were no reports of theft at Pandam Lake. This may be attributed to the limited entry permit regulation enforced which enables fishers to have greater knowledge of each other.

Table 35 Constraints faced by fishers at RENLAF and URENLAF sites.

Pandam (RENLAF)		
Constraints	**Frequency**	**Percentage**
Hippopotamus	30	100
High cost of gears	25	83
Cold/Wind	15	50
Polmakat (URENLAF)		
Hippopotamus	20	100
Stealing	18	90
Cost of gears	15	75
Water weed	15	75
Shimankar (URENLAF)		
Hippopotamus	20	100
Stealing	17	85
Water weed	15	75
Janta (URENLAF)		
Stealing	20	100
Cost of gears	17	85
Deben (URENLAF)		
Stealing	18	90
Water weed	11	55
High cost of gear	15	75
Poor price of fish	5	25

Chapter 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Improper management and inadequate property right resulting to exploitation beyond sustainable levels is raising significant concern among individuals and government mainly because an estimated one billion people mostly in low-income countries depend on fish as their primary source of protein, supplying over 16% of animal protein consumed by people. This study was designed to assess the impact of management policies on government regulated and the unregulated natural lake fisheries in Plateau State through the examination of economic benefit, individual catch efficiencies and improving resource for sustainable exploitation. The study was designed to establish the underlying factors and to assess the effects of management measures on economic benefit through technical efficiency and potential catch to actors.

This study is expected to provide baseline economic information necessary for evaluating management regulations and "Open access" fishery as a means where fishery managers reduce technical efficiency by constraining the use of certain inputs or improve by expanding these inputs and take measures that properly define the property rights of the fishery. The data used for this research were collected from one hundred and ten fishing households in five natural lakes across Plateau State using questionnaire and catch assessment survey logbook. The tools of analysis used were simple descriptive statistics; farm business analysis, logit model, multinomial logit, ordered probit and stochastic frontier analysis models. The results from the analysis were summaries below.

The study reveals that both RENLAF and URENLAF fishers had similar socio-economic characteristics. The distribution of fishers by educational status also indicated that the bulk of fishers had no formal educational, while majority were primary school leavers. The analysis of years of experience shows that a fisher average year in fishing was highest at RENLAF of about 27.20 years. The Household size in the study area shows adequate labour force for fishing at an average household. The types of fishing gears and crafts use for fishing in the study area shows that fishers at the RENLAF fishers had dugged-out canoes that are manually paddle.

The total gears in use in the fishery were 1702 units. On the average, every fisher of URENLAF had 43.5 gears. This number was about 76% of average number own per fisher at RENLAF. The general view of the majority of the fishers at URENLAF was that stocks were decreasing. At the regulated Pandam Lake fishery 52% believed stock level was constant, while 20% saw stock as decreasing. The perception of fishers about stock abundance was important for any policy option about future management regulation.

The participation decision variables were fitted in a logit model specification and found to be statistically significant at {(Prob [chisqd>value]= 0.0003}. The LR statistic also show that assumption of misspecification of model was rejected suggesting data were able to explain Participations of fishers by 63 %(R^2= 0.63). The variable extension contact and CPUE were statistically significant. Extension contact had positive sign, while CPUE was negatively significant. The positive and significant coefficient of extension contact indicate it`s positive influence on participation of fishers for RENLAF fishing. This indicates that as fishers gains more knowledge through extension education the probability of participation increases. The

variable of age and heterogeneous fishing skills were not strictly speaking significantly influential in regulated fishing participation decisions.

In the Multinomial logit model the chi-square statistic was highly significant at 1% Level of significance, suggesting the model has a strong explanatory power. The coefficient of age of fishers was statistically significant for Shimankar and Janta lakes, while the variable shows negative signs at Polmakat and Shimankar. Family size variable did not show statistical significance in all four choices, but had negative signs for Polmakar indicating that as age increases, the probability of fishers remaining at Polmakar will decrease. The coefficients of alternative source of income at all lakes were statistically significant except for Deben. This results show that the existence of alternatives sources of income such as farm lands, forest for hunting and crafts at these lakes determines fishers' choices.

The result also indicated catch per unit of effort (CPUE) was also statistical significant and positive for all choice of lakes, suggesting the variable have an influence on the probability of fishing in all unregulated fishery and abandoning the relatively risky regulated Pandam lake. Extension contact has positive influence on the Probability of choice of fishing at Shimankar and Polmakat. The coefficient of extension contact was not significant for Deben and Janta suggesting the variables was not influential in the choice of these areas. The multinomial logit assessment of choice decision among unregulated fishers demonstrate the important needs of government policies and strategic investment plans that support sustainable natural resource exploitation, research into the development of and information about fishers education, fishing

skills, CPUE, alternative source of income and technical efficiency and property right Development.

The ordered violation category was tested using Limdep statistical package and found to be well ordered according to the threshold parameter estimate. The violation categories were non-violators, occasional violators and persistent violators. The variables were subgroup according to how they are perceived to influence fishers' responses to regulation. The subgroups were deterrence, socio-economic, and social and legitimacy variables. The results indicated that variables under subgroups of deterrence, socioeconomic, social and legitimate variables show statistical significance. This was a confirmation that the classical crime model of behavioural violation was also applicable to fisheries management.

The probability that a fisher will remain a non-violator will increase with increase in level of education. However, the probability for a fisher being a non-violator will increase by 18% for every extra year of formal schooling. Interestingly, if a fisher is an occasional violator, the probability that he remains will decrease with an extra year of formal schooling. The result also shows that for a unit increase in year of experience, the probability that a fisher remains a non-violator will decrease. Furthermore, it was revealed that for a unit increase in value of illegal fishing, the probability that fishers remains a non-violator decreases. This indicates that economic gains promote violation.

The least square estimates using the Praise-winteins correction method and white's estimator in a limdep statistical package were regress using two models because problem of degree of

freedom. In the first, using socio-economic and deterrence variables, the result indicated an Adjusted R-sqd of 0.62, with a white statistic value of 7.41 and a rho value of -0.77. The variables indicated that age and family size were negatively significant revealing that the increase in these variables will reduces the probability of fishers remaining occasional violators. The second regression of social and legitimate variables also shows an Adjusted R-sqd of 0.63, and white statistics of, the rho value of -0.025. Therefore, both social and legitimate variable were also important in determine compliance or otherwise of fishers.

The cost analysis indicated that the total cost for regulated RENLAF was higher than at the URENLAF system. This would have been due to the higher number of gear per average that was recorded for RENLAF fishers. The results indicated that fishing gears form a total of 61.82% of total cost incurred by RENLAF fishers, while fishing gears cost about 39% of total cost in URENLAF fishers. Returns from investments were ₦43, 988.91 and ₦60, 889.49 for URENLAF and RENLAF. The Net farm income from RENLAF fishing was ₦52, 194.45 and for unregulated fishing was ₦38, 017.01. The profitability index which indicated the ratios of net income to total cost of effort allocation reveals that URENLAF was ₦6.3 and ₦6.0 for RENLAF. These indicate that a naira invested in the fishing business could yield a profit of ₦5.3, and ₦5.0 at URENLAF and RENLAF respectively.

Technical efficiency estimates of both RENLAF and URENLAF using maximum likelihood estimates shows the existence of inefficiency effects in the URENLAF, but not among the RENLAF fishers. The translog and Cob-Douglass specifications were both found suitable for URENLAF and RENLAF respectively. A specification fitness test confirms the tranlog

functions as being best fit for Polmakat, Shimankar and combined URENLAF, while the Cob-Douglass was found best fit for Deben, Janta and RENLAF sites.

The results of estimates for Polmakat using the translog specification shows that the gamma (γ) parameter which measures technical efficiency was statistically significant at 5% level of significance, indicating that there was deviation from frontier. The LR test fails to reject the hypotheses that there were no technical inefficiency effects. The distribution and quartile range for the lake shows that over 4% of fishers have efficiency scores of 70% and above, while 20% of fisher had efficiency scores of less than 50%. This also reveals that 15% of fishers of the fishers at Polmakat were operating at 90% or above efficiency levels.

The Pooled URENLAF shows that the translog was a preferred specification. The sum of elasticity was 0.393 suggesting that one percent increase unit in explanatory variable would result in about less than proportionate increase in output. Furthermore, it suggests fish capture was in stage II of Production function. The gamma parameter of model II which measures technical efficiency was statistically significant at 5% LOS, and was high at 0.68 suggesting the impact of inefficiency in deviation of individual fishers catch frontier. The result indicated that about 68% of the variations in value of individual catch were due to technical inefficiency effects.

The RENLAF result of linear restriction on the flexible translog functional form in the fish captures function confirms the assumption homogeneity. It was also indicated that the vast majority of residual variation were due to random errors and not technical inefficiency effects.

The one-sided generalise log likelihood ratio test (y = O provide a statistics of 7.07 which was less than 5% critical value 12.59). This suggested that traditional average response function was an adequate representation of the data. This result indicate that compose error was significantly different from zero. Suggesting variation in output was due to measurement error, illness, weather and luck. The sum of partial elasticity for input variable was 0.137, suggesting that fish capture at Pandam was at a decreasing return to scale i.e. at stage II of production function.

For the RENLAF fishers at Pandam the major constrains at fishery was threat to lives and destruction to fishing gears by Hippopotamus. This was followed by high cost of fishing gears. The problems were cited by 100% and 83% fishers respectively. Elsewhere, in the URENLAF, there was also an indication the hippopotamus was a major problem at Polmakat and Shimankar lakes. The constraint was both cited by all fishers from the two lakes. The result further indicated that stealing of fish at lake sites were reported by 90% of fishers at Polmakat and Deben, while 85% and 100% report by fishers from Shimankar and Janta. High costs of fishing gears were mention as constraints by fishers at Polmakar, Janta and Deben.

5.2 Conclusions

The RENLAF fishing system was found to be more rewarding than URENLAF. The profitability index, shows fishing was a profitable investment at both fisheries. But surprisingly higher return per naira invested at unregulated systems. Catch-per-unit of effort and extension education promotes the probability of participation in a RENLAF. The structural transformation of URENLAF for sustainable fishery into a renewable resource state would be enhanced through the considerations of factors such alternative sources of income, Heterogeneous fishing skills,

CPUE, and extension education. The RENLAF fishing has higher efficiency and effort limiting strategies were needed. The redefining of property rights of URENLAF is required for sustainable resource exploitation.

The behavioural models used can be led back to the trio of Effectiveness, Fairness and Justness. The fisher's behaviours were guided by their perception of the three systems. Really, what the fishers perceived as effective may not always perceived as right and, hence, as fair. Generally, the concept of fairness must be considered, indeed, as the pointer of the balance between the two scales of effectiveness and justness. Fairness (or equity) is the quality of what is able to reconcile the demands for the safeguards of the overall system with demands for the safeguard of the individual. As a fisher, effectiveness is related to the defence of the capital natural resource of RENLAF, whereas the concept of justness is put in relation with the defence of the human factor (Labour, knowledge, ability and physical capital) the regulation at Pandam would be perceived as fair only if, in the fishers opinion, it will be able to reconcile and to satisfy, at the sometime, the public and individual welfare.

At RENLAF, fishers gave judgment on the effective of regulations on the basic of the objectives of the regulation itself, i.e. protection and conservation of lake resource. Their judgment on the resources state depends on their daily experiences which, sometimes, differ from official stock assessment. Alternatively, fishers give judgement on the justness of regulation on the basis of the ability of the regulation itself to not be at odds with moral and social objectives. At the end, fishers will be guided by their own judgement on fairness of regulations. If, in the fishers view, regulation seems to give priority to the effective, violation will be the dominant behaviour. On

the contrary, if regulations seem to give priority to the resolution of problems related to the impact on local communities (income stability, employment, traditions safeguard, resolution of the conflicts among fishing gears) undoubtedly, the result would be a higher level of compliance.

When a fishery regulation is planned and implemented, it is importance to give to the fishers correct signals in order to obtain a spontaneous acceptance of regulation and self-enforcement mechanism, since the Pandam fishers have officials and association. This is because problem individual behaviour under regulation is basically a problem of asymmetry of information between the officials at lake and fishers. It is also a problem of temporal asymmetry between long-run and short-run. Authorities must launch appropriate signals to the fishers if they want the later have the desire behaviour. Signals that have a balanced satisfaction of collective and individuals needs i.e. towards fairness.

5.3 Recommendations

The objective and strategy of fishery management in Plateau State have been geared towards the idea of attaining natural resources conservation, and economic benefit such as increase family nutrition, income and employment. The study has shown that better ways of sustainable fishery exploitation for the overall economic growth are possible in the fish capture by effective supervision and monitoring of technical efficiency levels as well as setting some community friendly regulations, If the strategy for an appropriate package for redefining of properly rights and monitoring is bound to accomplish the desired objective. By this, policy recommendations arising from the study are as follows:

1 Although most fishery at the study area were “Open access” and unregulated, there seems to be a limited number of gillnets of extractive mesh size (i.e. below the minimum requirements) and absent of poisonous fishing in the areas. However, there were no community or state enforcing authority. Most of fishers view stock as being on the declined, and have signifies that the fisheries where their main source of livelihood. In the light of these, efforts geared towards setting a Community fishery Management Units (CFMU) that involve the fishers themselves and supervise by state authorities, will encourage the fishers and community to re-strategies natural resource management and sustainable exploitation of fisheries. Furthermore, research and extension education intervention will be required in the area of appropriate mesh size against capture of fingerlings juveniles and effort limiting strategies.

2 The empirical analyses confirms that roles of improve access to information, socioeconomic characteristics, existence of alternative source of income, CPUE and Heterogeneous fishing skills which were crucial for local participation in natural resource management decision making and planning. Policies aimed at promoting participation in regulated fisheries should emphasize the critical roles of the above factors. Furthermore, this result has demonstrated the importance of government policies and strategic investment plans that will support improved access to stock forecasting, research into the development of and information about sustainable fish exploitation especially in area of unregulated exploitation is vital for conservation and sustainability of captured fisheries, therefore, tertiary training institutions should partner with government and community people.

3 The behaviour model of violation analysis highlighted some key factors about socioeconomic, deterrence, social and legitimates aspects signifying that regulated fishery managers should ensure compliance through good governance to be fitted to a restricted number of significant factors, appropriate considerations of aspects related to the social and/or to the productive structure could generate, through the voluntary acceptance of regulations by fishers, considerable gains in terms of management efficiency. Furthermore, planning new fishing regulations like mesh size and close seasoned in lakes with due considerations to role of social organizations, a campaign of sensitization conducted to release the importance and utility of more regulations to increase social acceptance. This will involve granting more decisional autonomy to community associations and fishers. A deeper involvement of fishers through the associations they belong to, in the decisional and management process, result to increase in self enforcement level. This could have good result in terms of the perceived legitimacy of regulations and authorities.

4 The imposition of more regulations (mesh size and close seasons) to fishing lake areas should be set in order to be more coherent with the local characteristics of lake resources and with the socio-economic context. This could be reached by adjusting regulations to the specific features of the host community. At the same time it should not be in conflict with aspects related to the income stability of the community impacted by it. This could have positive result both in terms of the perceived effectiveness and of perceived fairness. In this way a trade off between income/employment and natural resources protection could be avoided and/or better balanced.

5 The stochastic model results indicated the potential for improving performance in the unregulated fishery. And from the perspective of equity and distribution improved efficiency is desirable; but improving efficiency at the unregulated at the moment when neither effort nor catch is limited could lead to further depletion of stock (negative a sign of `number of fishing gears` indicates overcapacity). Increased efficiency at the aggregate level is thus only possible if fishing effort is limited.

One potential policy option would be the retirement of a number of individuals preferably those with efficiency scores of less, than 50%. Improving efficiency would then lead to similar catch levels with a smaller number of fishers. However, such a prescription is problematic for two reasons firstly, control at the state level are currently lacking. Secondly, it requires the expulsion of a number of fishers and the unemployment of a number of fishers. Though theory state that in the long run, improved stocks and increased profits for the remaining fishers should be sufficient to compensate those who are force out of the industry, but there remain serious problem of distribution, enforcement and monitoring as it was reported in the Pandam case study. In the absence of aggregate control of effort and exit of less efficient or part time fishers. The situation may be resolve by taking measures that properly redefine the property right of the fisheries. With such reforms, the government of Plateau state could potentially carry out a limited entry, which would provide efficiency improvements and sustainable on all lakes in the state.

6 The high efficiency level at Pandam is good, but this may continue to increase to a certain level where it becomes a problems. This requires fishery managers at the lake to halt

technical efficiency by constraining number of gears- per- fisher, which at the moment averages fifty seven with a 91.50% mean technical efficiency.

7 RENLAF fishery managers should retire persistent violators if identified at the fishery. This will help management achieve its goal compliance and further act as deterrent in itself to intended violators.

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APPENDIX- A

Comparative economic analysis of regulated and unregulated natural lake fisheries: a case from plateau state.

Kindly answer these questions honestly and to the best of your ability. Your response shall be treated with outmost confidentiality and anonymity. {For Regulated}

Sample No ----------

1. Age of fisher ----------
2. Educational level (Number of years spend in formal school) ----------
3. Years of experience in fishing ----------
4. Number of family members ----------
5. Is fishing your major Occupation? Yes ☐ No ☐
6. Is your type of boat/canoe automated ☐ manual? ☐
7. Do you have an Alternative source of income? Yes ☐ No ☐
8. What was the total weight (kg) of fish you caught in today's fishing? ----------
9. How much did you realise from sales of today's catch? ----------
10. How much was price per unit of kilogram sold? ----------
11. How much did you give as gift to people (kg)? ----------
12. How much did your family consume (kg)? ----------
13. How long did you take to fish today (fishing duration) ----------
14. How long did you allow your passive gears active in water?

Name of gear	Number	Duration
----------	----------	----------
----------	----------	----------
----------	----------	----------
----------	----------	----------

15. How many gears do you have in all? ----------
16. How many gears did you used today? ----------
17.

	Gears.	Year of Purchase.	Cost price	Expected useful life.	Salvage Value
a.	----------	----------	---------	----------	----------
b.	----------	----------	----------	----------	--- -------
c.	----------	----------	----------	----------	----- ----

d. ---------- ---------- ---------- ---------- ----------

18 How much did you spend on the following?

i. Mending of Nets this fishing season? ----------

ii. Repairs of canoes/calabash/boats? ----------

18 How much did you pay as licence fee to fish this year's fishing season? ----------

19 What are the lengths of the gears you are using?

Name	Length	Mesh size
----------	----------	----------
----------	----------	----------
----------	----------	----------
----------	---------- -	------- ---------
----------	----------	----- ----------

20 Do you get advice from extension workers? Yes ☐ No ☐

21. Do you have Alternative source of income? Yes ☐ No ☐

22. What are the constraints you faced when fishing at the lake?

SECTION B

23. How many times have you violated close season regulations? 1. Never. 2. Just once or twice. 3. 3-4times. 4. Frequently.

24. Have you seen officials when landing/ coming out of the water? Yes [ ] No [ ]

25. How many times have you been arrested in past years? ----------

26. Expected value of catch from illegal fishing? ----------

27. What would you consider to be your overall chance of being detected? 1. Low 2. very low 3. High 4. Very high

28. What is your perceived probability of getting caught? 1. Low 2. very low 3. High 4. Very high

29. What is your risk of being arrested and given detection? 1. Low 2. very low 3. High 4. Very high
30. Do you think your of chance of be detained if arrested? 1. Low 2. very low 3. High 4. Very high
31. Do you think your of chance of be taken to court and convicted? 1. Low 2. very low 3. High 4. Very high
32. Do you see the Guards at the lake when fishing? Yes ☐ No ☐
33. How many others do you think violate regulations? ----------
34. Do your groups/friends think violation is right or wrong? 1. right 2. very right 3. wrong 4. Very wrong
35. Do they seek your opinion during the design of regulation? Yes ☐ No ☐
36. It is right for government to impose regulation 1. right 2. very right 3. wrong 4. Very wrong
37. Regulation is not enforced consistently? 1. Consistent 2. very consistent 3. Not consistent 4.not Very consistent
38. Seasonal closure is fair? 1. fair 2. very fair 3. Not fair 4. not Very fair 39. Seasonal closure improves the well-being of all? Yes ☐ No ☐
40. Seasonal closure is an effective measure? 1. Effective 2. very effective 3. Not effective 4.not Very effective
41. Enforcement of closure is adequate? 1. Adequate 2. very adequate 3. Not adequate 4.not Very adequate
42. Many offenders are not detected? Yes ☐ No ☐
43. Which of the following regulatory strategies will you like to be abrogated?
    a. Close season
    b. Mesh size regulation
    c. Limited entry
    d. Both regulations

Thank you

Dawang, Naanpoes Charles

APPENDIX- B

Comparative economic Analysis of regulated and unregulated natural lake fisheries: a case of from plateau state.

Kindly answer these questions honestly and to the best of your ability. Your response shall be treated with outmost confidentiality and anonymity.

{For unregulated fishers} *sample No* ----------

1. Age of fisher (number of years) ----------
2. Educational level (number of years spent in formal school) ----------
3. Years of experience (number of years) ----------
4. Number of family members ----------
5. Alternative source of income exist (Yes or No) ----------
6. Fishing is your major occupation (yes or No) ----------
7. Is your boat/canoe automated or manually driven? ----------
8. Did you pay licensed fees before being allowed entry (yes or No) ----------?
9. If yes, how much did you pay for the permission to fish at the lake----------?
10. What is the total weight (kg) of fish you caught today ----------?
11. How much did you realised from sales of fish caught today (₦) ----------?
12. How much did you sale per kilogram of fish caught ----------?
13. How much of fish did you give as a gift (Kg) ---------- (₦) ----------?
14. How much of fish did your family consume (Kg) ---------- (₦) ----------?
15. How long did you take to fish (duration of fishing) ----------?
16. How long did you allow your passive gears active in water?

Name of gear	Number	Duration
----------	----------	----------
----------	----------	----------
----------	----------	----------
----------	----------	----------

18. How many people do assist you when fishing? ----------
19. How many gears do you have in all? ----------
20. How many gears did you use today? ----------21.

How much did you spend on the following?

i. Mending of Nets this fishing season ----------

ii. Repairs of canoes/calabash/boats this fishing season ----------

22.

	Gears	Year of Purchase	Cost price	Expected useful Life	Salvage Value
a.	----------	----------	----------	----------	----------
b.	----------	----------	----------	----------	----------
c.	----------	----------	----------	----------	----------
d.	----------	----------	----------	----------	----------

23. What are lengths of the gears you are using?

Name	Length	Mesh size
----------	----------	----------
----------	----------	----------

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

a. Close season
b. Mesh size regulation
c. Limited entry
d. All the above
e. None of the above

25. How long does it take you to get to the fishing site from your House?

26. Do extension workers visit you to advice on fishing regulation? Yes ☐ ☐

27. If yes, how regular do they visit you? Once a while ☐ every 2 wks ☐ every month ☐

28. Mention the kind of advice they give you. ----------

29. Do you know of mesh size regulation? Yes ☐ No ☐

30. List the type (species) of fish you caught today

---

31. What are the constraints that you face when fishing at the lakes?

Thanks

Dawang, Naanpoes Charles.

APPENDIX - C

Comparative economic analysis of regulated and unregulated natural lake fisheries: a case from plateau state.

Catch Assessment survey (CAS) logbook for identified fishermen

Week 1. Month ---------- Week 2. Month ----------

1	2	3	4	5	6	7	Mean	1	2	3	4	5	6	7	Mean	DAYS
																1
																2
																3
																4
																5
																6
																7
																8
																9
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																26
																27
																28
																29
																30
																31

APPENDIX D

POLMAKAT LAKE
Output from the program FRONTIER (Version 4.1c)

Instruction file = pj6-ins.txt
Data file = pj6-dta.txt
Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged
the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.40113396E+01	0.67846717E+01	0.59123562E+00
beta 1	0.94511289E+00	0.95697306E+00	0.98760658E+00
beta 2	0.35793126E+00	0.16590016E+01	0.21575101E+00
beta 3	-0.15097531E+00	0.24482657E+01	-0.61666227E-01
beta 4	-0.18962004E+00	0.27076860E+00	-0.70030289E+00
beta 5	-0.81935910E-01	0.39456322E+00	-0.20766231E+00
beta 6	0.57698473E-01	0.23264636E+00	0.24800935E+00
beta 7	0.23042344E+00	0.43763796E+00	0.52651612E+00
beta 8	-0.31378857E-01	0.45507265E+00	-0.68953510E-01
beta 9	0.55661372E-01	0.39320272E+00	0.14155897E+00
sigma-squared	0.16211453E+00		

log likelihood function = -0.32527759E+01
the estimates after the grid search were :

beta 0	0.43411177E+01
beta 1	0.94511289E+00
beta 2	0.35793126E+00
beta 3	-0.15097531E+00
beta 4	-0.18962004E+00
beta 5	-0.81935910E-01
beta 6	0.57698473E-01
beta 7	0.23042344E+00
beta 8	-0.31378857E-01
beta 9	0.55661372E-01
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
sigma-squared	0.18981091E+00

```
 gamma          0.90000000E+00

the final mle estimates are :

                coefficient         standard-error         t-ratio
 beta 0        0.43052630E+01  0.98134036E+00  0.43871251E+01
 beta 1        0.79140523E+00  0.24494802E+00  0.32309109E+01
 beta 2        0.49329286E+00  0.46975807E+00  0.10500998E+01
 beta 3       -0.50760743E-01  0.87014783E+00 -0.58335769E-01
 beta 4       -0.12211459E+00  0.10193960E+00 -0.11979112E+01
 beta 5       -0.11146564E+00  0.43230596E+00 -0.25783971E+00
 beta 6       -0.33596977E-01  0.31521083E+00 -0.10658573E+00
 beta 7        0.95998953E-01  0.29608851E+00  0.32422383E+00
 beta 8        0.14988328E+00  0.44126611E+00  0.33966642E+00
 beta 9        0.11715968E+00  0.53700807E+00  0.21817118E+00
 delta 0      -0.23167973E+00  0.99924104E+00 -0.23185570E+00
 delta 1       0.46340946E-01  0.27408231E-01  0.16907675E+01
 delta 2      -0.76471084E-03  0.43019562E-01 -0.17775886E-01
 delta 3      -0.53225644E-01  0.21639232E-01 -0.24596827E+01
 delta 4      -0.37727005E-01  0.10352120E+00 -0.36443747E+00
 sigma-squared  0.11460790E+00  0.80889517E-01  0.14168450E+01
 gamma          0.99790454E+00  0.38680308E-02  0.25798774E+03

log likelihood function =   0.19486788E+01
LR test of the one-sided error =   0.10402909E+02
with number of restrictions = 6
 [note that this statistic has a mixed chi-square distribution]
number of iterations =    100
(maximum number of iterations set at :    100)
number of cross-sections =     20
number of time periods =      1
total number of observations =     20
thus there are:      0  obsns not in the panel
technical efficiency estimates :

firm  year           eff.-est.
1     1          0.91662257E+00
2     1          0.93649979E+00
3     1          0.75712029E+00
.
.
.
19 1           0.60370360E+00
 20 1          0.74760733E+00

 mean efficiency =   0.66956806E+00
```

SHIMMANKAR LAKE
Output from the program FRONTIER (Version 4.1c)
instruction file = pj5-ins.txt
data file = pj5-dta.txt
Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged
the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.24601248E+00	0.71920809E+01	0.34206022E-01
beta 1	0.14550399E+01	0.12068672E+01	0.12056337E+01
beta 2	0.46105084E+00	0.16692496E+01	0.27620246E+00
beta 3	0.73223055E+00	0.20139854E+01	0.36357292E+00
beta 4	-0.23787095E+00	0.48419712E+00	-0.49126883E+00
beta 5	-0.84891982E-01	0.57155671E+00	-0.14852766E+00
beta 6	-0.59023450E-01	0.27872207E+00	-0.21176454E+00
beta 7	0.30259401E+00	0.68396843E+00	0.44240933E+00
beta 8	-0.17964212E+00	0.74541342E+00	-0.24099663E+00
beta 9	0.21037618E+00	0.61529578E+00	0.34191065E+00
sigma-squared	0.45979269E+00		

log likelihood function = -0.13677503E+02
the estimates after the grid search were :

beta 0	0.83914713E+00
beta 1	0.14550399E+01
beta 2	0.46105084E+00
beta 3	0.73223055E+00
beta 4	-0.23787095E+00
beta 5	-0.84891982E-01
beta 6	-0.59023450E-01
beta 7	0.30259401E+00
beta 8	-0.17964212E+00
beta 9	0.21037618E+00
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
sigma-squared	0.58170505E+00
gamma	0.95000000E+00

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.82637183E+00	0.94669179E+00	0.87290483E+00
beta 1	0.13301211E+01	0.26790643E+00	0.49648718E+01
beta 2	0.52252146E+00	0.37587744E+00	0.13901379E+01
beta 3	0.81777514E+00	0.96763276E+00	0.84512966E+00
beta 4	-0.98154592E-01	0.13646163E-01	-0.71928343E+01
beta 5	-0.27339408E+00	0.23112597E+00	-0.11828791E+01
beta 6	0.16360353E-01	0.41171900E-01	0.39736697E+00
beta 7	0.89496135E-01	0.18944458E+00	0.47241328E+00
beta 8	0.12141691E+00	0.20252377E+00	0.59951933E+00
beta 9	-0.28718488E-03	0.20049943E+00	-0.14323476E-02
delta 0	-0.21890751E+00	0.22436306E+01	-0.97568430E-01
delta 1	-0.53390807E-01	0.11113984E+00	-0.48039306E+00
delta 2	0.23137676E-02	0.66380917E-01	0.34855914E-01
delta 3	-0.58085058E-01	0.43452012E-01	-0.13367634E+01
delta 4	0.22453270E+00	0.24653328E+00	0.91076019E+00
sigma-squared	0.84305820E+00	0.59579532E+00	0.14150131E+01
gamma	0.99999999E+00	0.25238379E-06	0.39622195E+07

log likelihood function = -0.19251474E+01
LR test of the one-sided error = 0.23504710E+02
with number of restrictions = 6
[note that this statistic has a mixed chi-square distribution]
number of iterations = 100
(maximum number of iterations set at : 100)
number of cross-sections = 20
number of time periods = 1
total number of observations = 20
thus there are: 0 obsns not in the panel
technical efficiency estimates :

firm	year	eff.-est.
1	1	0.93797962E+00
2	1	0.51968806E+00
3	1	0.98388629E+00
4	1	0.99970415E+00
5	1	0.58567136E+00
6	1	0.77540741E+00
7	1	0.98730155E-01
8	1	0.97440695E+00
9	1	0.98578904E+00
10	1	0.63692335E+00
11	1	0.88358705E+00
12	1	0.99499319E+00
13	1	0.59228611E+00

14	1	0.96650782E+00
15	1	0.72156286E+00
16	1	0.70720859E+00
17	1	0.47286500E+00
18	1	0.48779991E+00
19	1	0.53283448E+00
20	1	0.43349061E+00

mean efficiency = 0.71456610E+00

DEBEN LAKE
Output from the program FRONTIER (Version 4.1c)
instruction file = pj9-ins.txt
data file = pj9-dta.txt
Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged
the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.83649638E+01	0.13642936E+01	0.61313514E+01
beta 1	0.16820292E+00	0.69339887E-01	0.24257744E+01
beta 2	-0.89986612E+00	0.60962733E+00	-0.14760922E+01
beta 3	0.13016220E+01	0.75778275E+00	0.17176717E+01
sigma-squared	0.11388895E+00		

log likelihood function = -0.44220204E+01
the estimates after the grid search were :

beta 0	0.84196950E+01
beta 1	0.16820292E+00
beta 2	-0.89986612E+00
beta 3	0.13016220E+01
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
sigma-squared	0.94106668E-01
gamma	0.50000000E-01

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.86870693E+01	0.90653596E+00	0.95827079E+01
beta 1	0.13129549E+00	0.49652210E-01	0.26443031E+01
beta 2	-0.58912394E+00	0.24533773E+00	-0.24012773E+01

beta 3	0.92513348E+00	0.28835875E+00	0.32082726E+01
delta 0	0.13009930E+01	0.59304012E+00	0.21937690E+01
delta 1	-0.27220892E-01	0.12087330E-01	-0.22520185E+01
delta 2	0.35281110E-01	0.85205291E-02	0.41407182E+01
delta 3	-0.74509154E-02	0.10855741E-01	-0.68635716E+00
delta 4	0.34392024E-01	0.12088900E-01	0.28449259E+01
sigma-squared	0.63761595E-01	0.17759669E-01	0.35902467E+01
gamma	0.99313051E+00	0.12349892E+00	0.80416127E+01

log likelihood function = -0.60105106E+00

LR test of the one-sided error = 0.76419386E+01
with number of restrictions = 6
[note that this statistic has a mixed chi-square distribution]
number of iterations = 37
(maximum number of iterations set at : 100)
number of cross-sections = 20
number of time periods = 1
total number of observations = 20
thus there are: 0 obsns not in the panel
technical efficiency estimates :

firm	year	eff.-est.
1	1	0.47485938E+00
2	1	0.32805624E+00
3	1	0.42674988E+00
4	1	0.31717985E+00
5	1	0.49251405E+00
6	1	0.94545766E+00
7	1	0.48699575E+00
8	1	0.35394303E+00
9	1	0.38067903E+00
10	1	0.33320767E+00
11	1	0.75508904E+00
12	1	0.45627745E+00
13	1	0.57838743E+00
14	1	0.51359443E+00
15	1	0.41911506E+00
16	1	0.44835217E+00
17	1	0.43509552E+00
18	1	0.32590879E+00
19	1	0.35440734E+00
20	1	0.83622516E+00

mean efficiency = 0.48310475E+00

JANTA LAKE

```
Output from the program FRONTIER (Version 4.1c)
instruction file = pj10-ins.txt
data file =        pj10-dta.txt
 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a production function
 The dependent variable is logged
the ols estimates are :

              coefficient          standard-error        t-ratio
  beta 0        0.57238085E+01  0.12493462E+01  0.45814431E+01
  beta 1        0.33997414E+00  0.91851339E-01  0.37013521E+01
  beta 2        0.25657544E+00  0.36100486E+00  0.71072573E+00
  beta 3       -0.53201841E+00  0.44457206E+00 -0.11966978E+01
  sigma-squared  0.88672219E-01

log likelihood function =  -0.19192482E+01
the estimates after the grid search were :
  beta 0        0.59535095E+01
  beta 1        0.33997414E+00
  beta 2        0.25657544E+00
  beta 3       -0.53201841E+00
  delta 0       0.00000000E+00
  delta 1       0.00000000E+00
  delta 2       0.00000000E+00
  delta 3       0.00000000E+00
  delta 4       0.00000000E+00
  sigma-squared  0.12370033E+00
  gamma         0.67000000E+00

the final mle estimates are :
              coefficient          standard-error        t-ratio
  beta 0        0.62928204E+01  0.68908592E+00  0.91321274E+01
  beta 1        0.34933425E+00  0.80751423E-01  0.43260446E+01
  beta 2        0.14600672E+00  0.23402549E+00  0.62389239E+00
  beta 3       -0.48998953E+00  0.30807389E+00 -0.15904935E+01
  delta 0      -0.89524465E+00  0.83501778E+00 -0.10721265E+01
  delta 1      -0.10035553E-01  0.18420175E-01 -0.54481310E+00
  delta 2       0.23134411E-01  0.48201389E-01  0.47995321E+00
  delta 3       0.30948045E-01  0.15746361E-01  0.19654094E+01
  delta 4       0.71001458E-01  0.29987978E-01  0.23676641E+01
  sigma-squared  0.51342401E-01  0.47426228E-01  0.10825740E+01
  gamma         0.27023406E+00  0.44282131E+00  0.61025533E+00

log likelihood function =   0.32851962E+01
LR test of the one-sided error =   0.10408889E+02
with number of restrictions = 6
```

[note that this statistic has a mixed chi-square distribution]
number of iterations = 14
(maximum number of iterations set at : 100)
number of cross-sections = 20
number of time periods = 1
total number of observations = 20
thus there are: 0 obsns not in the panel
technical efficiency estimates :

firm	year	eff.-est.
1	1	0.97985298E+00
2	1	0.98366361E+00
3	1	0.98658321E+00
4	1	0.98304914E+00
5	1	0.97540177E+00
6	1	0.94474309E+00
7	1	0.97927547E+00
8	1	0.98231754E+00
9	1	0.97506770E+00
10	1	0.50450766E+00
11	1	0.90141743E+00
12	1	0.69659407E+00
13	1	0.92450841E+00
14	1	0.65429268E+00
15	1	0.96344109E+00
16	1	0.95935675E+00
17	1	0.97887508E+00
18	1	0.96977843E+00
19	1	0.98027145E+00
20	1	0.93565792E+00

mean efficiency = 0.91293277E+00

URENLAF (COMBINE)
Output from the program FRONTIER (Version 4.1c)
instruction file = pj7-ins.txt
data file = pj7-dta.txt
Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged
the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.53735258E+01	0.25478684E+01	0.21090280E+01
beta 1	0.33362530E+00	0.38025792E+00	0.87736582E+00
beta 2	0.45015785E+00	0.73645855E+00	0.61124669E+00
beta 3	-0.29723652E+00	0.90861198E+00	-0.32713252E+00

```
 beta 4       -0.15218339E-01  0.15464236E+00 -0.98409896E-01
 beta 5        0.73460061E-01  0.18990070E+00  0.38683407E+00
 beta 6        0.88179012E-01  0.10080194E+00  0.87477493E+00
 beta 7       -0.87630898E-01  0.17748504E+00 -0.49373682E+00
 beta 8       -0.71793894E-01  0.20830812E+00 -0.34465241E+00
 beta 9       -0.15076266E+00  0.19059379E+00 -0.79101560E+00
 sigma-squared  0.19592972E+00

log likelihood function =  -0.42973854E+02
the estimates after the grid search were :
 beta 0        0.57495651E+01
 beta 1        0.33362530E+00
 beta 2        0.45015785E+00
 beta 3       -0.29723652E+00
 beta 4       -0.15218339E-01
 beta 5        0.73460061E-01
 beta 6        0.88179012E-01
 beta 7       -0.87630898E-01
 beta 8       -0.71793894E-01
 beta 9       -0.15076266E+00
 delta 0       0.00000000E+00
 delta 1       0.00000000E+00
 delta 2       0.00000000E+00
 delta 3       0.00000000E+00
 delta 4       0.00000000E+00
 sigma-squared  0.31284401E+00
 gamma         0.71000000E+00
 the final mle estimates are :

              coefficient          standard-error       t-ratio
 beta 0        0.55666818E+01  0.10557733E+01  0.52726108E+01
 beta 1        0.29683669E+00  0.17192464E+00  0.17265512E+01
 beta 2        0.47645176E+00  0.39238685E+00  0.12142399E+01
 beta 3       -0.15235196E+00  0.63189347E+00 -0.24110387E+00
 beta 4       -0.22675493E-01  0.95917682E-01 -0.23640577E+00
 beta 5       -0.34469769E-01  0.15137911E+00 -0.22770493E+00
 beta 6        0.57372197E-01  0.87575745E-01  0.65511515E+00
 beta 7       -0.47552897E-01  0.14944612E+00 -0.31819426E+00
 beta 8        0.10338768E+00  0.18692498E+00  0.55309718E+00
 beta 9       -0.12259132E+00  0.16324645E+00 -0.75095857E+00
 delta 0      -0.18593354E+01  0.18267553E+01 -0.10178349E+01
 delta 1       0.97600881E-02  0.27739516E-01  0.35184781E+00
 delta 2       0.83987317E-01  0.65883176E-01  0.12747916E+01
 delta 3      -0.92113004E-01  0.53219163E-01 -0.17308240E+01
 delta 4       0.14457867E+00  0.70478071E-01  0.20513994E+01
 sigma-squared  0.34093598E+00  0.12132652E+00  0.28100696E+01
```

```
  gamma          0.68207105E+00  0.15212791E+00  0.44835365E+01
log likelihood function =  -0.34552490E+02
LR test of the one-sided error =   0.16842728E+02
with number of restrictions = 6
 [note that this statistic has a mixed chi-square distribution]
number of iterations =     24
(maximum number of iterations set at :    100)
number of cross-sections =     80
number of time periods =      1
total number of observations =     80
thus there are:      0  obsns not in the panel
technical efficiency estimates :

    firm  year          eff.-est.
      1     1         0.83883117E+00
      2     1         0.82383971E+00
      3     1         0.83779966E+00
     .
     .
     .
     78     1         0.76138677E+00
     79     1         0.83569300E+00
     80     1         0.91133511E+00

 mean efficiency =   0.84161126E+00
 RENLAF LAKE
Output from the program FRONTIER (Version 4.1c)
instruction file = pj8-ins.txt
data file =        pj8-dta.txt
 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a production function
 The dependent variable is logged
the ols estimates are :
                      coefficient          standard-error    t-ratio
  beta 0        0.72821058E+01  0.45028196E+00  0.16172324E+02
  beta 1        0.56048557E-01  0.62374672E-01  0.89857879E+00
  beta 2        0.13043974E-01  0.10831144E+00  0.12043025E+00
  beta 3        0.42001625E-01  0.12109388E+00  0.34685177E+00
  sigma-squared  0.50708056E-01

log likelihood function =   0.43034147E+01
the estimates after the grid search were :
  beta 0        0.73201173E+01
  beta 1        0.56048557E-01
  beta 2        0.13043974E-01
  beta 3        0.42001625E-01
```

```
 delta 0        0.00000000E+00
 delta 1        0.00000000E+00
 delta 2        0.00000000E+00
 delta 3        0.00000000E+00
 delta 4        0.00000000E+00
 sigma-squared  0.45391849E-01
 gamma          0.50000000E-01

the final mle estimates are :

                    coefficient             standard-error    t-ratio
 beta 0         0.70869499E+01  0.50643571E+00  0.13993780E+02
 beta 1         0.60093261E-01  0.64952602E-01  0.92518634E+00
 beta 2         0.66556171E-01  0.12246542E+00  0.54346908E+00
 beta 3         0.66767256E-02  0.12212041E+00  0.54673297E-01
 delta 0        0.77134356E+00  0.46195162E+00  0.16697497E+01
 delta 1       -0.44252295E-01  0.17161423E-01 -0.25785912E+01
 delta 2       -0.18526388E-01  0.49951878E-01 -0.37088471E+00
 delta 3        0.40168486E-01  0.17930556E-01  0.22402254E+01
 delta 4        0.13846208E-01  0.13575974E-01  0.10199054E+01
 sigma-squared  0.40761241E-01  0.23550908E-01  0.17307715E+01
 gamma          0.15091558E+00  0.73115534E+00  0.20640701E+00
log likelihood function =   0.78411299E+01
LR test of the one-sided error =   0.70754304E+01
with number of restrictions = 6
 [note that this statistic has a mixed chi-square distribution]
number of iterations =     22
(maximum number of iterations set at :    100)
number of cross-sections =     30
number of time periods =      1
total number of observations =     30
thus there are:      0  obsns not in the panel
technical efficiency estimates :

    firm  year          eff.-est.
      1     1         0.98651210E+00
      2     1         0.89599678E+00
      3     1         0.95738001E+00
     .
     .
     .
     28     1         0.97315083E+00
     29     1         0.98053984E+00
     30     1         0.99101904E+00
 mean efficiency =   0.92504136E+00
```

APPENDIX E

--> READ;FILE="C:\Users\Charles\Documents\victory 2011.xls"$
--> REGRESS;Lhs=VLF;Rhs=ONE,X1,X4,B1,B4,P2,P3,P4,P5;Het;Ar1;PrintVC$

```
+----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = VLF      Mean=   3.500000000    , S.D.=   1.167748416     |
| Model size: Observations =      12, Parameters =   9, Deg.Fr.=      3 |
| Residuals:  Sum of squares= 1.554698409    , Std.Dev.=        .71988 |
| Fit:        R-squared=  .621353, Adjusted R-squared =         .61996 |
| Model test: F[  8,     3] =    3.24,    Prob value =         .03107 |
| Diagnostic: Log-L =     -4.7655, Restricted(b=0) Log-L =     -18.3661 |
|           LogAmemiyaPrCrt.=    -.098, Akaike Info. Crt.=      2.294 |
| Autocorrel: Durbin-Watson Statistic =   1.63180,   Rho =      -.19912 |
+----------------------------------------------------------------------+
+---------+-------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+----------------+--------+---------+----------+
 Constant     5.832262487       .87166053    6.691   .0068
 X1       -.5836452779E-01  .21850713E-01   -2.671   .0756     43.916667
 X4           .1213665663   .55781162E-01    2.176   .0178     8.3333333
 B1           .3729932196       .47223034     .790   .4873     .50000000
 B4          -1.470313581       .72193729   -2.037   .1345     .25000000
 P2       -.6122085682E-01      .28312516    -.216   .8427     1.2500000
 P3           2.362822527       .67626671    3.494   .0397     .58333333
 P4          -1.439338082       .70240864   -2.049   .0329     .75000000
 P5          -1.408588715       .72962548   -1.931   .0491     .58333333
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)



+--------------------------------------------+

| AR(1) Model:     e(t) = rho * e(t-1) + u(t) |
| Initial value of rho       =       -.19912 |
| Maximum iterations         =           100 |
| Method = Prais - Winsten                   |
| Iter=  1, SS=      3.527, Log-L= -10.479203 |
| Iter=  2, SS=      3.100, Log-L=  -8.635790 |
| Iter=  3, SS=      2.793, Log-L=  -7.240830 |
| Iter=  4, SS=      2.744, Log-L=  -7.108162 |
| Iter=  5, SS=      2.669, Log-L=  -6.743169 |
| Iter=  6, SS=      2.671, Log-L=  -6.761287 |
| Final value of Rho    =          -.777991 |
| Iter=  6, SS=      2.671, Log-L=  -6.761287 |
```

```
| Durbin-Watson:   e(t) =          3.568844 |
| Std. Deviation:  e(t) =          .567482 |
| Std. Deviation:  u(t) =          .356536 |
| Durbin-Watson:   u(t) =          2.729583 |
| Autocorrelation: u(t) =          -.364792 |
| N[0,1] used for significance levels        |
+--------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 Constant     5.789964305       .36790810   15.738   .0000
 X1       -.7776168390E-01  .98086064E-02   -7.928   .0000    -581.83333
 X4        .4829225224E-01  .29386876E-01    1.643   .1003    -596.06667
 B1          1.038388764       .17321672    5.995   .0000    -599.20000
 B4          -.5684916507      .28212128   -2.015   .0439    -599.30000
 P2          .3959528023       .12038816    3.289   .0010    -598.90000
 P3          2.994879808       .34706792    8.629   .0000    -599.16667
 P4          -1.498119498      .28218855   -5.309   .0000    -599.10000
 P5          -1.327344380      .26878631   -4.938   .0000    -599.16667
 RHO         -.2979905346      .11666792   -1.280   .2320
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

--> REGRESS;Lhs=VLF;Rhs=ONE,S2,S3,S4,S5,S6,S7,S8,S9,S11;Het;Ar1;PrintVC$

```
+-----------------------------------------------------------------------+
| Ordinary    least squares regression    Weighting variable = none     |
| Dep. var. = VLF      Mean=   3.500000000    , S.D.=   1.167748416     |
| Model size: Observations =      12, Parameters =  10, Deg.Fr.=      4 |
| Residuals:  Sum of squares= 2.307335419    , Std.Dev.=       1.07409 |
| Fit:        R-squared=  .999705, Adjusted R-squared =         .99676 |
| Model test: F[  9,     2] =    1.22,    Prob value =         .00840 |
| Diagnostic: Log-L =     -7.1344, Restricted(b=0) Log-L =     -18.3661 |
|           LogAmemiyaPrCrt.=     .749, Akaike Info. Crt.=      2.856 |
| Autocorrel: Durbin-Watson Statistic =   1.55410,   Rho =      -.02530 |
+-----------------------------------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |t-ratio |P[|T|>t] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 Constant     1.877578995       2.4164308     .777   .1185
 S2          .1378510421   .64311951E-01    2.143   .0653     7.5833333
 S3          2.774102843       1.1636592    2.384   .0399     .58333333
 S4          3.896910478       2.7411132    1.422   .0910     .83333333
 S5          -1.772064251      2.0334832    -.871   .4754     .66666667
 S6          2.011458297       1.4619966    1.376   .3027     .33333333
```

```
 S7      -.7135074338E-01      1.8672846    -.038   .9730     .66666667
 S8         2.963797406       2.4392039    1.215   .1183     .41666667
 S9        -4.992337703       1.9469536   -2.564   .0243     .58333333
 S11       -4.105725634       1.8844049   -2.179   .0612     .50000000
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+--------------------------------------------+


| AR(1) Model:     e(t) = rho * e(t-1) + u(t) |
| Initial value of rho       =       -.02530 |
| Maximum iterations         =           100 |
| Method = Prais - Winsten                   |
| Iter=  1, SS=      2.058, Log-L=  -2.376960 |
| Iter=  2, SS=      2.793, Log-L=  -6.960898 |
| Final value of Rho    =          -.025298 |
| Iter=  2, SS=      2.793, Log-L=  -6.960898 |
| Durbin-Watson:   e(t) =          2.245191 |
| Std. Deviation:  e(t) =           .320888 |
| Std. Deviation:  u(t) =           .320785 |
| Durbin-Watson:   u(t) =          1.005642 |
| Autocorrelation: u(t) =          -.102821 |
| N[0,1] used for significance levels        |
+--------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
 Constant     1.763056745       .18079778    9.752   .0000
 S2          .1385151558   .18118368E-01    7.645   .0000    -596.36667
 S3          2.831851060       .26371329   10.738   .0000    -599.16667
 S4          4.015765421       .46733758    8.593   .0000    -599.06667
 S5         -1.834864281       .50684148   -3.620   .0003    -599.13333
 S6          1.998963144       .42345293    4.721   .0000    -599.26667
 S7       -.1354963891E-01      .42489297    -.032   .9746    -599.13333
 S8          3.055901803       .45077302    6.779   .0000    -599.23333
 S9         -5.057361320       .52311845   -9.668   .0000    -599.16667
 S11        -4.133455075       .51405069   -8.041   .0000    -599.20000
 RHO         -.252980934       .18563591    -.136   .8916
 (Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```

APPENDIX F

```
--> READ;FILE="C:\Users\Charles\Documents\oprbit data 2.xls"$
--> ORDERED;Lhs=VL;Rhs=X1,X2,X3,X4,B1,B4,P2,P3,P4,P5,S2,S3,S4,S5,S6,S7,S8,S9
   ;Marginal Effects;Parameters;PrintVC;List$
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Ordered Probability Model                   |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 02, 2011 at 04:40:05PM.|
| Dependent variable                VL        |
| Weighting variable                None      |
| Number of observations            30        |
| Iterations completed              30        |
| Log likelihood function       -15.79755     |
| Restricted log likelihood     -32.66700     |
| Chi squared                   33.73890      |
| Degrees of freedom            17            |
| Prob[ChiSqd > value] =        .9071965E-02  |
| Underlying probabilities based on Normal    |
|    Cell frequencies for outcomes            |
|  Y Count Freq  Y Count Freq  Y Count Freq   |
|  0    12 .400  1     9 .300  2     9 .300   |
+---------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
        Index function for probability
 X1         -.4280000082      .21120206   -2.026   .0427     45.166667
 X2         -.5666404506      .31147411   -1.819   .0689     6.1666667
 X3          .4917707449      .22972816    2.141   .0323     27.200000
 X4         -.1396231598   .93175230E-01   -1.499   .1340     9.7666667
 B1          1.645916995      .71819387    2.292   .0219     1.7000000
 B4          .5676435845      .48224704    1.177   .2392     1.1000000
 P2          .5808192883      .39359379    1.476   .1400     1.7000000
 P3          1.508401070      .96671958    1.560   .1187     1.7666667
 P4          .3761678456      .41078819     .916   .3598     1.9000000
 P5          1.503840033      .90144170    1.668   .0953     1.7000000
 S2       .8347272333E-01      .10826792     .771   .4407     6.3666667
 S3         -.1717034307      .44550035    -.385   .6999     1.4333333
 S4         -3.304141343      1.7169959   -1.924   .0543     1.9333333
 S5          2.556211536      1.3855661    1.845   .0651     1.8333333
 S6         -.4132060450      .52561980    -.786   .4318     1.2666667
 S7         -.4055939251      .41877528    -.969   .3328     1.4000000
 S8          4.075818949      1.7990488    2.266   .0235     1.0666667
```

```
S9        -.4381616285       .52189626    -.840   .4012     1.6333333
        Threshold parameters for index
Mu(1)       1.841640231       .56180466    3.278   .0010
(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+----------------------------------------------------+
| Marginal effects for ordered probability model     |
| M.E.s for dummy variables are Pr[y|x=1]-Pr[y|x=0]  |
| Names for dummy variables are marked by *.         |
+----------------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
        These are the effects on Prob[Y=00] at means.
 X1          .1375823078   .77262009E-01    1.781   .0750     45.166667
 X2          .1821488303       .11117115    1.638   .1013     6.1666667
 X3         -.1580816652   .87033126E-01   -1.816   .0693     27.200000
 X4       .4488242097E-01  .34074969E-01    1.317   .1878     9.7666667
 B1         -.5290865755       .29300935   -1.806   .0710     1.7000000
 B4         -.1824712917       .15108103   -1.208   .2271     1.1000000
 P2         -.1867066742       .14159498   -1.319   .1873     1.7000000
 P3         -.4848815333       .31233988   -1.552   .1206     1.7666667
 P4         -.1209206526       .12057586   -1.003   .3159     1.9000000
 P5         -.4834153698       .32745984   -1.476   .1399     1.7000000
 S2       -.2683263947E-01  .33365156E-01    -.804   .4213     6.3666667
 S3        .5519475187E-01     .15011650     .368   .7131     1.4333333
 S4          1.062129398       .58604999    1.812   .0699     1.9333333
 S5         -.8217043823       .46556384   -1.765   .0776     1.8333333
 S6          .1328267294       .16243100     .818   .4135     1.2666667
 S7          .1303797831       .13635914     .956   .3390     1.4000000
 S8         -1.310188239       .62964428   -2.081   .0374     1.0666667
 S9          .1408488011       .16487491     .854   .3930     1.6333333
        These are the effects on Prob[Y=01] at means.
 X1       -.5291352927E-01  .90986373E-01    -.582   .5609     45.166667
 X2       -.7005361095E-01     .12148152    -.577   .5642     6.1666667
 X3        .6079748879E-01     .10535670     .577   .5639     27.200000
 X4       -.1726157479E-01  .32216215E-01    -.536   .5921     9.7666667
 B1          .2034842884       .36099929     .564   .5730     1.7000000
 B4        .7017762814E-01     .11831508     .593   .5531     1.1000000
 P2        .7180653696E-01     .13268081     .541   .5884     1.7000000
 P3          .1864832304       .30941570     .603   .5467     1.7666667
 P4        .4650553254E-01  .72415466E-01     .642   .5207     1.9000000
 P5          .1859193506       .33384955     .557   .5776     1.7000000
 S2        .1031971099E-01  .18618226E-01     .554   .5794     6.3666667
 S3       -.2122765031E-01  .75646063E-01    -.281   .7790     1.4333333
```

S4	-.4084901316	.68084240	-.600	.5485	1.9333333
S5	.3160237648	.52523267	.602	.5474	1.8333333
S6	-.5108455546E-01	.92299979E-01	-.553	.5799	1.2666667
S7	-.5014347106E-01	.94312141E-01	-.532	.5950	1.4000000
S8	.5038924325	.82984134	.607	.5437	1.0666667
S9	-.5416980773E-01	.10093849	-.537	.5915	1.6333333

These are the effects on Prob[Y=02] at means.

X1	-.8466877853E-01	.96125102	-.088	.9298	45.166667
X2	-.1120952194	1.3298447	-.084	.9328	6.1666667
X3	.9728417637E-01	1.1490964	.085	.9325	27.200000
X4	-.2762084618E-01	.32696088	-.084	.9327	9.7666667
B1	.3256022871	3.8118150	.085	.9319	1.7000000
B4	.1122936636	1.3382946	.084	.9331	1.1000000
P2	.1149001372	1.3749802	.084	.9334	1.7000000
P3	.2983983029	3.5555011	.084	.9331	1.7666667
P4	.7441512009E-01	.85320510	.087	.9305	1.9000000
P5	.2974960192	3.5374080	.084	.9330	1.7000000
S2	.1651292848E-01	.20095372	.082	.9345	6.3666667
S3	-.3396710156E-01	.42221646	-.080	.9359	1.4333333
S4	-.6536392669	7.7312317	-.085	.9326	1.9333333
S5	.5056806175	5.9820872	.085	.9326	1.8333333
S6	-.8174217393E-01	.97602678	-.084	.9333	1.2666667
S7	-.8023631205E-01	.90115870	-.089	.9291	1.4000000
S8	.8062958067	9.4879448	.085	.9323	1.0666667
S9	-.8667899339E-01	.98480935	-.088	.9299	1.6333333

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

Summary of Marginal Effects for Ordered Probability Model (probit)							
Variable	Y=00	Y=01	Y=02	Y=03	Y=04	Y=05	Y=06	Y=07
X1	.1376	-.0529	-.0847					
X2	.1821	-.0701	-.1121					
X3	-.1581	.0608	.0973					
X4	.0449	-.0173	-.0276					
B1	-.5291	.2035	.3256					
B4	-.1825	.0702	.1123					
P2	-.1867	.0718	.1149					
P3	-.4849	.1865	.2984					
P4	-.1209	.0465	.0744					
P5	-.4834	.1859	.2975					
S2	-.0268	.0103	.0165					
S3	.0552	-.0212	-.0340					
S4	1.0621	-.4085	-.6536					
S5	-.8217	.3160	.5057					

S6	.1328	-.0511	-.0817
S7	.1304	-.0501	-.0802
S8	-1.3102	.5039	.8063
S9	.1408	-.0542	-.0867

Predicted Values (* => observation was not in estimating sample.)

APPENDIX G

--> LOGIT;Lhs=Y;Rhs=YEAR,AGE,FMSIZE,ALTSOU,HFS,CPUE,EXTCON;Marginal Effects$

Normal exit from iterations. Exit status=0.

```
+--------------------------------------------+
| Multinomial Logit Model                    |
| Maximum Likelihood Estimates               |
| Model estimated: Jan 11, 2012 at 04:36:32PM.|
| Dependent variable                Y        |
| Weighting variable                None     |
| Number of observations            110      |
| Iterations completed              7        |
| Log likelihood function       -114.8241    |
| Restricted log likelihood     -175.3083    |
| Chi squared                   120.9684     |
| Degrees of freedom            24           |
| Prob[ChiSqd > value] =        .0000000     |
+--------------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
        Characteristics in numerator of Prob[Y = 1]
 YEAR        12.11126116       3.2089218    3.774   .0002     1.0000000
 AGE      -.6997902327E-01  .53867326E-01   -1.299   .1939     38.509091
 FMSIZE   -.7304543891E-01      .11248064    -.649   .5161     8.0545455
 ALTSOU      -4.321388848       1.1508775   -3.755   .0002     .53636364
 HFS         -15.60229411       3.7618110   -4.148   .0000     .69363636
 CPUE         .3331099039       .13187789    2.526   .0115     6.1634455
 EXTCON       1.631767576       1.0241251    1.593   .1111     .47272727
        Characteristics in numerator of Prob[Y = 2]
 YEAR        4.484615033       2.8228314    1.589   .1121     1.0000000
 AGE      -.9464432286E-01  .49536850E-01   -1.911   .0561     38.509091
 FMSIZE    .3040702032E-01  .69200595E-01     .439   .6604     8.0545455
 ALTSOU      -2.673303428       .89761682   -2.978   .0029     .53636364
 HFS         -3.248802171       2.5074375   -1.296   .1951     .69363636
 CPUE         .2633099935       .12145103    2.168   .0302     6.1634455
 EXTCON       2.423959943       .89153413    2.719   .0066     .47272727
        Characteristics in numerator of Prob[Y = 3]
 YEAR        5.223438027       2.1806913    2.395   .0166     1.0000000
 AGE      -.2219685373E-01  .31334362E-01    -.708   .4787     38.509091
 FMSIZE   -.1136409721E-01  .65910228E-01    -.172   .8631     8.0545455
 ALTSOU      -.7189199474       .85738074    -.839   .4017     .53636364
 HFS         -5.663615090       2.1170482   -2.675   .0075     .69363636
 CPUE      .5070637617E-01      .12289158     .413   .6799     6.1634455
```

```
EXTCON   -.6247229108E-01      .72607827    -.086   .9314     .47272727
        Characteristics in numerator of Prob[Y = 4]
YEAR        6.431553278       2.5236564    2.549   .0108     1.0000000
AGE         -.1101392262   .46079085E-01   -2.390   .0168     38.509091
FMSIZE    .4800739229E-01  .66035431E-01     .727   .4672     8.0545455
ALTSOU      -2.576781050       .83058354   -3.102   .0019     .53636364
HFS         -3.663743166       2.3351735   -1.569   .1167     .69363636
CPUE         .2182024640       .11979275    1.821   .0685     6.1634455
EXTCON       1.006057861       .80403981    1.251   .2108     .47272727
(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)


+--------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                  |
|                         M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)     -114.82412        -175.30832    -177.03817 |
| LR Statistic vs. MC      120.96839           .00000       .00000 |
| Degrees of Freedom        24.00000           .00000       .00000 |
| Prob. Value for LR          .00000           .00000       .00000 |
| Entropy for probs.        114.82412         175.30832     177.03817 |
| Normalized Entropy          .64858           .99023      1.00000 |
| Entropy Ratio Stat.       124.42810          3.45971       .00000 |
| Bayes Info Criterion      342.45977        463.42816     466.88787 |
| BIC - BIC(no model)       124.42810          3.45971       .00000 |
| Pseudo R-squared            .34502           .00000       .00000 |
| Pct. Correct Prec.        52.72727           .00000     20.00000 |
| Means:       y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7 |
| Outcome     .2727  .1909  .1727  .1818  .1818  .0000  .0000  .0000 |
| Pred.Pr     .2727  .1909  .1727  .1818  .1818  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).     |
|        Normalized entropy is computed against M0.                  |
|        Entropy ratio statistic is computed against M0.             |
|        BIC = 2*criterion - log(N)*degrees of freedom.              |
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.               |
+--------------------------------------------------------------------+

+----------------------------------------+
| Partial derivatives of probabilities with |
| respect to the vector of characteristics. |
| They are computed at the means of the Xs. |
| Observations used for means are All Obs.  |
| A full set is given for the entire set of |
| outcomes, Y       = 0 to Y       =  4.  |
| Probabilities at the mean vector are      |
|  0= .189 1= .043 2= .223 3= .242 4= .304  |
```

```
+----------------------------------------+
+---------+-------------+---------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+----------+
        Marginal effects on Prob[Y = 0]
 YEAR       -.8942214797      .30667181   -2.916   .0035     1.0000000
 AGE       .1188608963E-01  .58506313E-02    2.032   .0422     38.509091
 FMSIZE   -.2927463406E-02  .78322704E-02    -.374   .7086     8.0545455
 ALTSOU      .3282069234      .10534936    3.115   .0018     .53636364
 HFS         .7316240090      .27338564    2.676   .0074     .69363636
 CPUE     -.2862068962E-01  .14525723E-01   -1.970   .0488     6.1634455
 EXTCON      -.1702227205      .10154168   -1.676   .0937     .47272727
        Marginal effects on Prob[Y = 1]
 YEAR        .3150076043      .20043951    1.572   .1160     1.0000000
 AGE      -.3021157910E-03  .17505084E-02    -.173   .8630     38.509091
 FMSIZE   -.3779666729E-02  .38968548E-02    -.970   .3321     8.0545455
 ALTSOU      -.1103317378  .77501766E-01   -1.424   .1546     .53636364
 HFS         -.5007730275      .30946495   -1.618   .1056     .69363636
 CPUE      .7754494767E-02  .63494804E-02    1.221   .2220     6.1634455
 EXTCON    .3120359925E-01  .34079292E-01     .916   .3599     .47272727
        Marginal effects on Prob[Y = 2]
 YEAR     -.5526634647E-01      .36313021    -.152   .8790     1.0000000
 AGE      -.7083171335E-02  .68430738E-02   -1.035   .3006     38.509091
 FMSIZE    .3328153165E-02  .10325566E-01     .322   .7472     8.0545455
 ALTSOU      -.2089561119      .11655075   -1.793   .0730     .53636364
 HFS         .1390210288      .31618817     .440   .6602     .69363636
 CPUE      .2495829229E-01  .13603078E-01    1.835   .0665     6.1634455
 EXTCON       .3398804916      .11513267    2.952   .0032     .47272727
        Marginal effects on Prob[Y = 3]
 YEAR        .1186971063      .31908694     .372   .7099     1.0000000
 AGE       .9837209699E-02  .64902877E-02    1.516   .1296     38.509091
 FMSIZE   -.6490389062E-02  .11718140E-01    -.554   .5797     8.0545455
 ALTSOU       .2460136159      .12010580    2.048   .0405     .53636364
 HFS         -.4330259165      .33167892   -1.306   .1917     .69363636
 CPUE     -.2434976040E-01  .17840595E-01   -1.365   .1723     6.1634455
 EXTCON      -.2328011879      .11878796   -1.960   .0500     .47272727
        Marginal effects on Prob[Y = 4]
 YEAR        .5157831156      .37316459    1.382   .1669     1.0000000
 AGE      -.1433801221E-01  .75869516E-02   -1.890   .0588     38.509091
 FMSIZE    .9869366033E-02  .12003869E-01     .822   .4110     8.0545455
 ALTSOU      -.2549326896      .12788993   -1.993   .0462     .53636364
 HFS       .6315390628E-01      .34794539     .182   .8560     .69363636
 CPUE      .2025766296E-01  .16083810E-01    1.260   .2078     6.1634455
 EXTCON    .3193981758E-01      .12874068     .248   .8041     .47272727
(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)
```