Catch Efficiency of Some Fishing Gears in the Lower Benue River, Nigeria

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ABSTRACT

The Benue River fishery is yet to be investigated beyond frame surveys and hence the need to assess the catch efficiency of operational gears that exploit the resources with a view to predicting its status. The Lower Benue River was sampled at the Abinsi and Makurdi fishing ground on longitudes 7^o 47'N and 6^{o}48'E for 12 months. Sampling started in July 2010 and ended in June 2011. Four fishing gears (castnet, dragnet, gill set net and hook and line) were assessed for their efficiency. A total of 5,853 specimens from 88 species in 22 families were caught. Castnet had the highest catch for both dry seasons (25%) and wet seasons (22.6%), drag net ranked second with 22.8% and 10.87%, gill net (2cm-5cm) ranked third and recorded higher catches in the wet season (7%), than the dry season (6.6%). Hook and line that was ranked least also recorded higher catches in wet season (3.2%) than in dry seasons1.8%. Individual species that constituted up to 5% of the total catch for each gear in any particular season were considered as highly selective for it and are used to compare efficiency among the gears. Twenty three (23) species were recorded in these categories. They included *Alestes baremose, Tilapia zillii, Brycinus nurse, Synodontis clarias, Citharinus citharus, Lates niloticus, Mormyrus rume, Hepsetus odoe, Hermichromis bimaculatus, Heterobranchus bidorsalis, Bagrus filamentosus, Mormyrops angulloides, Mormyrops macrophthalmus, Auchinoglanis occidentalis Hydrocynus brevis, Synodontis courteti and labeo coubie*. The most dominant species in numbers included *Tilapia zilii* (413), *Alestes baremose* (405), *Synodontis clarias* (309), *Lates niloticus* (237), *Synodontis batensoda* (230), *Hydrocynus brevis* (206). Species with the highest biomass (wt in kg) included *Labeo cubie* (107.3kg) *Lates niloticus* (89.5kg), *Hydrocynus brevis* (67.3kg), *Alestes baremose* (60.4kg) and *Hepsotus ode* (59.1kg). The longest lengths and highest weights were observed in *Labeo cubie* (71cm and 8.5kg), and were caught by dragnet, next were *Hydrocynus brevies* (61cm and 4.5kg), caught by gill net and *Bagrus filamentosus* (61cm and 2.3kg) and caught by dragnet. The seasonality of the gears showed that castnet and gill net were all season gears but with some limitations. Dragnet was more effective in dry season but its present operational conditions does not favour resource conservation concept. The most efficient gears in the wet seasons were the gill net and hook and line which recorded low catches but caught bigger species with higher biomass (high commercial value). Water parameters were observed and the average depth of the river was 11M. The velocity of water recorded ranged between 25 and 35 m/minute. Other mean water parameters recorded were dissolved oxygen 7.9±0.49 mg/l, temperature 25 ± 2.06(^{o}C) and turbidity 51.0 ±2.0. (cm). Among the water parameters recorded, only temperature and turbidity showed significance difference in the different seasons. DO showed significance difference in relationship to fish distribution in the dry season $p<0.5$. The parameters indicated that the river water was at optimal conditions for high productivity. The ongoing human activities (as observed) are enhancing aquatic ecosystem degradation via land development which does not support fish productivity. There is need for the enforcement of existing regularity laws to check the trend. It is recommended that mesh sizes of fishing nets below 2cm should be restricted for use in the area especially for cast and Drag nets. There is need for constant monitoring of the fishing activities and the hydrographic parameters in the area.

DECLARATION

I hereby declare that this dissertation represents my original field work and has not been previously submitted elsewhere or in this University for an award of Master of Science (M.Sc.) or any other degree.

Name: IORCHOR Simon Iorer,

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Date: -----------------------------

CERTIFICATION

We the undersigned certify that this work was carried out by IORCHOR, Simon Iorer (PG.2008/00085) under the supervision of Dr. S.N. Deekae and Dr. A. D. I. George in the Department of Fisheries and Aquatic Environment, Faculty of Agriculture of the Rivers State University of Science and Technology, Nkpolu-Oroworukwo, Port Harcourt, in partial fulfillment of the requirements for the award of Master of Science (MSc) Degree in Fisheries Biology and Management.

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DEDICATION

This work is dedicated to my late mother Mrs. Avese Iorchor who laid the foundation for my educational career.

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CHAPTER 1

INTRODUCTION

The Benue River is the major tributary of the Niger River. The river is approximately 1,400 km long and is almost entirely navigable during the wet season between the months of August and February and so it serve as transportation route in the regions through which it flows. It rises in the Adamawa Plateau of northern Cameroon, from where it flows west, and through the town of Garoua and Lagdo Reservoir, into Nigeria south of the Mandara-mountains, and through Jimeta, Ibi and Makurdi before meeting the Niger at Lokoja. Apart from being an important water route, it is also one of the major fishing areas in Nigeria and several fishing gears are used along this river (Reid and Sydenham, 1979).

Fishing gear deals with the equipment and techniques (methods) employed in the exploitation of the fisheries resources of the inland, brackish, coastal waters and high seas (FAO, 1990). Fisheries resources are nothing but shellfishes (shrimps, crabs, mollusks etc.) and fin fishes (Tilapia, Sharks, Mullets, rays, groupers, cat fishes etc.) Many factors play in the choice of methods used to catch particular species in a particular area. Principally, the choice is dependent on some factors, which may include the target species of fish, its habitat and biology, the depth of water and the characteristics of the fishing ground (type of substratum) as well as individual value of the species as regards consumer preference.

Fishing has direct effects on the population of target species but can also affect non-target species and their habitats (Hamley 1973, Craig 1993). Benthic organisms are caught as by-catch, suffering pressure changes, air exposure, crushing by inert or biotic material leading to low survival rates even if discarded back into the sea. Additionally, benthic organisms are often directly damaged or killed by the physical impact of the fishing gear while it is towed across the sea floor. The amount of damage a fishing gear causes can vary considerably depending on its design and operational deployment (Collie *et al*., 2000, Kaiser *et al*., 2006). Furthermore the amount of damage to benthic biota depends on its faunal composition and its respective susceptibility to this type of physical disturbance (Kaiser *et al*., 2006).

Efficiency (or effectiveness) is commonly expressed in terms of numbers or mass of fish captured by a fishing gear in a unit of time. Efficiency tries to express or quantify the effort, time and resource input in relation to catch output and the selectivity of that fishing gear. Selectivity is the capacity of any method or gear type to capture certain fractions or sections of the fish population whether grouped by species, age, size or behaviour, and to exclude others (King, 1995).

In recent years there has been a growing focus on "ecosystem effects of fisheries", addressing the impact of fishing operations not only on the target species, but also on by-catch of or other effects on non-commercial species or habitats. Energy efficiency, reduced pollution and improved quality of the catch are also important aspects related to fishing gears and fishing operations as highlighted in the "Code of Conduct for Responsible Fisheries, Article 7.2.2" (FAO, 1992). From a situation where the development of fishing gears and methods only focused on the highest possible catching efficiency for the target species, now fisheries research, fisheries management and the fishing industry are challenged to develop gear, methods and regulations that meet the different considerations mentioned above. This is part of an emerging ecosystem approach to fisheries management and in the process of moving towards sustainable fisheries management, different fishing gears with their specific properties and potential for improvement are an important compartment in the "fisheries manager's toolbox". A basic understanding of the properties, function and operation of the major fishing gears and methods is therefore fundamental for decision-making in fisheries management, particularly when it comes to technical measures in fisheries regulations.

Efficient fishing refers to a fishing method with the ability to target and capture organisms by size and species during the fishing operation allowing non-targets to be avoided or released unharmed as well as save time, energy and resources. In a fishing area, a range of fish and other species with varying sizes normally occur together so when encountered with fishing gear and may be captured at different rates, depending on the gear design and its mode of operation (Methven and Schneider, 1998). Various gears are more efficient in this regard than others but no one gear is one hundred percent efficient (Hinz *et al.,* 2009). So many fishing gears are operational in Nigeria's marine, brackish and fresh water bodies. These may include trawl and seine nets in the commercial fisheries, gill net, cast net, dragnets, hook and line and many other traps as well as wounding gears supported by various crafts in the artisanal fisheries sector (Moses, 1990).

Net and hook gears have been used throughout history and, before the industrial revolution, were the main methods of fish capture. In modern fisheries, their importance is overshadowed by various bag-type gears, such as towed gears (trawls and seines) or encircling gears (purse seines). However, gillnets and longlines have some advantages and are therefore still popular in a number of fisheries; for example, they are cheap to purchase and use (Dufeu, 1995). They are also technologically simple, easy to mend and require little maintenance as compared to the equipment on board the vessels used for the fisheries. The gears may be set in areas with difficult bottom conditions, as are often found around coral reefs, in coastal rocky areas or in fresh water bodies were towed gears cannot be used. For these reasons, gillnets and longlines are commonly used in a number of artisanal fisheries from the tropics to the arctic. Gillnets and longlines are also found to be economically advantageous in those fisheries targeting large and expensive fish species that are relatively thinly distributed. Being passive gears, the energy consumption is generally low implying an environmental advantage compared to the more energy consuming fisheries using towed gears (Garner, 1977).

Tejerina – Garro and Merona (2001) described a gillnet as a series of netting attached between a head-rope and a foot-rope, that is kept open vertically by the differences in buoyancy between the two ropes. The head-rope is given positive buoyancy by using various floating devices. In shallow waters, floating is typically applied by attachable cork or styrene floats or by using head-ropes where styrene is embedded in the rope. For deep-water fisheries, hollow metal or hard plastic rings are used to provide buoyancy. Weight is most simply applied to the foot-rope by embedding lead into the rope but may also be applied by using various sinkers (e.g. metal rings). In regulating the net's overall buoyancy, gillnets may be designed to float (used for pelagic fishes e.g. tuna, salmon or small pelagic fish) or to stand at the bottom (used for demersal species e.g. cod, flatfish). In ordinary gillnets the netting consists of a single net sheet. In trammel nets the net is constructed by joining three parallel sheets of netting where the two outer sheets are made of netting with large mesh and the inner sheet with small mesh (FAO, 1990).

Gillnets are very efficient in fish size selection because a specific mesh size tends to catch fish of a limited size range. The mesh size may therefore be considered the most important characteristic of gillnet while mesh sizes are either given in bar length (i.e. measured from knot-to-knot) or as stretched mesh (i.e. the sum of two bars). The bar length measure is often used by commercial fishers and by net manufacturers. The stretched mesh measure is normally, used in scientific literature and is used in this work (Hamley and Skud, 1980).

Gill net and drag net have the same basic design. The difference lies in the modification for active and passive operations. Gill net is left suspended in water either stationary or drifting and the principle of catch is dependent on fish movement for entangling and gilling. It is mainly, operated by one fisher and the stationary nets are best suited for uncleared water bodies. Poles (steel or wooden) or head and foot ropes may be enlongated in dragnet to permit for active dragging. It is usually operated by two men. In the same manner larger nets are operated by groups of up to eight or more fishers. They are used in rivers from banks, beaches and swamps.

Cast Net is a conically shaped net that is constructed by tapering the webbing material in a trapezoidal form. Two tapered cuttings are joined, to form a cone shaped bag. A head rope is then lined at the beginning. Weights are also attached to the rope. The design is such that it forms an open circle when it throws open. One needs great skill to operate the gear. Cast net is an active fishing gear that captures fish by encircling when it throws open and the weights sink to close at the base. The attached rope is used to pull the catch out of water. It is operated with canoe and at steep gradient of the river banks.

Hook and line **:** A longline consists of a groundline (also called mainline) supplied with gangions (also called snoods) carrying baited or unbaited hooks. The groundline is typically made of various synthetic materials typically of a diameter 0.5–1 cm, while the gangions are thinner. The length of gangions and their spacing differ considerably depending on the fisheries. The buoyancy of the materials used determines whether the longline is to float at the surface or to dwell near the bottom. Hooks are manufactured in extensive numbers of models and sizes. Quinn *et al.* (1985) remarks that the number of models exceed the number of fish species generally. One may distinguish between traditional J-shaped hooks and more modern circle shaped hooks introduced in the late 1970s. The size of hook may be described by linear measures namely the shank length and gape width (the distance between the end point and the shank (Takeuchi and Koike 1969, Cortez-Zaragoza *et al.* 1989) or by squared distance measures in the form of the product of width and length (Ralston 1982, Otway and Craig 1993). The gape-width measure normally relates to the size of the fish mouth. Commercially used hooks vary considerably in size, ranging in gape-width from less than 0.5 cm to more than 10 cm. The bait is believed to be the single most important factor determining the catch efficiency of longlines. The bait is a priori selected for its attracting properties (e.g. freshness, fatness) and for its mechanical properties (i.e. ease of baiting and durability in water). Wide variations in types and sizes of baits are used in the various commercial line fisheries.

For stock monitoring purposes, gillnets and longlines share the virtue of being deployable in areas with difficult bottoms, which cannot be covered by trawl surveys. Gillnets are typically used as a survey gear in fresh water bodies, but both gears may also be useful for covering various marine areas, e.g. coastal habitats and very deep waters. Both gear types suffer from being potentially saturated as the number of available catching sites (meshes or hooks) may decline during the fishing operation. Being passive gears deployed for several hours also implies that fishing station allocations will typically differ from those used in trawl surveys (Brandt, 1972). Understanding the size, species-selectivity and efficiency of a fishing gear is fundamental to interpreting catch data accurately, determining the size structure of fish populations, and assessing the effects of fishing on exploited stocks (Hamley, 1975; Kirkwood and Walker, 1989; Millar and Fryer, 1999).

It is pertinent to also note that catch and abundance of fish in an area is affected by some number of factors such as Physico-chemical parameters, season, efficiency of gears used and the nature of environment in question. It is also of interest to note that the catch rate under normal circumstances depends on the factors such as size, species type and the efficiency of the gear used. It is on this understanding that the Physico-chemical parameters and the type of fishing gear used in the area, is put into consideration. According to Boyd (1979), maintaining optimum water quality means keeping the water at an optimum for the physiological requirements of aquatic species, precisely, fish and plankton.

Justification

Reed *et al*, (1967), described the fisheries of Northern Nigeria including the Benue River. Reid and Sydenham (1979), provided a checklist; Ita,(1993), discussed the fisheries resources and Marie *et al.,* (2001) discussed the river system, while Okayi *et al.,* (2001) and (2005) assessed seasonal patterns in Zooplankton and metal concentration in fish. Obande *et al.,* (2010) provided a checklist of some efficient fishing gears in the Lower Benue River but was more specific about their nomenclature. The National Institute for Fresh Water Fisheries (NIFFRI) (2002) considered four of the following fishing gears; gill net, dragnet, castnet and hook and line, among several other fishing gears to be the most commonly operated in Nigerian fisheries. The assessment for efficiency of these gears as operated in the Benue River is yet to be carried out. The findings from this work will contribute to the understanding of the principles of gear operation (efficiency and seasonality) and their effect on the Benue River fisheries. It will also enhance the fishing regulatory and conservative laws of the federal, state and local governments.

Objectives

The general objective of this project is to determine the efficiency of four fishing gears; gill net, drag net, cast net and hook and line in the Benue River. The specific objectives are to;

(i). Determine the relative catch efficiency among the gears in the Benue River

(ii). Determine the availability and spatial distribution of fish resources harvested by the artisanal fishers in the area

(iii). Determine the effect of seasonality on the gears and fish abundance

(iv) . Investigate some of the Physico-chemical parameters of the Benue River

CHAPTER 2

LITERATURE REVIEW

2.1 Gear Efficiency and Fish Stock Assessment

Generally, technical efficiency is defined 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) (Kumbhakar and Lovell, 2000). Newman *et al.,* (2012) stated that technical efficiency, its measurement, and the factors determining it are of 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 it allows stakeholders to take measures to limit or improve it.

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, 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 it by expanding these inputs or by taking measures that properly define the property rights of the fishery. The efficiency of fishing gears is an important tool in fisheries management. According to Balik *et al* (2001), gillnets are used widely in the coastal and inland fisheries of the world because of their versatility, low cost, and ease of operation. Thus, these gears are important in inland fisheries and the efficiency of these net types are influenced by mesh size, exposed net area, floatation, mesh shape and hanging ratios, visibility and type of netting material in relation with stiffness, and breaking strength. Knowledge of the efficiency of gillnets is important for the reconstruction of the fish population (Machiels *et al*., 1994).

The efficiency of fishing gears (nets, traps, hook and line) are very important as they employ large numbers of fishers and take a significant proportion of the total catch. The gear selectivity in these fisheries and their impact on stocks needs to be understood. Due to the pronounced size selectivity of gillnets, surveyors normally use different mesh-size nets concurrently, typically deployed as ‘gangs’ of short sections tied together. However, special multi-mesh research nets, whereby the nets of different mesh-size are mounted on the same head and foot rope, are also available (Kurkilahti and Rask, 1996). In fresh water research, mesh sizes ranging from one cm upward are commonly in use enabling a large range of fish sizes to be caught.

Although longlines and gillnets may be considered as simple gears their fishing performance can be considerably modified by varying a number of parameters. Hamley (1975), states that the researchers use the technologies applied by the local commercial fishers. The fishermen have usually accumulated and adopted a considerable amount of experience and are therefore usually up-to-date with technical development (Newman et al., 2012).

Fishers optimise their behaviour to achieve goals that differ from those of a researcher. For instance, gillnets and longline will most often be used for targeting relatively large individuals. Hovgård (1996) and Erzini *et al.* (1996) note that applying large mesh-sizes or hook-sizes as used in the commercial fisheries may impede the estimation of reliable selection curves. Also, with regard to the costs, durability and the ease of work differences may be found between fishermen and researchers.

2.2 The major parameters of gillnet

A net may be rigged with varying degrees of slack, which is primarily regulated by the hanging ratio. The hanging ratio measures how tightly the net is stretched along the head and foot rope. The hanging ratio may theoretically vary between the value 0.1 (all meshes mounted at the same point on the ropes, so the net has no length dimension) and a value of 1.0mm (the netting is fully stretched out, so the net has no height dimension. In commercial fisheries, hanging ratios are normally found between 0.25 and 0.65mm. Slackness may also be introduced by vertical snoods between the head and foot ropes (Machiels *et al.* (1994), states that they are more efficient in cleared areas.

2.2.1 Colour of Netting

Gillnets are marketed in a variety of colours and shades and individual fishermen often show strong preferences for certain colours. Balik and Cubuk (2001), compared the efficiency of gillnet with varied coloration in Lake Beysehir in Turkey. Despite the individual variations a general trend is often observed. In the Danish fisheries, for instance, orange coloured nets dominate in the Baltic Sea whereas grey or green nets are preferred for the North Sea fisheries. The efficiencies of different colours also show seasonal differences in fish catch (Jester 1973).

Wardle *et al.* (1991) discussed the visibility of monofilament nets from a physical perspective and show interesting patterns regarding the importance of object orientation in water as well as the differences in reflection in air and water. They further inferred that the visibility of nets depends on both the water colour and the colour of the seabed. Cui *et al.* (1991) used light intensity thresholds as an indicator of the fishing power of different coloured nets by comparing mackerel (*Scomber scombrus*) behaviour towards different coloured twine. Considerable differences in colour detection thresholds were observed for both a thin monofile thread and a thicker multifilament thread.

2.2.2 Dimensions of Netting Material

It is a well-known fact to fishermen and net manufacturers that nets constructed of thinner twine catch considerably more fish than nets made of coarser materials Hovgård (1996). Fishers usually attribute the higher fishing power of finer nets to these nets being 'softer'. The available experimental information suggests that the effect of twine thickness is found for all materials, i.e. multifilament, monofilament (Jensen 1995 and Hovgård 1996).

Baranov (1948) explained that twine dimensions could be related to fishing power. The choice of dimensions of netting material implies a trade-off between fishing power and net durability as nets made of fine, materials are more easily damaged (Hovgård 1996). In commercial fisheries, durability and ease of handling are often the main arguments to use relatively coarse netting materials. In research, where the cost associated with net damage is typically low compared to vessel and crew costs, it may generally be suggested to use nets of finer material than those used commercially (Wardle *et al* 1991).

2.2.3 Types of Netting Material and Design

Fishers have clear notions of the importance of the material type where considerations are given to both catch performance and physical attributes. Multifilament nets (MF) are considered to be the least efficient while at the same time being the strongest. Multi-monofilament nets (MM) are generally considered to be the most efficient as the use of thin parallel threads make the net more 'soft' than the monofilament (MO) or multifilament (MF) nets (Jensen 1995). A stated draw-back of multifilament nets is the higher tendency for entangling various unwanted by-catches, e.g. crabs or starfish, which may considerably slow down the cleaning process (Baranov1948). The different qualities of the netting materials often led to clear patterns in their use. The mesh sizes included in net series used for stock surveying should be selected to enable full coverage of the potential size distribution of fish that may be encountered. This may imply using a high number of different mesh-sizes, more than 10 mesh-sizes are often used (Degerman, *et al.* 1992; Henderson, 1992). The catches in mesh sizes matching the most abundant size groups may be high whereas other mesh sizes (mainly the larger mesh) may catch fewer fish.

2.3.1 Hook and Line

In hook-and-line fishing, a hook is fixed to a line only or to a line attached to a pole. Many hooks are fixed to many secondary lines (snoods) and are attached to the main line. The longlines include the set longlines and the drifting longlines, which are used in the coastal waters, rivers, lakes and creeks. Solarin (2003) states that efficiency depends on size (hooks vary in size and are numbered from 1 to 20, with No. 20 being the smallest), quantity and shape of bait (artificial lure or natural bait), soak time and other factors. A positive correlation obtains between hook and fish size. Efficiency is also highly associated with the feeding pattern of the fish and the type of food as well as seasonal and diurnal variations in feeding behaviour. Hooking without bait also occurs when the fish get hooked by their scales, gills, fins or other appendages. Hausa fishermen use unbaited bottom-set *marimari* or *mamari* longlines to catch soft and scaleless fish such as *Clarias* spp (Solarin 2003).

Hooks may be differentiated by a multitude of parameters such as their general form (various models of both the traditional J-shaped and modern circle-shaped hooks). Their sizes are measured by gape width, shank length and wire dimension; material (examples like iron, stainless steel); the shape of the point (those with/without barb, the way an edge may be cut); the form of the eye (on a loop or a flat plate) and finishing like colour and coating. Hooks are often also available in flat and twisted models. Special shapes of hooks have been constructed to comply with the different storage and baiting devices used in the various automated line systems introduced in the last few decades. The number of different hook types appears to be very large. The traditional 'J' shape hooks have in many fisheries been changed to 'semi-circle' hooks. The semi-circle hook has proven to be clearly superior to the traditional 'J' shaped hooks in a number of fisheries (Forster 1973, Skeide *et al*. 1986, Quinn *et al*. 1985). Bjordal (1989) infers that the higher fishing power of the semi-circle hook designs are caused by both a higher hooking efficiency and a lower level of escapement of hooked fish. The higher hooking efficiency of the semi-circle hooks has been related to the pull exerted by a caught fish as being directly in the direction of the hook eye.

The size of the hook will influence its efficiency and selective properties. The choice of hook size and the targeted fish is important with respect to the breaking strength of such hook. Erzini *et al* (1996) however observed that a high number of hook experiments showed decreased catch efficiency with increased hook size because hooks made of small wire diameter could easily penetrate the fish mouth tissue than did coarser hook wire.

Most fishers consider bait probably the most important single factor for enhancing longline catches and they often have good experience as to what kind of bait is particularly suited to their target fishery. However, bait is a very significant cost component in many longline fisheries and the actual choice of bait is therefore often a trade-off between bait quality and cost. In some fisheries, it is customary to use a less valuable bycatch species for bait. The attractiveness of bait has been related to bait quality. For instance, pre-soaked bait, where attractants have been washed out, have shown a poorer catching performance than fresh bait (Løkkeborg and Johannessen, 1992).

2.3.2 Line Materials

In traditional longlines the main line and the gangions were made of various types of multifilament ropes (nylon, polyester, polypropylene). The main line is typically of a diameter of 4–12 mm whereas the gangions are considerably thinner. In several longline fisheries, transparent monofile lines have replaced the traditional materials, which has typically lead to increased catches. The monofile line is stronger allowing the lines to have a thinner diameter. The higher efficiency of the monofile lines may at least partly be due to the lower visibility of the thin monofile line. Bjordal (1983) found that catch rates were 10–20% higher when traditional multifilament gangions were replaced by monofile gangions. As the buoyancy of line materials differs, the choice of materials allows the setting of lines at various distances from the bottom or the surface. Moving a demersal line just off bottom or a pelagic line well below the surface provides a simple mechanism for reducing the bait loss caused by sessile scavengers or birds respectively.

2.3.3 Gangion Attachment

The spacing between gangions differs considerably in commercial fisheries depending on the species targeted. High spacing is typically applied in fisheries targeting large and valuable species found in relatively low densities (e.g. tuna, salmon and halibut). In these fisheries gangion distances are typically 10 and 50m (Skud 1978). Much lower distances are used in fisheries targeting mixtures of smaller species. A typical distance in North Atlantic fisheries of this kind is about one fathom (1.8 m). Hamley and Skud (1980) found that the catch per hook increased with increasing gangion spacing, which may be interpreted as due to a larger area being affected by the odour plume from the bait when hooks are well spaced. The importance of gangion length and attachment has been evaluated in various Norwegian experiments. Karlsen (1976) found a considerable reduction in catches of tusk and ling when gangion was shortened in length from the conventional 40 cm to 15 cm. Bjordal (1987) noted that attaching gangions to the main line by swivels, instead of the conventional attachment by a knot, increased catches by about 15%.

2.3.4 Recent Improvements in Long line Technology

Major improvements in longline technology have occurred in recent years. Sainsbury (1996) summarises the potential improvements in catch rates as: change of the conventional 'J' shaped hook to the circle hooks 15–20%; use of monofile material for gangions 10% and attaching gangions by swivels 15–20%. If longlines are to be part of ongoing stock surveillance programmes consideration should be given to equipping research vessels with mechanised line setting systems. In Greenland this has allowed the daily survey effort to be increased four-fold in abundance surveys for Greenland Halibut. The researchers should also consider using other bait than that used in the commercial fisheries as the commercial bait-choice may be based on some trade-off between efficiency and cost.

Løkkeborg and Bjordal (1992), observed the importance of hook size and that of bait. Otway and Craig (1993) stressed the need for standardising bait size. Punt *et al.* (1996) also reported the confusing effects between hook and bait sizes and noted that hook and bait size are usually correlated in commercial fisheries. They therefore implicitly treat the hook-bait combination as one entity.

2.4 Gill-net Efficiency and Fish Abundance

Argent *et al* (2005) assessed the efficiency of gill net and his studies indicated that gill-net efficiency varies with mesh size and material, fish morphology and sampling period. Therefore, the efficiency of gill netting must be understood to be used to sample target fish communities (TFCs) as part of a temporal monitoring program. Elliott and Fletcher (2001); Colvin (2002) observed that most existing studies focus on comparisons among gear types (e.g., gill netting versus other gears) rather than efficiency within a specific gill-net mesh size

Some studies on gill net and other gear efficiency (especially in African fisheries) have been conducted. Sætersdal (1963), Hopson (1968) during their studies in Lake Chad observed the high efficiency and selectivity of gill-net and reported that gill net catches all kinds of fish species. Vanderpuye (1973) sampled the upper Volta Lake for two and a half years with various mesh sizes of gill net ranging from 13mm with a view to establishing the most appropriate mesh sizes to enhance the development of the fishery. That study observed that Clupeids comprised an average of 77% of the gill net catches yielding 2,149.14kg. Nets with mesh size of 13mm, which caught 97% by number and 86% of the weight of all clupeids was reported to be the most efficient. Abowei *et al* (2008) discussed gill net efficiency as one characteristic of Artisanal fisheries. Sagua and Otobo (1976) carried out an experimental fishing with mid-water trawl nets of different mesh sizes in Lake Kainji and reported a higher catch rate with 3mm mesh size nets. They further reported that fish catches of between 106 and 124kg/hr[1], were obtained with the 3mm cod end comprising more than 90% of the total fish caught. Fagade,(1979) reported gill net fisheries of Nigeria

Coastal waters in the Lagos lagoon and observed a high selectivity of the gill net, he however attributed it to the heterogeneous mesh sizes of the different panels of the nets used. Bankole (1990) studied gill net monitoring at Tiga and Jakara reservoirs in Kano State and noted that the most efficient mesh size was 9mm. Ita and Macliele, (1997) reported that large *Citharinus citharus* were caught in nets with 5 inches mesh sizes. That study reported that the general trend in fish caught with different mesh sizes showed a sharp decline in both number and total weight of fish caught with larger mesh sizes measuring 12mm to 21mm.

Alfred-Ockiya (1998) reported the gear selectivity in Kolo Creek (Niger delta) and observed that gill net had the highest catch (44.9%) followed by cast net (39.7%). The gill net's high selectivity was attributed to the morphometric projections and the presence of scales on most of the fishes. These projections made the fish more susceptible to be gilled in the net. Alfred-Ockiya (1998) used cast nets consisting of two panels of different mesh sizes (30mm and 40mm). He observed that gill nets and cast nets were used all year round whereas hooks and traps were used mostly in the wet season. The catch ability of a fish on a particular mesh size of gill net depends on the body girth of the fish, presence of fins (dorsal), spines, scales and teeth structure. Sikoki *et al* (1998) worked in the Nun River and recorded a total weight of 57.47kg and total number of 1457 fish caught. The highest catch in weight and number was recorded in nets with mesh sizes of 6mm and 7mm which accounted for 26.6%and 19.6%of the catch respectively. The lowest catch in terms of weight and number of fish caught was in nets with mesh sizes 1mm and 21mm accounting for 0.3% and

1.6%of the catch respectively. That study recommended a minimum mesh size of 7mm for sustainable exploitation of the fishery.

2.5 Fish Species Composition, Abundance and Distribution

Various studies on fish composition, abundance and distribution in different water bodies have been carried out. Reed *et al* (1967), reported on the occurrence of various species such as *Citharinus citharus, Distichodus rostratus, Schilbe mystus, Eutropius niloticus and Hemichromis fasciatus* in the northern parts of Nigeria. Lowe-Mc Lonnel (1987) recorded 44 species of fish in the Rupununi River. Imevbore and Okpo (1975) recorded 70 species in the Niger river while Reid *et al* (1979) recorded only 13 species in Odo Ona stream in Ibadan. Reid and Sydenham (1979) also recorded total no of 85 species in Ogun River and 120 species in the lower Benue River. Victor and Tetteh (1988) recorded 58 species in Ikpoba River, Benin, while Okereke (1990) in the study of Otamiri River in Imo State observed 46 species in 20 families and in Nworie River- Owerri, Imo State they recorded 19 species. In Bayelsa State, Alfred-Ockiya (1998) recorded 41 species belonging to 28 families in Kolo creek. Out of the 41 species encountered in his study, only four species were ranked abundant. These were *Schilbe mystus, Eutropius niloticus, Hemichromis fasciatus* and *Clarias gariepinnis*. Those ranked as common species were *Parachanna obscura, Tilapia spp, Lates niloticus, Citharinus citharus. Cynoglossus senegalensis and mugil cephalus* were observed towards Itokopiri end whose water is blackish during the dry season. Sikoki *et al*, (1998) recorded a total number of 38 species in their study of gill net selectivity and fish abundance in the lower Nun River. Davies (2009) assessed the fin fish assemblage of Okpoka creek also in the Niger Delta but information about the species composition and gear efficiency of the lower Benue River is yet to be documented.

2.6 Physico-Chemical Parameters

Physico-chemical parameters or variables refer to the characteristics or features of water affecting the survival, growth, reproduction, production and general management of aquatic organisms (Stickney and Robert (1979). Maintaining optimum water quality means keeping the water at an optimum for the physiological requirements of aquatic species, precisely, fish and plankton. Boyd (1982) also noted that physico-chemical parameters refer to all physical, biological and chemical variables affecting the desirability of water for any particular use. The physical and chemical factors include temperature, pH, salinity, alkalinity, dissolved oxygen and nutrient availability.

In the determination of water quality of any water body, physico-chemical parameters or water chemistry have been in use for years (USEPA, 2002, Adamus, 1996). The knowledge of the state of water quality of a water body in rivers and Creeks due to changes produced by human activities is usually the first step in establishing an efficient water management system which is essential for the preservation of the ecosystem (Douterelo *et al*, 2004).These parameters in detail include:

2.6.1 Turbidity

The sources of turbidity are the amount of solid materials in water resulting from erosion, runoff and algal blooms, although man may contribute to the presence of such materials. Turbidity in water bodies may be attributed to wind and erosion sweeping sediments from land into the continental shelf or any part of the water preventing high penetration of light into the aquatic environment thus reducing productivity (Lucinda and Martin, 1999). A persistent clay turbidity restricting light penetration to 30cm or less would adversely decrease or reduce phytoplankton blooms and consequently fish production (Sikoki and Veen, 2004). High turbidity reduces photosynthesis of submerged rooted aquatic vegetation and algae which in turn reduces plant growth and fish productivity (McNeely *et al* 1979). Turbidity therefore affects aquatic biological communities. Boyd (1979) reported that it accelerates the rate at which water absorbs heat.

Pendergraft (2003) disclosed that rivers can be classified by appearance and clarity of water, for instance, brown or White Water Rivers carry a lot of sediments that make them look muddy while black water rivers are tea colored as they contain decaying dissolved organic matter (plant) that produces tannic acid. Clear water rivers are usually fed by spring and carries little sediments).According to Adirondack (2010) abundance and species composition of algae can have significant implications with regard to both the water clarity and quality of any given body

2.6.2 Water Temperature

It is pertinent to note that for every 10^0C rise in temperature the rate of reaction doubles i.e. the higher the temperature (above 10^0C), the higher the metabolic activities. The metabolism of cold blooded organisms (Poikilotherms) is dependent on temperature as well as the solubility of dissolved oxygen, the density and viscosity of the water. Therefore, the survival, growth and behaviour of aquatic organisms are dependent on temperature. Sikoki and Veen (2004) noted that fish and many other aquatic organisms grow best at temperatures between 25 – 32^0C especially in the tropic. Guy (1992) also reported that temperatures between 30 – 35^0C is tolerated by fish and many other aquatic organisms but above this range, aquatic life is threatened. The productivity of aquatic ecosystem in terms of phytoplankton density is dependent on the water temperature.

Water temperature depends on latitude, altitude and the mean daily number of sunshine hours. Spatial and temporal variations in air and water temperatures are governed mainly by the local climate conditions, volume of the water, the degree of exposure to sunlight and time of sampling (Ogbeibu and Victor, 1995). The sun is the primary source of energy on earth that brings solar energy to water bodies, which is absorbed to warm up the water mass. The low thermal conductivity of water restricts the heating to the upper layer. Turbid water increases more rapidly in temperature than non-turbid (transparent) water, regardless of whether turbidity is mineral or organic (Guy,1992). The effects of water temperature on fishes phytoplankton and other aquatic organisms have been studied in many freshwater ecosystems and it was found that water temperature regulates the seasonal variation of Phytoplankton (Richardson *et al* 2000) also light conditions could control phytoplankton growth.

2.6.3 Dissolved Oxygen (DO)

Oxygen is needed for all oxidation, nitrification and decomposition processes. Oxygen concentration is controlled by the four factors, photosynthesis, respiration, exchanges at the air – water inter face and supply of water to the pond (Erez, *et al* 1990).The photosynthetic activity aided by aquatic flora in the aquatic environment determine the concentration of oxygen in water, therefore, the higher the photosynthetic activity, the higher the oxygen dissolution and vice versa. Respiration by both heterotrophic and autotrophic organisms in the aquatic environment constantly leads to depletion of oxygen. Dissolved oxygen is determined in the laboratory using modified Winkler l and ll through titrimetric method.

The quantity of oxygen dissolving in water depends on atmospheric pressure and on the partial pressure of oxygen in contact with the surface water. Between the two media, equilibrium is established which is responsible for exchange of oxygen between air and water according to the degree of saturation of the water (Guy 1992). Transfer at the interface is proportional to the ratio of saturation level to concentration, to the surface area of contact, and to the transfer coefficient. Decomposition of organic matter in the aquatic environment aided by the activities of saprophytes consumes oxygen (Scurlock *et al* 2002). Chindah (2003) observed higher dissolved oxygen (DO) value in dry season than wet season in New Calabar River which could be due to anthropogenic inputs which conforms to the finding of Okpokwasili (1996) but contrasting to Otobo (1995).

Onuoha (2010) observed high dissolved oxygen levels throughout the period of study in Ologe lagoon, though comparatively higher in the wet season than the dry season which was attributed to heavy influx of freshwater from adjoining rivers and Creeks and lower temperature. It is possible that higher primary productivity which resulted in higher chlorophyll *a* values during the dry season, did not reveal a similar trend in dissolved oxygen values, as a result of masking of high dissolved oxygen by higher biochemical oxygen demand and higher temperature during this period.

2.6.4 Hydrogen Ion Concentration (pH)

pH is a general measure whose value is determined by a number of processes occurring in the aquatic environment. It values has a scale range of 1-14 with neutrality at 7-0, pH measure of 1-5.5 is considered acidic and the measure from 9 – 14 is alkaline. The optimum pH for fish growth is 6.5 – 9.0. It affects the general metabolic activities of organisms. pH values below 4 and above 11 are lethal for most fishes and other aquatic organisms such as planktonic algae, macrophytes and among others. Boyd and Lichtkoppler (1979) reported that pH of a water body rises during the day and decreases at night due to the removal of carbon (1V) oxide by aquatic plants during photosynthesis. The optimum pH values range between 6.5 and 8.The productivity of aquatic ecosystem is affected by the pH of the water.

In natural water pH value ranges from between 4 to 9. Swamp waters having lower and inland water passing through limestone deposits have higher pH values. In fresh water lakes pH range is from 6 to 9 and most of them are bicarbonate-type lakes (Wetzel, 1983). However, Kaftar Lake with 7.47 to 9.46 pH value can be categorized as a bicarbonate-type lake as well (Norwrouzi andValazi, 2011).

2.6.5 Water Depth

The depth of a water body affects the quantity of light penetration which also affects the primary productivity. It is therefore clear that the primary productivity of an aquatic ecosystem is a function of the light energy received and is also dependent on the depth of the water. The depth of the water is thus in principle negatively correlated to the rate of production which among many other things depend on the supply of nutrient from outside and on their recycling through the system. In most lakes, especially the shallow ones, the immediate source of nutrients is from recycling. The more frequently a lake is stirred by wind to the bottom the faster the nutrients are recycled from the mud into the photo zone where they may accelerate the rate of primary production.

Water depth is measured with line and sinker and expressed in metres. The line and the sinker are thrown into the water bed and the depth is determined using either metre rule or tape (calibrated). It is of importance to note that water depth affect the ecological distribution and migration of aquatic organisms especially fishes and plankton. Distribution according to APHA (1998) is determined by water depth, shore line activity and sediment type. Ockiya (1998) reports that depth of Nun river was significantly higher at the peak of the flood season in early October but no significant difference occurred during the normal dry season period

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

The lower Benue River as defined by Reid and Sydenham (1979) as the Benue River Basin downstream of the faro Benue confluence, an area, which is contained within the Federal Republic of Nigeria. The study was carried out at three stations namely; (i) Head bridge, (ii) Agbaaye and (iii) Abinsi on the stretch between Makurdi and Abinsi fishing ground on the coordinates; 8° 31'N and 7° 35'E (Figures 3.1). The lower Benue strongly flows through an extensive alluvial plain which stretch for many kilometers along the river route. The greater part of this plain is flooded during the rainy season and forms breeding ground for many fish species. At bank full, the area of the lower Benue is 129,000 hectares, but when flooded, this rises to 310,000 hectares. There can be as much as 25m difference between high and low water mark. The highest water levels are in August- September and the lowest are in March and April. At the upper reaches of the Benue River there is the Lake Chad connection which swells in the flood season when the Mayo kebbi (Benue) tributary captures the Logone River, which otherwise flows northwards to Lake Chad. The link ways are, interrupted in the dry season (January - May) when many tributaries of the lower Benue River are reduced to isolated pools and anatomizing channels which are not connected to the main river. The river's largest tributary is the Mayo Kébbi, which connects it with the Logone River during floods. Other tributaries are Taraba River, Donga and Katsina-Ala Rivers.

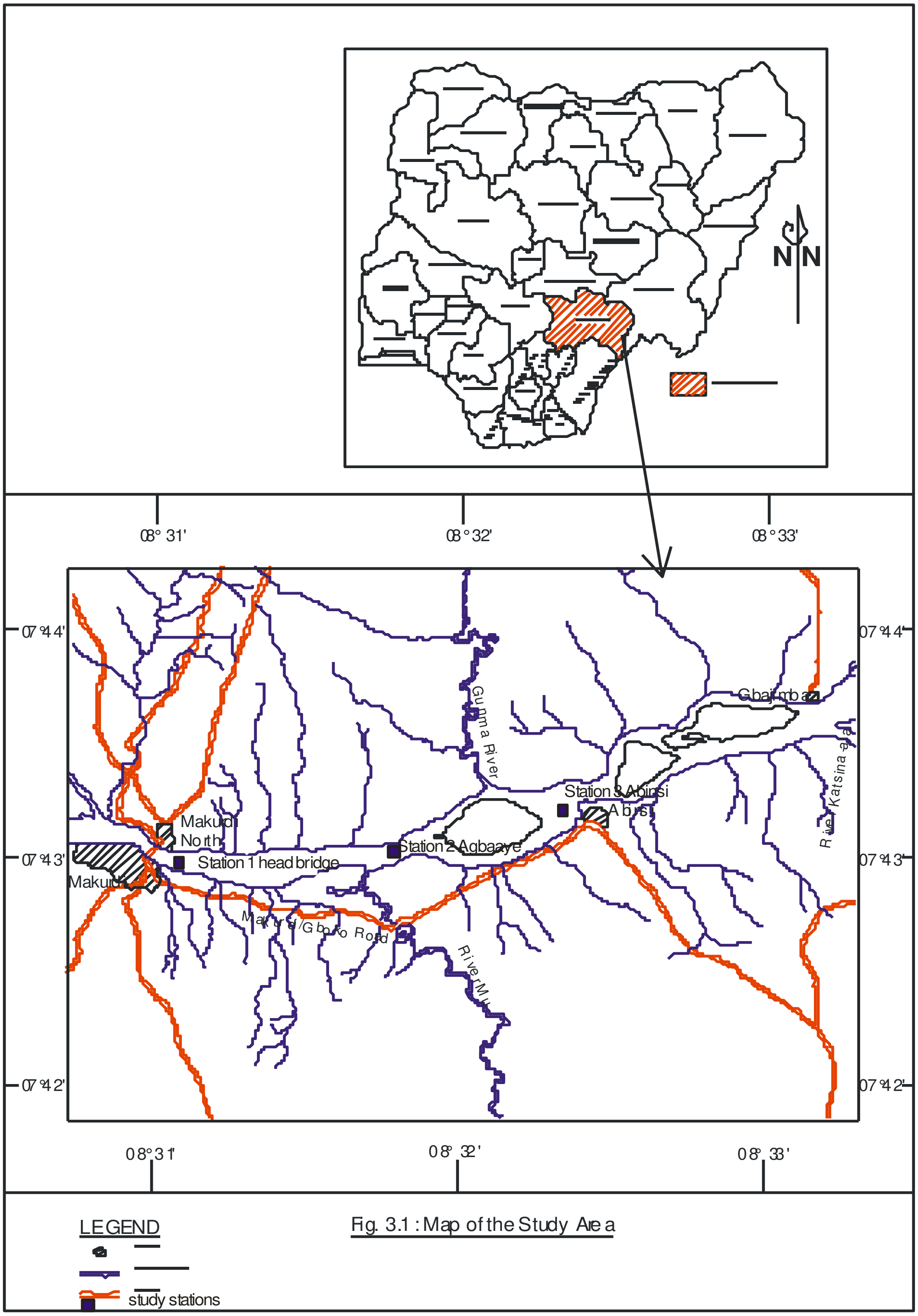


Fig. 3.1 : Map of the Study Area

3.2. Fish Sampling

Fish specimens were collected with the assistance of the fishers operating in the study area. The researcher accompanied the fishers on their fishing trips to observe the setting and operation of these gears two days in a month for twelve months (one year), after which each of their catches were sampled. The 12 months comprised of two seasons (dry and wet seasons), dry season begins from December and end in May while the wet season is from June to November. Gill net and hooks and line were usually set in the evening and retrieved the following morning for fish collection. Cast net and Drag net were actively operated any time of the day. Specimens were collected through purchase and personal donations from the fishers. A motorized wooden canoe was the main navigational craft for the field operations.

3.3. Assessment of Gear

The common gears in operation were observed based on the following parameters; lengths, depths (Cast, Gill net and Dragnets), and sizes for hooks and meshes of nets. Setting, retrieval and active operation of the gears were also noted. Fish caught by individual gears were recorded and fishers were identified by personal communication and in few cases catch per individual effort was noted. Materials used in constructing various gears were observed as well as the riparian vegetation of the river (Plates 3.1 to 3.4 below).

3.3.1 Material used for Gear Construction

The common gears (nets and hooks and line) observed in the Benue River were made of synthetic fibres and metal. The synthetic fibres included Nylon, Polypropylene (pp), polyethylene (PE) and Polyster. The twine sizes for Nylon, polypropylene and polyster twines ranged between $210D^2$ -^{120} ply while the PE twines mostly used for head and foot ropes were $380D^{2\text{-}120m}$. Nylon mono filaments within the sizes 0.25-2.1mm were also used. Hooks were made of metals (iron and steel) and those in common use were nos 17-1 .

3.3.2 Gear sizes

The mesh sizes for both, cast net, gill net and dragnets fall within the ranges of 4cm-32cm stretched meshes. Stretched cast nets mesh sizes were common in the ranges of 4cm – 8cm. Dragnets were mostly in the ranges of 4cm-18cm. Small mesh size below 2cm where observed and were mostly operated by children below 12year and older fishers above 65 years. The largest mesh sizes (Stretched) ranged between 20-32cm were recorded in the gill nets. Hooks were made of metal steel (mainly circle-shaped) with size range between No. 17 to 5 (small sizes – big sizes) were recorded.

3.4. Cast Net

Cast nets as observed, were designed such that the lead rope per net is tucked underneath and attached at intervals to the inner side of the net to form pockets for trapping fish. Cast nets are either operated from the shore or from a boat and they catch the fish by falling and closing in on them, their escape is prevented by the pockets as the closed fish is trapped in the pockets. These nets were mainly operated in shallow waters. Throwing a cast net requires a great skill such that it will fold in the form of a large circle and this cover the largest possible area. The nets are usually cast at random in depths of up to four metres. When fishing for certain species, the fisher remains poised at alert until the tell-tale whirl of a fish is seen. He then throws the net and encircles the exact spot. The fisher allows the net to sink to the bottom and to close on the fish, after which the net is retrieved with the aid of a line while the leads/sinkers close together thus capturing the fish (Plate 3.1).

3.5 Gill and Drag Nets

The common lengths and depths of Gill net observed ranged between 20x3m and 30x3m. Information obtained from the fishers showed that the cost per yard (1m) including head and footropes with floats and sinkers was between N400 and N550 depending on the filamentation (yarn count). The common floats observed were cut offs from rubber materials made by West African Rubber products (W A P as inscribed), other fishers used Styrofoam obtained from packaging materials. The sinkers were chiefly of aluminium and lead materials. Weights for anchoring were stones but sticks were also used in some cases. Most of the fishers purchase factory webbing material to construct the nets themselves.

Nets were not dyed in the area during the study period. Occasionally, they were washed with detergent to remove dirt and the greenish coating of the growth of algae due to long emersion in water and then exposed to the sun to dry. Under-water drifting wood that became trapped by the nets often caused some damage to the meshes which were then mended after the net had been dried. However, the operation of the different categories of Gill nets (surface-drift, mid-water-set and bottom set) were found to be seasonal in the study area. At the end of the operational season, they were finally dried in the sun and preserved till the next gill net fishing season. Interviews with the fishermen revealed that a gill net carefully used could last for 1½ - 2½ years depending on the frequency of usage and maintenance. Drag net has the same characteristics as gill net, the major difference among the two is the mode of operation, while the former is actively dragged along the bottom to trap fish, the later is set stationary and fish are caught by entangling themselves on contact with the gear (Plate 3.2).

3.6 Hook and line

The hooks and line observed (Plate 3.4) had their main lines made of nylon and consist of main lines and gangions. Spacing between gangions and their lengths differed according to the size of hook used and probably on individual choice. Closely spaced and short gangions were observed at low depths and edges of the river. The spacing between gagions was between 12cm and 24 cm with gagion lengths in the ranges of 8cm and 18cm for small hooks at low depths while in the bigger hooks, spacing between gagions was between 30 and 50cm with lengths of up to 40cm.

Plate 3.1 Cast Net Observed in the study Area

Plate 3.2 Gill net Observed in the Study Area

Plate 3.3 Drag net Observed in the Study Area

Plate 3.4 Hooks and line Observed in the Study Area

3.7 Water Parameters

The physical, chemical and biological water parameters in the sampled area were assessed using the standard methods as described in APHA (1998), where the required equipment was not available alternative means was devised to achieve it especially for the physical parameters.

3.7.1 Temperature

A mecury (Hg) in glass thermometer calibrated in degree celcius 0^o -100^oC was used in the determination of air and water temperature. The thermometer scale was read off for air temperature before dipping it in water. When immersed in the water column it was allowed to stand for 5 minutes and the reading was taken immediately it was removed. An average record was taken after taking three measurements.

3.7.2. Turbidity

To determine turbidity a Sechi disc of 40cm diameter attached to a measured rope (Calibrated in centimeters) was used. The disc was lowered into the water and reading was taken off the rope where it just disappeared and reappeared when raised. Average of three readings was taken as the measurement for turbidity. Since the centimeter calibration on the scale is based on Nephlemetric Turbidity Units (NTU), turbidity readings were taken in NTU.

3.7.3. Depth

Depth in the study area was measured using a weighted rope. It was lowered into the water until the weight settled on the bottom. Part of the rope just above the water surface was marked with a masking tape. The weight was retrieved and the length (distance between weight and the marked tape) of immersion was recorded. The average dept measurement was taken after three readings were made to ensure accuracy.

3.7.4 Current Velocity

In the absence of a current meter, the velocity of current flow was measured using a partially inflated nylon football, measuring tape, stopwatch and two wooden canoes. The two wooden canoes were held still at two points in the middle of flowing water (one at the upper end and the other at the lower end). A measuring tape was held between the two points. The football partially deflated to flow at water column was then released to flow towards the lower end. A stop watch was used to record time taken for the ball to reach the lower end while the measuring tape was used to determine distance of travel by the ball. After three readings were taken, an average record was obtained

3.7.5. Dissolved Oxygen (DO)

A fish farmer's water quality Test Kit: Model FF-1A Cat. No.2430-02, a product of Hach Company based in the United States of America containing the relevant chemical reagents was used based on the manual guide of the kit to determine the two chemical parameters. The procedure for analysis was as follows;

The glass-stoppered DO bottle was filled the water and allowed to overflow for three minutes. No air bubbles were allowed present in the bottle by inclining the bottle slightly and inserting the stopper with a quick thrust. The stopper was carefully removed from the bottle. One pillow each of Dissolved Oxygen 1 reagent and Dissolved Oxygen 2 reagents were added to the contents of the bottle. It was thoroughly shaked to mix properly. A flocculent precipitate was formed and it was allowed to settle. One Dissolved Oxygen 3 Powder Pillow was added to it and a yellowish colour developed. It was then filled in a measuring tube up to 5 ml. The 5ml content was carefully put in a mixing bottle, five droplets of sodium Thiosulfate (Standard Solution) were added drop by drop to the contents of the mixing bottle. The bottle was swirled while drops were added until the sample colour changed from yellow to neutral (each drop is equal to 1mg/L dissolved oxygen), the number of drops determine the concentration of dissolved oxygen (DO) in mg/l in the water.

3.7.6. Hydrogen ion concentration (pH)

The two colour viewing tubes from the kit were rinsed thoroughly and filled with 5ml of water to be tested. Six drops of wide range 4 pH indicator solution were added to the content in one of the tubes. The two tubes were inserted in a colour comparator and was then viewed against sunlight. The disc on the colour comparator was rotated to obtain a colour match. P^H range was then read off the colour that matched with the prepared solution.

3.8 Laboratory Activities

Samples collected (specimens of fish, water and gear) and most of the records obtained from on the spot assessments and observations were put together and moved to the laboratory for further analysis.

3.8.1 Efficiency of the Gears and Catch composition

Data on fish caught with the gears under this investigation in the lower Benue River (Hook and line, Cast net, Gill set and Seine nets) was analyzed, like; length and weight of individual fish caught and the common sizes of gears in operation were recorded as obtained. The composition for each gear were determined in the laboratory where length, weight of fishes, mesh sizes of nets and the number of size of hook gears were recorded, using a meter rule. Factory numbering of hook sizes is such that the larger the hooks the lower the figure.

3.8.2 Data analysis

Fish specimens caught, were identified using the keys provided by Reed *et al* 1967; Teugel *et al,* (1992), Olaosebikan and Aminu Raji (1998) and Idodo-Umeh, (2003). The length was measured in cm and the weight of each fish was weighed in gramms. Lengths and weights of the fish measured were grouped in to ranges and their means were obtained. Frequency analysis for species occurrence was determined using SPSS (Gamanilo, 1978). The FAO-ICLARM Stock assessment tools were used in predicting and estimating the maximum lengths from extreme values while FISAT was used to estimate the Powell-Wetheral plots of some fish species (Pauly, 1983).

CHAPTER 4

RESULTS

4.1 Fish Species Composition in Gear Catches

Individual fish species as caught by each gear during sampling are shown Table 4.1. Efficiency of the gear was determined by considering any fish that constituted up to 5% of its total catch since no gear is 100% efficient. 23 species of the fishes caught showed significant differenc in the percentage composition and were regarded as selective both in numbers and biomass, they include; *Alestes baremose*, *Auchenoglanis biscutatus, A. occidentalis, A.occidentalis, Bagrus bayad, Bagrus filamentosus, Brycinus nurse, Citharinus citharus, Clarias anguillaris, C. gariepinus, Clarotes laticeps, Hemichromis bimaculatus, Hepsetus odoe, Heterobranchus bidorsalis, Hydrocynus brevis, Labeo coubie, Lates niloticus, Mormyrops anguilloides, M. macrophthalmus, M. rume rume, Synodontis batensoda, S. clarias, S. courteti* and *Tilapia zillii.*

The number/spread of each species of fish caught within the above range were regarded as being selective for the gear. Species selectivity of each gear for the two seasons (Dry and Wet) are shown in Table 4.2 and Figures 4.1 to 4.4.

Cast net caught more fish in the dry season than in the wet season. *Synodontis clarias* was caught only in the wet season (Figure 4.1). It however caught different species in both seasons.

Dragnet caught more fish in the dry season than the wet season. Among the fishes caught only *Tilapia zillii* was caught in both seasons and *Hepsotus odoe* was caught only in the dry season (Figure 4.2).

Gill net caught more fish in the wet season and less in the dry season. Two species (*Hydrocynus brevis* and C*itharinus citharus*) were caught only in the wet season (figure 4.3).

Hook and line hook was also more efficient in the wet season. It caught eight (8) species in the wet season and only six (6) in the dry season and none of the species were caught in both seasons (Figure 4.4).

Table: 4.1 Fish Species composition and Efficiency of the Four Gears

Family	Fish species	C n	Dn	Gn	HL
ARIIDAE	*Arius gigas*	X	X	-	X
BAGRIDAE	*Auchenoglanis biscutatus*	X	X	x	X
	A. occidentalis	X	X	x	X
	Bagrus bayad	X	X	x	X
	B. docmak	X	-	-	X
	B. filamentosus	X	X	x	X
	Chrysichthys auratus	X	X	x	X
	C. nigrodigitatus	X	X	x	X
	Clarotes laticeps	X	X	x	X
CENTROPOMIDAE	*Lates niloticus*	X	X	x	X
CHARACIDAE	*A. baremose*	X	X	x	X
	A. dantex	-	-	x	-
	A. macralepideth	-	-	x	-
	Brycinus brevis	X	-	x	-
	B. leuciscus	X	-	-	-
	B. macrolepidotus	X	-	-	-
	B. nurse	X	-	x	-
	Hydrocynus brevis	X	X	X	X
	H. forskalii	X	X	X	-
	H. vittatus	X	-	X	-
	Micralestes humilis	X	-	-	-
CICHILIDAE	*Chromidotilapia guentheri*	-	-	X	-
	Haplochromis bloyeti	X	-	-	-
	Hemichromis bimaculatus	X	-	-	-
	Oreochromis aureus	X	X	X	-
	O. niloticus	X	-	X	-
	Tilapia dageti	-	-	X	-
	T. melaneupleura	-	-	X	-
	T. zillii	X	X	X	X
CITHARINIDAE	*Citharidium ansorgii*	-	X	-	-
	Citharinus citharus	X	X	X	X
	Citharinus latus	-	X	X	-
	Distichodus brevipinnis	X	X	X	X
	D. engycephalus	X	X	X	X
	D. rostratus	-	X	X	X
	Nannocharax fasciatus	X	-	-	-

Cn= Cast net, DN= Drag net, Gn= Gill set net, LH= Line hook

X; indicates presence

FAMILY	Genus species	Cn	Dn	Gn	Hl
CLARIIDAE	*Clarias anguillaris*	X	X	X	X
	C. gariepinus	X	X	X	X
	C. macromystax	-	X	-	-
	C. lazera	-	-	X	-
	Heterobranchus bidorsalis	X	X	X	X
	H. longifilis	-	X	X	-
CYPRINIDAE	*Barbus ablabes*	X	-	-	-
	Labeo coubie	X	X	X	X
	L. parvus	X	X	X	-
	L.senegalensis	X	-	-	-
	Leptocypris niloticus	X	-	-	-
CYPRINODONTIDAE	*Epiplatys bifasciatus*	-	-	-	X
GYMNARCHIDAE	*Gymnarchus niloticus*				
HEPSETIDAE	*Hepsetus odoe*	X	X	X	X
ICTHYBORIDAE	*Phago loricatus*	X	-	-	-
LOPIDOSIRENIDAE	*Protopterus annectens*	-	X	-	X
MALAPTERURIDAE	*Malapterurus electricus*	-	-	X	-
MASTERCAMBALIDAE	*Mastercembelus loennbergi*	X	-	-	-
MOCHOKIDAE	*Synodontis batensoda*	X	X	X	X
	S. budgetti	X	-	X	-
	S. clarias	X	X	X	X
	S. courteti	-	-	X	X
	S. eupterus	X	-	-	-
	S. filamentosus	-	-	X	-
	S. membranaceus	-	X	-	-
	S.nigrita	X	X	X	-
	S. sorex	X	-	X	-
MORMYRIDAE	*Gnathonemus tamandua*	-	X	-	-
	G. petersii	-	X	-	-
	G. abadii	X	-	-	-
	Hyperopisus bebe bebe o.	-	X	-	-
	Marcusenius mento	X	-	-	-
	M. senegalensis	X	-	-	-
	Mormyrops anguilloides	X	X	X	X
	M. caballus	X	X	X	-
	M. hasselquistii	X	-	X	-
	M. macrophthalmus	X	X	-	-
	M. rume rume	X	X	X	-

Cn= Cast net, DN= Drag net, Gn= Gill net, HL= Hook and Line
X; indicates presence

Family	Fish species	C n	Dn	Gn	HL
OPHIOCEPHALIDAE	*Paranchanna obscura*	X	-	-	-
OSTEOGLOSIDAE	*Heterotis niloticus*	X	X	X	-
PANTODONTIDAE	*Cynothrissa mento*	X	-	-	-
	Pantodon buchholzi	X	-	-	-
SCHILBEDAE	*Schilbe intermedius*	X	-	-	-
	Schilbe mystus	X	X	X	-
TETRAODONTIDAE	*Tetraodon fahaka*	-	X	-	-

Cn= Cast net, DN= Drag net, Gn= Gill net, HL= hook and line

X; indicates presence

Table 4.2 Seasonal Variation and Fish Abundance

Gear	dry season	wet season
Castnet	1465(25%)	1321(22.57%)
Drag net	1336(22.8%)	636(10.87%)
Gil net	395(6.75%)	408(3.20%)
Hook and Line	104(1.78%)	188(3.20%)
	3,300	2,553

Table 4.3 Dominance of Species in Numbers and Biomass among the Most Selected Fishes

Species	No of fishes	%	Biomass (kg)	%
Alestes baremoze	405	10.33	60.4	7.72
Auchenoglanis biscutatus	120	3.06	14.2	1.82
Auchenoglanis ocidentalis	107	2.73	22.6	2.89
Bagrus bayad	138	3.52	41.56	5.31
Bagrus filamentosus	118	3.01	15.3	1.96
Brycynus nurse	131	3.34	9.3	1.19
Citharinus citharus	130	3.32	26.05	3.33
Clarias anguilaris	137	3.49	45.3	5.79
Clarias garipinus	88	2.24	55.8	7.14
Clarotes laticeps	189	4.82	25.7	3.29
Hemichromis bimaculatus	88	2.24	1.12	0.14
Hepsotus odoe	199	5.08	59.1	7.56
Heterobranchus bidorsalis	101	2.58	41.5	5.31
Hydrocynus brevis	206	5.25	67.3	8.61
Labeo cubie	177	4.51	107.3	13.72
Lates niloticus	237	6.04	89.5	11.44
Mormyrus anguilloides	117	2.98	13.4	1.71
Mormyrus macrophthalnus	86	2.19	15.3	1.96
Mormyrus rume	150	3.83	15.2	1.94
Synodontis batensoda	230	5.87	18	2.30
Synodontis clarias	309	7.88	24.5	3.13
Synodontis courteti	45	1.15	2.4	0.31
Tilapia zilli	413	10.53	11.23	1.44
Totals	3921	100	782.06	100

Table 4.4 Max and Min Length (cm) Using Wetherall Plot for Fishes Recorded in the Benue River

Gear and Species	Loo*	Z/K	OEL	PEL
Cast net				
Lates niloticus	31.90	0.499	31.00	34.454
Tilapia zillii	19.44	0.539	-	-
Clarotis laticeps	47.50	2.488		
Dragnet				
Labeo cubie	71.00	0.000	71.00	63.38
Bagrus filamentosus	61.00	0.000	61.00	34.21
Synodontis clarias	32.23	1.536	31.00	27.66
Gill net				
Hydrocynus brevis	58.94	0.337	61.00	53.10
Auchinoglanis occidentalis	33.32	0.404	31.00	32.88
Alestes baremose	31.16	0.439	31.00	38.13
Hook and line				
Hydrocynus brevis	59.95	0.316	61.00	52.96
Alestes baremoze	40.31	0.887	41.00	43.49
Synodontis courteti	-	-	31.00	25.07

*Loo=Observed max length,
Z/K= Estimated max length,
OEL=Observed extreme length,
PEL=Predicted extreme length

Table 4.5 Means of Water Parameters Recorded in the Lower Benue River

	Turbidity(cm)	Temperature ^{0}C	pH	DOmg/l
2010				
July	27	29	6.6	5
August	28	29	6.5	6
September	26	29	6.4	11.4
October	28	26	6.8	11
November	41	21	8.4	10
December	41	20	7.8	8.5
2011				
January	47	26	8.0	5
February	50	24	8.4	6
March	68	25	6.7	11.4
April	69	32	8.4	11
May	69	32	7.8	10
June	25	30	6.4	8.5

Table 4.6 Maximum and Minimum Mean Water Parameters

	Min	Max	Mean
Depth (M)	3	25	6 ± 2.2
Velocity (M/min)	25	35	15 ± 2.2
Turbidity	25	69	51.0 ± 2.0
Temperature (^{O}C)	20	32	25.0 ± 2.06
DO (mg/l)	5	11.4	7.9 ± 2.0
pH	6.4	8.4	7.4± 0.49

Table 4.7 Relationship between fish count and physico-chemical parameters

Fishcount	Turbidity	Temp	pH	DO
Fishcount	1.00000			
Fishcount	1.00000			
Turbidity	0.06404	1.00000		
Turbidity	0.0291			
Temp	-0.40517	-0.08586	1.00000	
Temp	<.0001 ***	0.0034		
pH	0.31688	0.65591	-0.61058	1.00000
pH	<.0001***	<.0001	<.0001	
DO	0.03654	-0.03715	-0.43133	0.24980
DO	0.2135	0.2059	<.0001	<.0001

***** =** Highly Significant

* = Significant Difference

Table 4.8 Relationship between fish abundance & physiochemical parameters in the Dry Season

Fishcount	Turbidity	Temperature	pH	DO
Fishcount	1.00000			
Fishcount	1.00000			
Turbidity	-0.33308	1.00000		
Turbidity	<.0001***			
Temp	-0.24981	0.79181	1.00000	
Temp	<.0001***	<.0001***		
pH	0.11567	-0.32965	0.18850	1.00000
pH	0.0577*	<.0001***	0.0019	
DO	0.22946	-0.41740	-0.38416	0.45254
DO	0.0001***	<.0001	<.0001	<.0001***

*** = Highly Significant

* = significant Difference

Table 4.9 Relationship between fish abundance & physiochemical parameters in the Wet season

Fishcount	Turbidity	Temperature	pH	DO
Fishcount	1.00000			
Turbidity	0.33186	1.00000		
Turbidity	<.0001			
Temperature	-0.30092	-0.96250	1.00000	
Temperature	<.0001***	<.0001		
pH	0.33649	0.99396	-0.96429	1.00000
pH	<.0001***	<.0001	<.0001	
DO	0.10206	0.42206	-0.63446	0.43786
DO	0.1074	<.0001	<.0001	<.0001

*** = Highly Significant

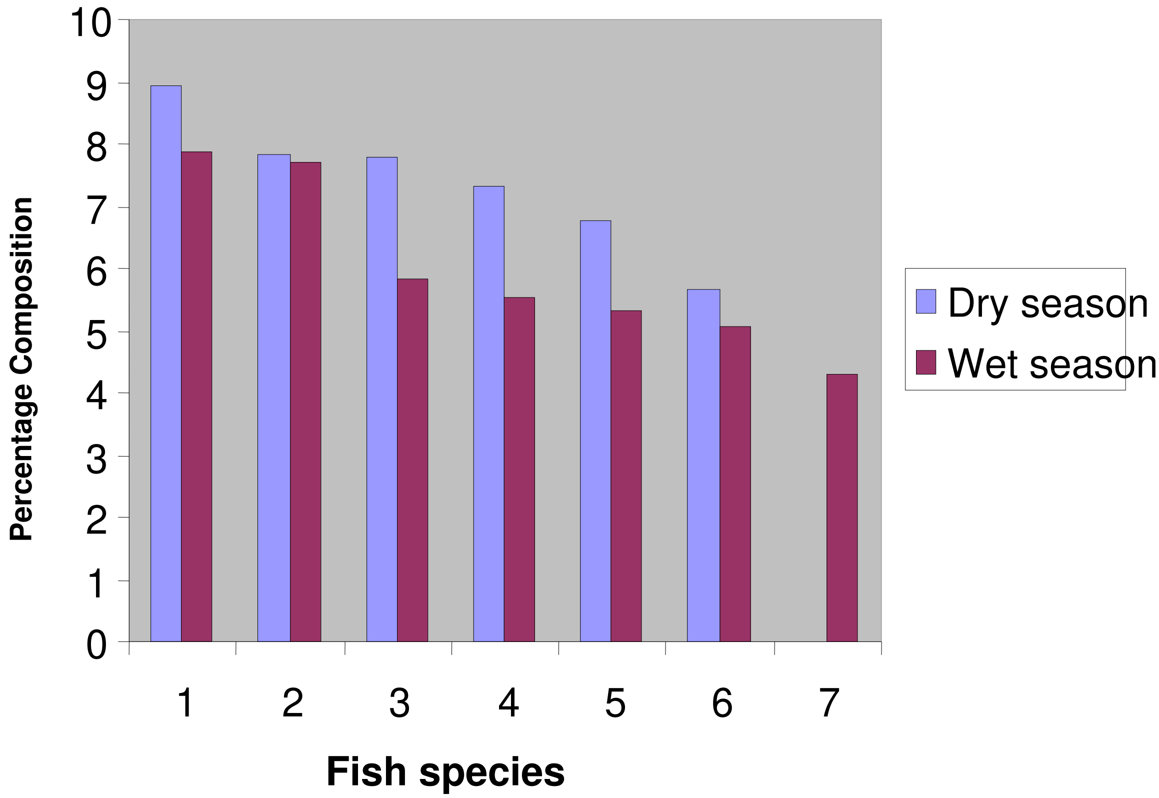


Figure 4. 1. Castnet efficiency for dry and wet seasons

Key (Dry): 1. *Alestes baremoze* 2.*Tilapia zillii* 3. *Brycinus nurse* 4. *Synodontis batensoda*
5. *Clarotes laticeps* 6. *Synodontis clarias* 7. *Citharinus citharus*

(Wet): 1. *Alestes baremoze* , 2. *Lates niloticus,*3.*Mormyrus rume,*4.*Hepsotus odoe*
5. *Hemichromis bimaculatus,* 6.*Tilapia zillii,* 7.*Synodontis clarias*

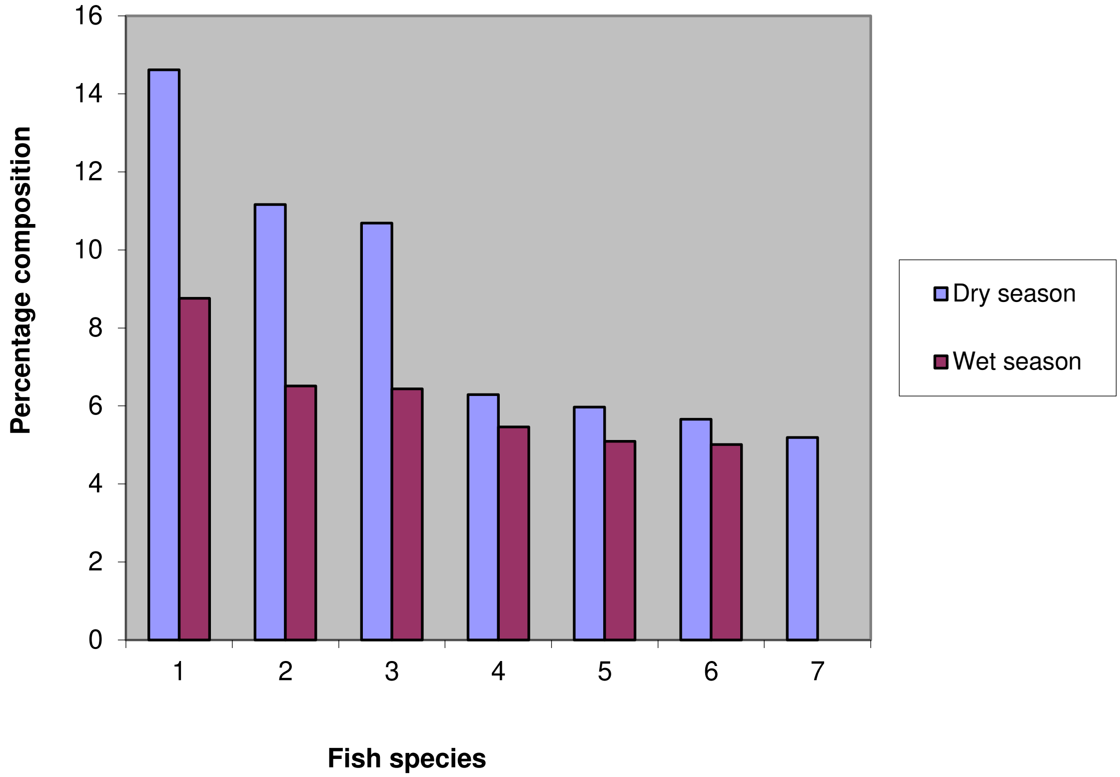


Figure 4.2 Dragnet Efficiency for dry and wet seasons

Key (Dry): 1. *Bagrus filamentosus, 2. Synodontis batensoda, 3. Tilapia zillii 4. Mormyrops anguilloides, 5. Bagrus bayad,6. Mormyrus macrophthalmus 7. Hepsotus odoe*

(Wet):*1.Tilapiazillii,2.Clarias anguillaris,3.Synodontis clarias,4.Auchinoglanis biscutatus,5.Heterobranchus bidorsalis,6.Alestes baremoze*

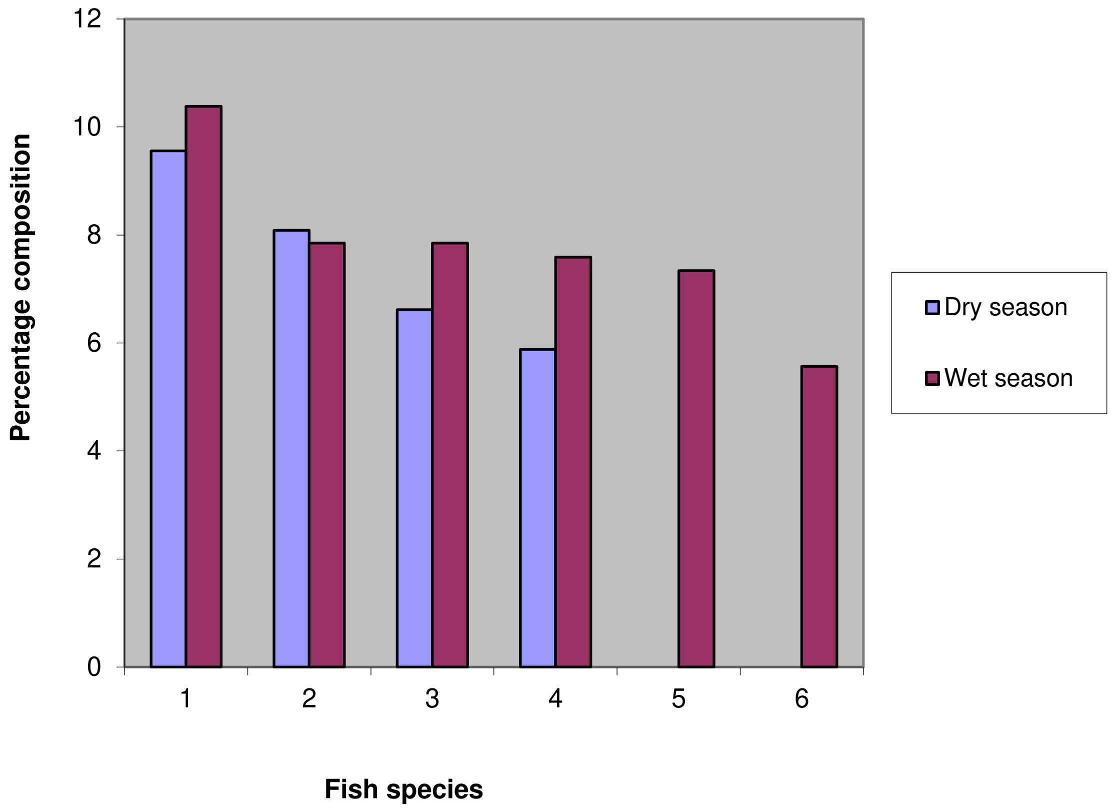


Figure 4.3 Gill net Efficiency for dry and wet seasons

Key (Dry): 1. *Hydrocynus brevis 2. Synodontis clarias3. Lates niloticus 4. Clarias anguillaris*
(Wet): 1.*Alestes baremoze*, 2.*Tilapia zillii*,3.*Synodontis clarias*, 4.*Auchinoglanis occidentalis*, 5.*Hydrocynus brevis*, 6.*Citharinus citharus*

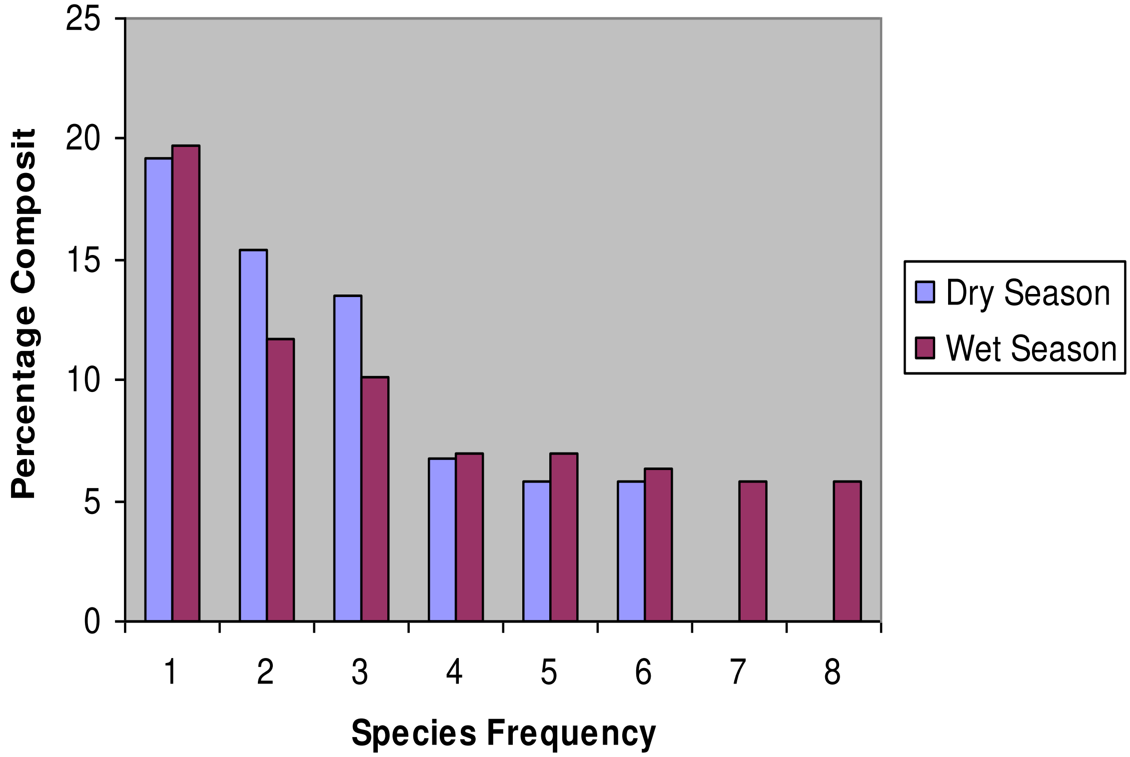


Figure 4.4 Hook and line Efficiency for dry and wet seasons

Key (Dry): 1. S*ynodontis courteti, 2. Bagrus bayad, 3.Clarias anguillaris, 4. Hydrocynus brevis 5.Clarotes lateceps, 6.Labeo coubie*

(Wet): 1. *Alestes baremose, 2. Hydrocynus brevis,3. Synodontis clarias, 4.Tilapia zillii 5. Lates niloticus, 6.Clarias gariepinus, 7. Citharinus citharus,* 8. *Hepsetus odoe*

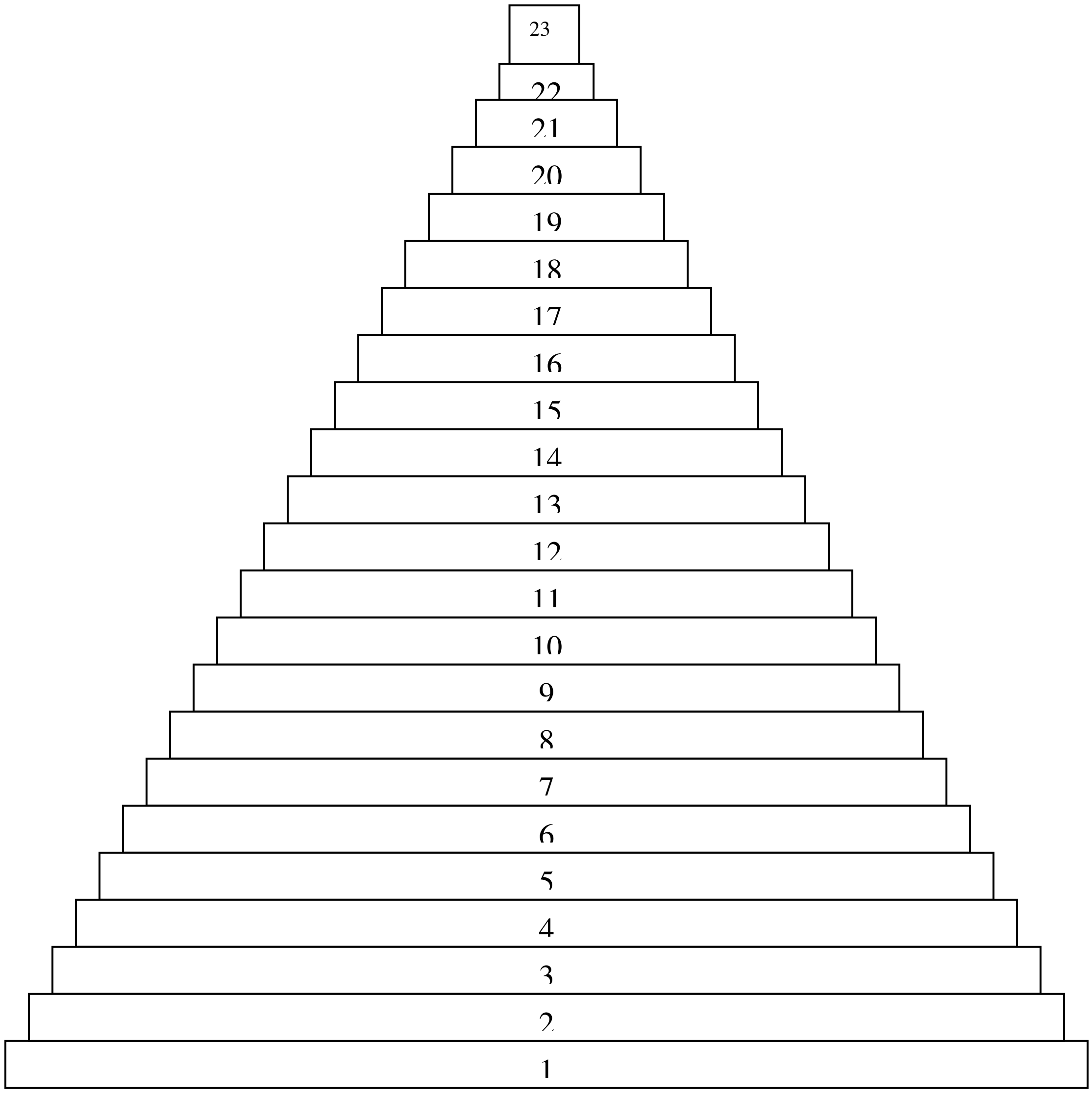


Figure: 4.5 Pyramids of Fish Dominance in Numbers

Key: 1.*Tilapia zillii* 2. *Alestes baremoze* 3.*Synodontis clarias* 4. *Lates niloticus* 5.*Synodontis batensoda* 6.*Hydrocynus brevis* 7.*Hepsotus odoe* 8.*Clarotis laticeps* 9.*Labeo coubie* 10.*Mormyrus rume* 11.*clarias anguilaris* 12.*Bagrus bayad* 13.*Brycinus nurse* 14.*Citharinus citharus* 15.*Bagrus filamentosus* 16.*Auchinoglanis occidentalis* 17.*Mormyrops anguilloides* 18.*Auchinoglanis biscutatus* 19.*Heterobranchus bidorsalis* 20.*Clarias garipinus* 21.*Hemichromis bimaculatus* 22.*Mormyrus macrophthalmus* 23.*Synodontis courteti*

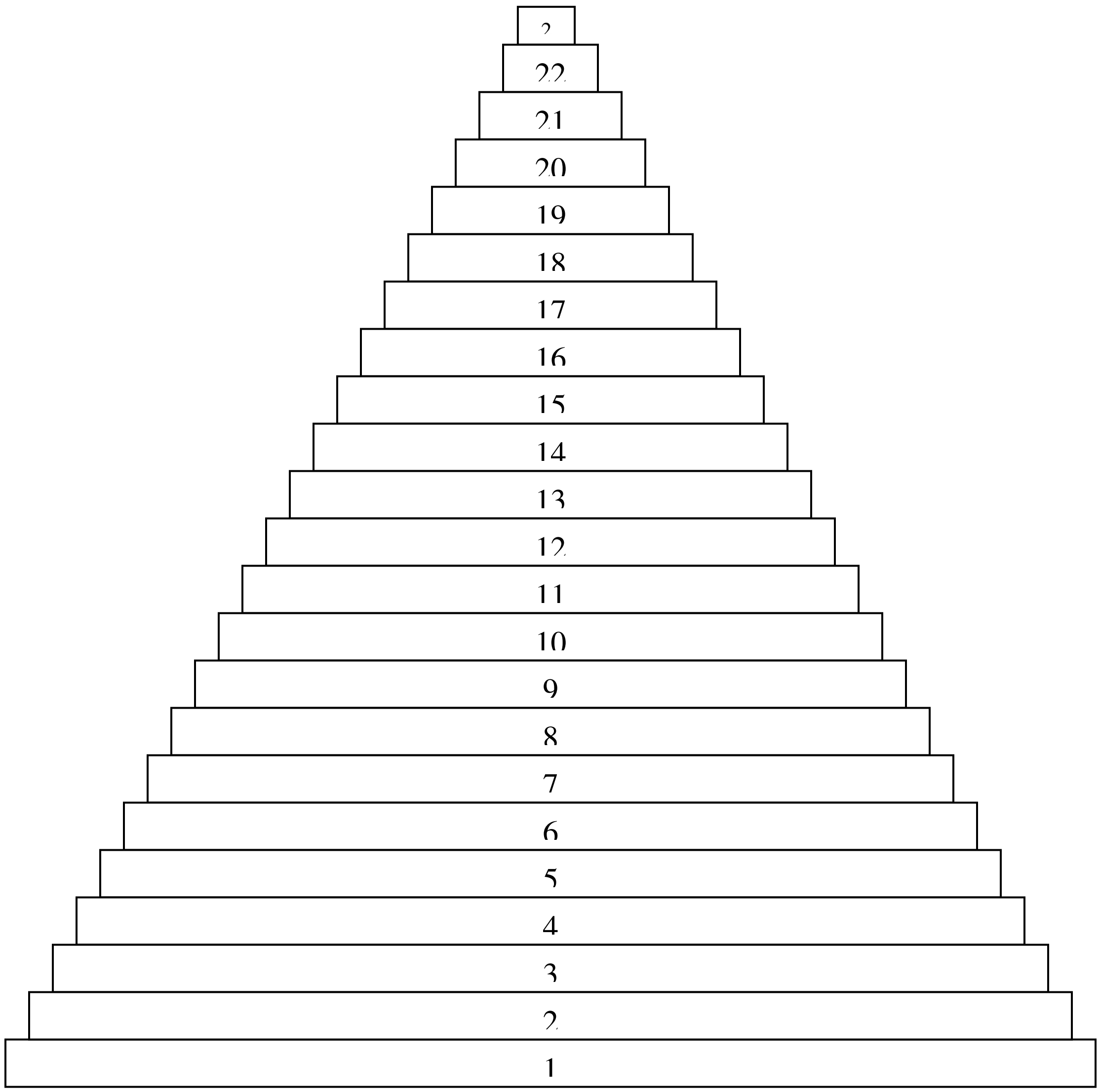


Fig: 4.6 Pyramids of biomass (kg) for the most selected species

Key:1.*Labeo cubie,* 2.*Lates niloticus,* 3. *Hydrocynus brevis,* 4.*Alestes baremose* 5.*Hepsotus odoe* 6.*Clarias garipinus* 7.*Clarias anguilaris* 8.*Hetrobranchus bidorsalis*, 9.*Bagrus bayad* 10.*Citharinus citharus* 11.*Clarotes laticeps* 12.*Synodontis clarias* 13.*Auchinoglaris occidentalis* 14.*Synodontis batensoda* 15.*Mormyrus rume,* 16.*Mormyrus macrophthalmus* 17. *Bagrus filamentosus,*18.*Mormyrops anguilloides* 19.*Auchinoglaris biscutatus* 20.*Tilapia zillii* 21.*Brycinus nurse* 22.*Synodontis courteti* 23.*Hemichromis bimacubatus*

4.2 Fish Abundance and Seasonality

A total number of 5,853 specimens which comprised of 82 species in 22 families were caught during the 12 months of the study (July 2010 – June, 2011). Of the four gears used for the experiment (cast net, dragnet, gill net and Hook and line), cast net had the highest catch with 2,786 specimens, dragnet ranked second with 1,972 specimens. Gill net recorded 803 specimen and hook and line recorded 292 specimens. The numbers of specimens caught by each gear, in the dry and wet seasons are shown in Table 4.2

4.3 Species Dominance and Gear Selection

The dominant species were determined based on their frequency of occurrence in numbers and biomass (total weight in kilograms), among the gears. Species that were caught exclusively by an individual gear were used to determine efficiency of that gear. Among the total sampled species, 23 of them were selective for the gears. The total fishes caught in the study area and their dominance in numbers and biomass is shown in Table 4.3 and Figures 4.5 and 4.6. Fish species count and distribution in relation to or as affected by water parameters recorded are shown in tables 4.7 to 4.9. The most dominant species in numbers were; *Tilapia zillii (418) Alestes baremose (405) and Synodontis clarias(309). Mormyrus macrophthalmus* (86) and *Synodontis courteti* (45) were least in numbers among the most selected species.

The total biomass recorded shows that *Labeo coubie (107.3kg), Lates niloticus (89.5kg)* and *Hydrocynus brevis (67.3kg)* ranked highest in weight while *Brycinus nurse (9.3kg), Synodontis courteti(2.4kg)* and *Hemichromis bimacuhulatus (1.12kg)* were least in the weight recorded. The species dominance were also ranked in pyramids of numbers and biomass (Figures 4.5 and 4.6).

4.4 Length of Fishes Caught in Relation to Gear

The lengths of fishes observed using Powell Wetherall plot among the four gears and the species selected for gear efficiency shows that Drag net recorded the highest length with *Labeo coubie* (71cm) and *Bagrus filamentosus* (61cm). Their predicted extreme lengths were lower than the observed lengths. Gill net and Hook and line had higher observed lengths than the predicted (61cm against 52 and 53 respectively). It was only Castnet that recorded fish lengths lower than the predicted length (31cm against 34cm) Table 4.4.

4.5 Physical and chemical parameters observed

Table 4.5 shows the monthly means of Physico-chemical parameters of water recorded during the study. Table 4.6 shows the minimum, maximum and the mean of means of the physic-chemical parameters. The parameters recorded include; depth, current velocity, turbidity, temperature, dissolved oxygen (DO) the power of hydrogen (pH)

4.5.1 Depth

The highest depth was recorded in September (25m) and lowest was recorded April (2m). The water level in the dry season is some times reduced so much that depth at some points for considerable stretch is below 1m. Flooding is occasionally recorded thus indicating abnormal high peaks in the water depth.

4.5.2 Current velocity

The highest velocity was recorded in July (35m/minute) while the lowest was in November (25m/minute) with mean of 15±2.2 (table 4.6) Velocity of the flowing water is highly affected in the dry season as volume is reduced and sand dunes appear in most places thus creating streams within the River with either higher or reduced velocities.

4.5.3 Turbidity

Turbidity as shown in Tables 4.5 and 4.6 had its highest value recorded the month of May (69cm) and the lowest in June (25cm). The values were observed to rise sequentially from June to reach its highest value in April and May.

4.5.4 Temperature

The highest temperature was recorded in April and May (32^0c) and the lowest was recorded in December (20^0c). (Table 4.6) Although temperature varies with the days weather conditions, so there were fluctuations at low (18^0c) and high (36^0c). it remained steady in July and August (29^0c) roused sharply from 25-32 in March to April.

4.5.5 pH Water

The highest pH values were recorded in the months of Nov, Feb and April (8.4) while the lowest were obtained in June and Sept (6.4) (Table 4.5). The mean of means was (7.4 ±0.49) (table 4.6) There was no sharp fluctuation during the study.

4.5.6 Dissolved Oxygen

The highest dissolved oxygen values were recorded in March and Sept (11.4mg/l) and the lowest were recorded in January and July (5mg/l) (table 4.5). Mean of means was (7.4 ±0.49 mg/l) The sharp variations in rise and fall was in Feb and March (6-11.4mg/l) and August to Sept table (4.5).

4.5.7 Correlation of fish count and physico-chemical parameters

The water parameters when correlated with the fish count as sampled in the river showed no significant differences except for temperature and pH which showed high significant differences. (Turbidity also showed significant differences (0-0.40517:0001), (0.31688.0001) and (0.06404:0.0291) (table 4.7).

4.5.8 Relationship between physico chemical and fish abundance in dry season

All the water parameters as shown in table 4.8 showed significant differences in fish abundance in the dry season. This implies that the parameters were major determinants of fish distribution in the dry season.

4.5.9 Relationship between fish abundance and physico-chemical parameters in the wet season.

The only physic chem parameters that showed significance difference in the correlation with fish abundance in the wet season were temperature (0.30092 :< 0001) and PH (0.33649 :<0001) (Table 4.9).

4.5.4 Temperature Effect on Fishes

Temperature (T^o) Dissolved oxygen, (DO) and P^H were recorded as shown in table 4.5. The maximum and minimum values as well as their standard deviations are shown in table 4.6. Their values and as they affect fish count in the area is shown in tables 4.7 Fish count in the sampled area was correlated with the values of the parameters recorded, it was observed that temperature and pH showed significance difference ($p<0.05$) in the availability of fish.

4.5.5 Seasonal variation of Fish Population and some Physico-chemical Parameters

Generally, the seasonal variation in the parameters is shown tables 4.8 and 4.9. Turbidity, temperature and P^H and Dissolved oxygen showed significance difference ($p=<0.05$) on fish abundance in the dry season (fish was more abundant at increased values) but only temperature and pH showed significant difference in the wet season.

CHAPTER 5

DISCUSSION

It was observed that the easy and fast collapse of the cast net during retrievals was afforded by the sinkers. This is in line with Brandt (1972) findings that the concentrating forces afforded by the sinkers during the retrieval of cast nets collapsed the circular net to the form of a rope-like structure. The construction of some small-sized cast nets in the area without segments may have some financial advantages; but observations have shown that this design does not allow the net to spread out well and fall like a cone on the water surface instead of maintaining a circular form typical of segmented cast nets. The structural, cone-shape of unsegmented cast net could decrease the useful fishing area of cast nets resulting in decreased efficiency. Udolisa and Solarin (1979) had similar opinions during their study in the Lagos lagoon.

The attachment of pockets to most cast nets in the study area is an interesting design technique aimed at securing the catches of any enclosed fish; and especially outwitting the very weird *Tilapia spp* that have a tendency to dig slightly into mud or sand duns to escape the net. It was observed that catches of enclosed fish in cast nets were always found to include *Tilapia spp* in the pockets of the net; few small-sized *Tilapia spp* were gilled in an attempt to escape through the meshes and rarely were they found within the main body of the collapsed net. Information gathered on the design of cast nets observed during operations by the fishermen showed that the presence of the mended net webbing near the attached pockets and sinkers were the gear portions that got stucked in under-water obstacles. This was probably the reason that the gear was used only in recognised spots devoid of under-water obstructions. Brandt (1972), Udolisa and Solarin (1979) had similar observations and they recommended that cast nets without pockets could be used specifically for shallow waters in which plants or obstacles were expected. The design of some cast nets in the study area with long retrieval lines of approximately 16m favoured their operation in deeper waters.

Results in table 4.1 shows that cast net has the highest fish composition among all the gears for both dry and wet seasons (48%). The species not caught by the gear are either bottom dwellers that are photophobic and feed mostly at night (*Heterobranchus bidorsalis*, some *Clarias spp,Malapterurus electricus*), some others are small and dwell at the edges of the river bank or hide under structures. Lack of scales and spines on fish body may make catch by cast net difficult. Babatunde *et al.,* (2008), highlights that cast net is selective for pelagic fishes although he recorded more catch in night fishing in a brackish water (lagoon) the situation may not be the same for some species in running water. Alfred-Ockiya (1998) used cast nets consisting of two panels of different mesh sizes (30mm and 40mm). He observed that the catch ability of a fish with cast net depends on the body girth of the fish, presence of fins (dorsal), spines, scales and teeth structure.

Apart from the fact that frequent occurrence of *Tilapia spp* in catches of cast nets denoted dominance of the species in the study area, the success of trapping *Tilapia spp* in cast nets may not be unconnected with the technique of attaching pockets to most cast nets in the study area. Observations had revealed that majority of the fishes were trapped in the pockets possibly while attempting to escape. The dominant species identified in the catches of cast nets were all pelagic species and have been found by Reed *et al (*1967) to have a tendency to move in shoals. Moses (1987) and Nawa (1982), had also identified in the lower reaches of the Cross River and in the Cross River estuary respectively, that cast nets were used to catch mainly those species that tend to move in shoals. The occurrence of some demersal species like *Clarias synodontis, Heterobranchus, Mormyrus, Auchenoglanis, Barbus,* and *Tetraodon spp* were quite minimal and more frequent in the October – December operational period of the cast nets. The presence of small specimens of fish in the catch was caused by the small mesh sizes of the net. The numerical and gravimetric catches of the cast nets increased with increased size of the net; likewise the catch per unit of effort. Meye and Ikomi (2012) assessed seasonal fish abundance and gear efficiency in Orogodo River in the Niger Delta and the results showed that dragnets caught 3734 or 40.46% of the total catch and had 33 species recorded, while gillnets had 3441 individuals or 37.28% of the catch, comprising 24 out of 37 species.

Personal observations in the rigging of most surface-set gill nets in the study area revealed that, the requirement for adequate displacement of the net in water was that the vertical line of meshes that carried a float on the float-line was the same line that carried a sinker on the foot-line. The result was that the total number of floats had to correspond with the total number of sinkers in an adequately rigged surface-drift net. The gear design implications in these observations were that the tendency of the net to sink which was due to the weight of the net itself, Head and foot ropes and the sinkers should be less than the tendency of the net to float which was solely afforded by the floats. These observations are in line with Baranov (1948) findings that the assignment of floats and sinkers, their total number and weights and the disposition of these floats and sinkers along the length of the net were necessary for endowing the net with the required buoyancy.

The characteristics design guided by the depth dispensation of some of the Mid-water-set gill nets in the study area was aimed mainly at attaching the net to vertical, messenger bush-ropes that maintains a vertical stretch in the desired Mid-water position instead of using a combination of only floats and sinkers to achieve the required Mid-water position, as was the case occasionally. The implication in the rigging of the second design was that a slight neutral buoyancy was achieved. This could be related to Fridman (1973) findings that in the rigging of set-nets the total buoyancy of the floats of the set nets should be proportional to the weights of the net and the rigging in water. It was also observed that while the length ranges of gill nets varied considerably depending on the fishing location, their calculated depths had little variation (1.0 – 2.9m). This could be due to the fact that tailoring and cutting of the lengths of the net in the Normal ("N") direction was determined by individual fishermen. Regarding the depth variation, Baranov (1948) had noted that the depth of the net was determined by the width of the ready made netting which in most cases was 2.0 to 3.0m from the manufacturers regardless of the fishing ground. The difference in depths of the mounted gill nets from the depths of the ready-made un-mounted gill nets was therefore due to the hanging coefficient (E). Fishers increase the factory depth of 3m based on individual choice.

The recession of water from the flooded plains to the main channel of the river and the low transparency most probably accounted for the high catches between October and November. The occurrence of species of Bagridae family in the 50mm stretched mesh in the operational period was an indication that the gear may be selective for the family due to it abundance, size ranges and circumference of this species permitted escape in the 50mm meshes but not in the 30 and 40mm meshes. Large mesh nets permit small sized and young fish to escape and as such may be more ideal for the fishery.

The sharp decrease in the effectiveness Gill net in the month of December was by obstructions caused by the appearance of sand duns (beaches) due to receding which is a common occurrence in the fishery of the locality in the dry season. A major contributing factor in the decline of effectiveness of the nets was the increased transparencies in the month of December as compared to those recorded in previous months. This could have resulted in increased visibility of the multifilament nets in water. This may not be unconnected with the observations that *Alestes* and *Hydrocynus spp* were often seen to leap over some surface –drift nets in the month of December. Similar findings have been reported by Etcheri and Lebo (1982) in the Cross rivers fisheries.

It was observed that the quality of products from cast and drag nets were better as compared to set gill net and line hook. The high rating of the quality of fish caught by drag and cast nets was due to the fact that the fish were removed quite promptly after each hauling. Personal observations in the decrease of their efficiency in the months of August and September could be due to the high volume of water and the turbulence created by the high current velocities of 0.40 and 0.42m/sec. which almost always sagged and prevent spread of cast net therefore reducing the useful fishing area of the net. Baranov (1948) had reported that such conditions could reduce the efficiency of the gear. The poor quality of catch products obtained from the set gill nets was due to the fact that the nets were set in the evenings and left over the night. Observations on the catches and interviews with the fisherman who owned the polyamide monofilament gill net revealed that the net caught relatively more fish than their multifilament counterparts especially at higher water volumes.

Observations have shown that the mode of hanging the nets with a hanging coefficient (E) of 0.5 enhances entangling of large-sized fish because of the loose shape of the mesh. Garner (1977), had ascertained the shape of the mesh as an important factor that determined the size of the fish caught, Udolisa and Solarin (1979) had found in Lagos lagoon that a coefficient of 0.5 increases the efficiency of gill net by entangling. Results also revealed that *Schilbe mystus* because of a slightly similar shape and the possession of morphometric projections like serrated spines as in *Clarias* and *Chrysichthys spp*, and also the presence of scales in *Tilapia* and *Alestes spp* affected their selectivity in gill nets. Hopson (1968) had similar findings in gill net fisheries in Lake Chad.

The composition for dragnet was high, next to cast net but was higher in the dry season and very low in wet season as compared to the difference among seasons in cast net. It was composed mainly of fish that avoid areas of high velocity as the gear is mostly operated in shallow pools that exist in dry season. The high composition was mainly due to the small mesh sizes (1 cm). Gill net and hook and line had the lowest composition in numbers but highest biomass. Alfred-Ockiya (1998) observed that gill nets and cast nets were used all year round whereas hooks and other traps were used mostly in the wet season. The difference here is that gill set net is almost not operational in the dry season due to low water levels. The high biomass composition in gillnet and lonehooks agrees with Sætersdal (1963) and Nederaas *et al.* (1993) who observed that in commercial fisheries, longlines are often found to catch more large fishes. Comparison between surveys, where identical distances are fished by different gears, suggests that longlines catch relatively fewer smaller fish, but significantly more larger fish than trawls (Hovgård and Riget 1992, Jørgensen 1995). Lokkeborg and Bjordal(1992), states that the important selection factors for linehooks fishing include; fish distribution, fishing strategy, feeding range, fish competition, type and size of bait, and hook design. Larger species and specimens have larger feeding ranges and are more successful in competing for bait which may explain the higher selectivity recorded in the linehooks. Although hooks operated do not have bait, some fishers apply feeds (left over and contaminated food of their households).

Individual species that constituted up to 5% of the total catch for each gear in any particular season was regarded as highly selective. The most dominant species in numbers include *Tilapia zilii* (413), *Alestes baremose* (405), *Synodontis clarias* (309), *Lates niloticus* (237), *Synodontis batensoda* (230), *Hydrocynus brevis* (206). Species with the highest biomass (wt in kg) include *Labeo cubie* (107.3kg) *Lates niloticus* (89.5kg), *Hydrocynus brevis* (67.3kg), *Alestes baremose* (60.4kg) and *Hepsotus ode* (59.1kg).

This dominance may be attributed to the optimum physical and chemical parameter ranges that have supported high nutrient availability (Plankton) from seasonal changes (Davies *et al,* 2008). The longest lengths and highest weights was observed in *Labeo cubie* (71cm and 8.5kg), and was caught by dragnet, *Hydrocynus brevies* (61cm and 4.5kg), caught by gillset net and *Bagrus filamentosus* (61cm and 2.3kg) and caught by dragnet. The seasonality of the gears show that cast net is an all season gear but catches small size fishes that are mostly pelagic species. Dragnet is more effective in dry season when the water levels are lower. The most effective and efficient gears in the wet seasons are the gillset net and line hooks which record low catches but catch species with higher biomass (high commercial value). They tend to be more environmentally fishing friendly as they allow juveniles to escape and thus give room for conservation.

Hydrographic conditions in the study area indicated seasonal variations of depth, current velocity, turbidity and temperature. Depth of water increased in the wet season to near maximum by flooding all the adjoining wetlands. The increase in depth occasioned the corresponding increase in current velocity and was near maximum in the months September and October (25m and 35m/min). This may be so because the wet season is characterized by high rain rainfall (not recorded), and as such, the river is fed by water from all its tributaries and the surface runoffs, this was also established by Reid and Sydenham (1979). Marie *et al.,* (2001) confirmed its strong flow and the flooding of its plains in the month of September. Reid and Sydenham (1979) states that the difference between high and low water levels can be as high as 25m between August-September, the difference recorded was 22m (3m and 25m) and the highest depth recorded was between September-October 25m, this may be and indication of aging of the river due to alluvial deposit from land erosion that has reduced the depth by 3m. Turbidity had its highest values in April and May (69cm) and the lowest value in September (26cm). It was observed that turbidity dropped sharply in May-June (69-25cm) and a sharp increase was recorded in October-November (28- 41cm) this may be because rains actually commence in April but increased flow of rivers and streams become stronger in June which moves debris and weathered materials during dry season into the river and thus increase its turbidity. The river water however maintains relatively high transparency between November and May. The highest water temperature recorded was in April and May (32^0 C) and temperature of the air fluctuated between 35 and 38^0C, it recorded lowest in

December (20^0 C) and temperature of the air was between 24 and 27^0C. Okayi *et al* (2005) recorded water temperatures of 31.0^0C and 24.0^0C (maximum and minimum). These temperatures recorded tend to agree with the atmospheric weather conditions in the Benue region as it experience harmattan in the months of December and January, while the hot humid weather is experienced between March and May. The highest P^H values were recorded in April and the lowest in July (8.4 and 6.6). Apeh and Ekanta (2012) recorded similar results in the Benue River. Chekroff (1976) reported that runoffs of rains carry acid from the soil to water. The fluctuation of P^H however did not follow with the seasonal variation but on short term basis of month to month. The fluctuation of Dissolved oxygen (DO) was similar to that of P^H and did not follow seasonal variation. The lowest DO recorded in July (5mg/l) may be due to the high decomposition of organic material that is being saturated in water from surface runoffs by the rains while the low record in January may due to low water level but the competitive use by aquatic plankton (macro and micro) and contamination by human use. After the two months DO fluctuated but was relatively stable within 8mg/l and 11mg/l, the ranges shows that the water is optimally oxygenated for aquatic life to thrive (table 4.1).

Among the water parameters recorded, Depth and velocity appear to be exerting major influence on fish distribution and abundance, dry season characterized by low water level causes fish disappearance and permit for temperature extremes (lowest during hamarttan and very high around April due to sun heat), temperature and turbidity showed significance difference in the different seasons. DO showed significance difference in relationship to fish distribution in the dry season at higher temperatures (28^OC). Fish become more abundant in the isolated pools created by the draught condition that influence aggregation.

CHAPTER 6

CONCLUSSION AND RECOMMENDATIONS

From the results of the study the following conclusions can be made;

1. This study establishes that cast net and gill set nets are all season gears in the Lower Benue River. However catch by cast net is negatively affected by high volumes of water associated with higher velocities during the wet season. Gill net is affected by dry season as the draught reduces the fishing area for the gear.
2. Hook and line appear to be more efficient and effective during the wet season as it records higher catches in biomass and is size selective for larger fishes.
3. Drag net is more effective in the dry season and make relatively higher catches but it appears to be environmentally unfriendly as the small mesh sizes observed are not size selective and does not allow for conservation.
4. Gill net and Drag nets only differ in operational methods (passive and active operations) but exhibit same catching principles. Drag net records higher catches and is most preferred by fish anglers.
5. The water parameters as observed for now appear to be at optimum for aquatic productivity as they indicate unpolluted condition. Their correlation with fish count and abundance for both seasons showed significant differences but are still within optimal limits

It is therefore recommended that;

1. There is need to review and implement some legislative and regulatory laws in areas like responsible and environmentally friendly fishing (regulation of mesh sizes). There is need for control of the current destruction of the river banks through fired bricks works.
2. Further studies on specific gears and mesh sizes selectivity is recommended, as this study has only given an insight to the seasonality, fish composition and efficiency of the gears. For more accurate results in further studies in the lower Benue River, the highlighted effective seasons of operation should be observed.
3. It is important to construct specific gears for research in Nigeria as adoption of those used by commercial fishers may not give good scientific results.
4. The mesh sizes of fishing nets operational (as observed) in the study area should be regulated by discouraging mesh sizes that are less than 4cm, mesh sizes not less than 4cm is recommended for all nets.
5. The construction of small cast nets without segments may have some financial advantages; but the design defect during operation did not allow the net to spread out well. Cast nets with segments are highly recommended because they spread out well to cover the largest possible fishing area resulting in increased efficiency.
6. The hanging segmentation ratio of 0.5(½) and 0.33(⅓) applied in the hanging of the meshes of one panel of a segmented cast net to the adjoining one are recommended.
7. Colouration of netting materials was not observed through out the study but colouring enhances netting efficiency and preservation and is therefore recommended.

8. Fish abundance may be at optimal level for now but further studies on stock exploitation is recommended, there is also, the need for an established water parameters monitoring scheme to check for the trend of unforeseen global hydrological phenomenon.

REFERENCES

Abowei J F N & Hart A. I. (2008). Artisanal fisheries characteristics of the fresh water reaches of lower Nun River, Niger Delta, Nigeria. *Journal of Applied Science and Environmental Management. 12(1) 5 – 11p.*

Adamus, P.R.(1996), Bioindicators for assessing ecological integrity of prairie Wetlands, Northern America. *Water Research, 34,33-45.*

Adirondack, L.L.C.(2010).*Schroon Lake Phytoplankton monitoring project*. Schroon Lake Association, New York

Alfred–Ockiya J.F. (1998), Studies on the Icthyo fauna of kolo Creek Niger Delta. *Biologia 1(2):24-28.*

Apeh, S. & Ekenta O.E. (2012). Assessment of Surface Water Quality of River Benue at Makurdi. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 3(6): 904-913*

American Public Health Authority (1998). *Standard methods for the examination of water and waste water*.20th(Ed), Washington D.C

Argent D.G. &William G. K.(2005). Efficiency and Selectivity of Gill Nets for Assessing Fish Community Composition of Large Rivers. *North American Journal of Fisheries Management 25:1315–1320,*

Babatunde E. E., Chukwu, L. O. & Azeez, L. O. (2008). Cast net design characteristics, catch composition and selectivity in tropical open lagoon. *African Journal of Biotechnolology*, 7: 2081–2089.

Balık I. & Çubuk H. (2001). Effect of Net Colours on Efficiency of Monofilament Gillnets for Catching Some Fish Species in Lake Beyehir. *Turkish Journal of Fisheries and Aquatic Sciences 1 29-32 (2001)*

Bankole N.O (1990), Gillnet monitoring at Tiga and Jankara Reservoir in Kano, FISON Conference paper 1990 pp 122-142 ABU Press

Baranov, F. I. (1948). Theory and assessment of fishing gears; Theory of fishing with gill nets. Pishchepromizdat, Moscow. 451pp. (Translation from Russian by Ontario Department of Lands and Forests), Maple. Onterio.

Bjordal (1983). Swivel connected gangions in mechanized long-lining — effects on catch rates and operations. ICES C.M. 1987/B: 18 (mimeo).

Bjordal (1987). Full scale test of improved long-line gear. ICES CM 1987/B:45 (mimeo).

Bjordal (1989) *Recent developments in long-line fishing-catching performance and conservation aspects*. *In*: Proceedings, World Symposium on Fishing Gear and Vessel Design, 1988. Newfoundland and Labrador Inst. of Fisheries and Marine Technology. St. John's Nfld. pp. 19–24.

Boyd, C.E. & Lichtkoppler, F.(1979).*Water quality management in fish pond*. Research and Development series No. 22. International Centre for Aquac-ulture and Agricultur (I.C.A.A), Experimental Station Auburn University Alabama, 45-47.

Boyd, C.E.(1982).*Water quality management for pond fish culture.* Elsevier Scrunch publishers

Brandt A. V. (1972), *Fish Catching Methods of the World* Fishing New Books Third Edition

Castilla D E., Ramón J. T. and Juan J. García.(2006) Determination of technical efficiency of fisheries by stochastic frontier models: a case on the Gulf of Cádiz (Spain) Technical efficiency analysis for the Iranian fishery in the Persian Gulf. *ICES Journal of Marine Science. (2006) 63 (9): 1759-1764*

Checkroff.M. (1976), *Fresh water fish pond culture and management*. VITA Publishers

Chindah, A.C. (2003), The Physico-chemistry, phytoplankton and periphyton of a swamp forest Stream in the lower Niger Delta. Scentia, Africana. 2: (1&2), 106- 116.

Collie J. S. Hall S. J. Kaiser M .J. and Poiner I. R (2000). A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology 69:785-798*

Colvin, M. (2002), A comparison of gill netting and electrofishing as sampling techniques for white bass in Missouri's large reservoirs. *North American Journal of Fisheries Management 22:690–702.*

Cortez-Zaragoza,E. Dalzell,P. and Pauly,D. (1989), Hook selectivity of yellowfin tuna *(Thunnus albacares) caught off Darigayos Cove, La Union, Philippines*. *Journal of Applied Ichthyology,* 1: 12–17.

Craig (1993), The effect of hook size on the size-specific selectivity of hottentot Pachymetopon blochii (Val.) and on yield per recruit. *South African Journal of Marine Science,* 17: 155–172.

Cui G; Wardle C.S; Glass C.W; Johnstone, A.D.F & Mojsiewicz, W.R. (1991.) Light level thresholds for visual reaction of mackerel, Scomber scombrus, to coloured monofilament nylon gillnet materials. *Fishery Resources Journal.* 10:255–263.

Davies, O. A. (2009), Fin fish Assemblage of the lower reaches of Okpoka Creek, Niger Delta. *Nigeria Journal of Applied Scienc and Biotechnology,* I (1): 16-21

Degerman, E., Appelberg, M. and Nyberg, P. (1992.) Effects of liming on the occurrence and abundance of fish populations in acidified Swedish lakes. *Hydrobiologia* 230: 201–212.

Douterelo, I. E, Perona and P., Meteo. (2004), Use of cyanobacteria to assess water quality in running waters *Elsevier Environmental Pollution, 127, 377 – 884.*

Dufeu,T.(1995), Survey of beach seine fishermen, Kainji lake, Niger- fishes Review of exploited fish stock CECAF/ECAF series FAO, Rome

Elliott J. M. and J. M. Fletcher (2001), Comparison of three methods for assessing the abundance of Arctic charr. *Salvelinus alpinus*, in Windermere (Northwest England). Fisheries Research 53:39–46.

Erez, J. M, Krom, D and Neuwith T. (1990), Daily oxygen variation in marine fish ponds Flat Israel. Aquaculture 84, 289-305.

Erzini, K.E; Gonçalves J. M. S Bentes L. Lino P. G. and Cruz, J, (1996) Species and size selectivity in a Portuguese multispecies artisanal long-line fishery *ICES J. Mar. Sci.,* 53: 811–819.

Etcheri I.E. Lebo P.E (1982), Synopsis of the Traditional Fishing Gear Used in the Upper part of Cross River. Proceedings of the 2nd national conference of fisheries society of Nigeria 1984 157-170

FAO (1990), *Definition and classification of fishing gears*. FAO Rome

FAO (1992) FAO Code of Conduct for Responsible Fisheries. Fisheries and Aquaculture Department, FAO Corporate Document Repository FAO Rome

F.A.O. (1994) *catalogue of small-scale fishing gear in Nigeria* F.A.O. Rome

Fagade S. O. (1979), Observations on the Biology of Two Species of Tilapia from the Lagos Lagoon, Nigeria Bulletin, Institute of foundation Africa

Forster, G.R., (1973), Line fishing on the continental slope, The selectivity effect of different hook patterns *Journal of Marine Biology Ass U.K.* 53:749–751.

Fridman A. L. (1973) Theory and design of commercial Fishing Gears Israel Program for Scientific Translation Keter Press.

Garner J (1977), *How to make and set net technology of Netting.* Fishing New books

Guy, D. (1992). *The Ecology of the fish pond ecosystem with special reference to Africa* Pergamon press 220-230

Hamley J.M. and Skud, B.E., (1980) Factors affecting long-line catch and effort: II. Hook spacing. Int. Pac. Halibot *Comm. Sci. Rep.,* 64: 15–24.

Hamley, J.M. & Regier, H. A. (1973), Direct estimates, of gillnet selectivity to walleye (Stizostedion vitreum vitreum)**.** *Journal of Fishery Resources Bd. Can.* 30: 817–830.

Hamley, J.M. (1975). Review of Gillnet Selectivity. *Journal of Fishery Res. Bd. Can.* 32: 1943–1969.

Hamley, J.M. Skud B.E. (1975) Review of gillnet selectivity. J. Fish. Res. Bd. Can. 32: 1943-1969.

Henderson, B.A. and Nepszy, S.J., 1992. Comparison of catches in mono- and multifilament gillnets in Lake Erie. *N. Am. Jour. Fish. Man.* 12:618–624

Hinz, H. Murray, L.G. and Kaiser, M.J. (2009), Efficiency and environmental impacts of three different Queen scallop fishing gears. Fisheries & Conservation report No. 8, Bangor University 1 3; 23.

Hopson A. S. (1968), *The gill net fisheries of Lake Chad*, Fed. Dept of fisheries Nigeria

Hovgård, H.and Riget, F.F. (1992), Comparison of long-line and trawl selectivity in cod surveys off West Greenland. *Fishery Resources* 13: 323–333.

Hovgård, H., (1996). Effect of twine diameter on fishing power of experimental gillnets used in Greenland waters. *Canadian Journal of Fishery and Aquatic Science,* 53: 1014–1017.

Idodo-Umeh,G. (2003), *Fresh Water fishes of Nigeria Taxonomy, Ecological notes and utilization* Idodo-umeh Publishers Limited

Imovbore A. M. A and Okpo w.s. (1975) Aspects of the Biology of kainji lake fisheries and Ecology of lake kaniji in kaniji .The transition from river to lake 163 -176 NIFFR Research publications

Ita E.O. and Machili M. (1997), The current Status of fish stock in kano State NIFFR Research publications

Ita E.O (1993) Inland Fisheries Resources of Nigeria. CIFA Occasional paper No. 20 FAO Rome

Jensen, J.W. (1995). Evaluating catches of salmonids taken by gillnets. *Journal of Fishery Biology,* 46: 862–871.

Jester, D.B. (1973).Variations in catchability of fishes with color of gillnets. *Trans. American Fishery Society,* 102:109–115.

Jørgensen, O.A. (1995) A comparison of deep water trawl and long-line research fishing in the David Strait. *In:* A.G. Hopper (*ed.*), Deep-water fisheries of the North Atlantic Slope, 235–250. Kluwer Academic Publishers.

Kaiser M. J. & de Groot, S. J. (2006). The Effects of Fishing on Non-target Species and Habitats. Blackwell Science Ltd., Oxford. 399pp.

Karlsen, L. (1976). Basic Studies of Norwegian Long-line Gear . ICES CM 1976/B: 27 (mimeo). Int. J. Environ. Bioener. 2012 , 2(2): 68-78

Khan K. U.& John B. H. (2005), Studies on the fish catch efficiency of different types of fishing gear in Kaptai Reservoir, Bangladesh Lakes & Reservoirs Research & Management 12/2005; 10(4):221 - 234.

King M. (1995), *Fisheries Biology; Assessment and Management* Fishing News Books, Oxford

Kirkwood G. P and Walker T. I. (1989), Gillnet Mesh Selectivities for gummy shark *Mustelus antarcticus* Gunther taken in south-eastern Australian waters *Aust. J. Mar. Fresh. Res.* 37: 689–697.

Kumbhakar S. C. and Lovell C. A. K. (2000), *Stochastic Frontier Analysis Cambridge: Cambridge University Press*

Kurkilahti, M. and Rask, M. (1996), .A comparative study of the usefulness and catchability of multimesh gillnets series in sampling perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) *Fish. Res.* 27: 243–260

Løkkeborg S. and Bjordal A. (1992). Species and size selectivity in long-line fishing: a review *Fishery Resources.* 13: 311–322.

Løkkeborg, S. and Johannessen T. (1992), The Importance of Chemical stimuli in bait fishing - fishing trials with pre soaked bait. *Fishery Resources* 14: 21–29.

Lowe-Mcconnel (1987). Ecological studies in tropical fish communities Cambridge University Press

Lucinda, C. and Martin, N. (1999), Oxford English Mini-Dictionary. Oxford Univ management. *Limnologica, 38,200-208.*

Machiels, M. A. M., Klinge, M., Lanters, R., and Van Densen, W.L.T., (1994), Effect of snood length and hanging ratio on efficiency and selectivity of bottom-set gillnets for pikeperch, Stizostedion lucioperca, and bream, Abramis brama. *Fishery Resources* 19:231–239.

Marie, T. S., Madakan S. P& Ladu B. L. (2001) Investigating systems of Fisheries access along the River Benue in Nigeria trv Tech paper 26pp.

McNeely, R.N., V.P. Neimanis and L. Dwyer (1979).Water quality source book: A Metry Ecological *Letter, 10,282-289.*

Methven, D. A. and Schneider, D.C., (1998), Gear-independent patterns of variation in catch of juvenile Atlantic cod *(Gadus morhua*) in coastal habitat*s. Canadian Journal of Fishery and Aquatic Science, 55: 1430–1442.*

Meye J. A. Ikomi R. B. (2012), Seasonal Fish Abundance and Fishing Gear Efficiency in River Orogodo, Niger Delta, Nigeria. *World Journal of Fish and Marine Sciences 4 (2): 191-200, 2012.*

Millar, R.B. &Fryer R.J. (1999) Estimating the size selection curves of towed gears, traps, nets and hooks. *Reviews in Fish Biology and Fisheries,* JASA

Moses B. S. (1987), The influence of flood regime of fish catch and fish communities of the Cross Rivers flood plan ecosystem, Nigeria." *Environmental biology of fishes 18. No.1 51-65.*

Moses, B. S. (1990) .Distribution, ecology and fisheries potentials of Nigerian wetlands. In: T.V.I. Akpata and D.U.U. Okali (Eds.*) Nigerian wetlands*. UNESCO/MAB. Port Harcourt, Nigeria

National Institute for Freshwater Fisheries Research (NIFFR), (2002) National Surveys of Fishing Gears and Crafts on Nigerian inland water bodies NIFFR Occasional Paper No.4

Nawa I. C. (1982). An ecological study of the Cross Rivers Estuary (Dissertation Kiel University, W. Germany).

Nederaas, K., Soldal, V.S. and Bjordal, A. *(1993*), Performance and biological implications of a multi-gear fishery for Greenland halibut *(Reinhardtius hippoglossoides)*. NAFO Science. Res. Doc. 93/118, 15 pp (mimeo). Nigeria. UNDP/FAO Rome SF:74/NIR6

Newman, S.J. Harvey E. S. Rome, B.M., McLean, D.L. & Skepper, C.L. (2012) Relative efficiency of fishing gears and investigation of resource availability in tropical demersal scalefish fisheries. Fisheries Research Report No. 231. Department of Fisheries, Western Australia

Norwrouzi, S. and H.Valavi (2011), Effects of Environmental Factors on Phytoplankton Abundance and Diversity in Kaftar Lake. *Journal of Fisheries and Aquatic Science, 6,130-140.*

Obande R.A., Omeji S. & Nyam S.K. (2010). Checklist and Assessment of Efficiency of Some Traditional Gears And Crafts Used On River Benue. *Journal of Research in Forestry, Wildlife and Environment 2, No.2, 2010.*

Ogbeibu A. E. and Victor R. (1995), Hydrological studies of water biology in the Okumu Forest (sanctuary) in southern Nigeria, 2. Physical and chemical hydrology, *Tropical fresh water Biology* 4.83-100

Okayi G. Fagade S. Ogbe F. (2005) Metal and mineral Nutrient concentration, in O. niloticus, C. gariepinus and C. Furcatus from Benue Rivers, Makurdi, Nigeria *Journal of Animal research international 2(3) 369-371.*

Okayi R. G. Jeje C. Y and Fagade F. O. (2001). Seasonal patterns in the zooplankton community of river Benue (Makurdi), Nigeria. *African Journal of Environmental Studies. 21): 9 – 19.*

Okereke F. O. (1990) Studies on the fish fauna of Otamiri (unpulished) M.Sc. Thesis in the University of Port Harcourt

Okpokwasili, G.S.C. (1996), Seasonal influence of the organic pollution monitoring of the New Calabar River, Nigeria. Environment Monitoring Assessment, 12(20), 51-54.

Olaosebikan B.D and Aminu Raji (2013) *Field Guide to Nigerian Fresh water Fishes* Revised Edition Renu Thomas Press.

Onuoha,P.C.(2010).Chlorophyll-a dynamics in relation to environmental parameters in a tropical lagoon. *Journal of American Science,6,12-20*

Otobo, A.J.T. (1995), The ecology and fishery of the Pygmy Herring Sierratherissa Leonensis (thys Van Dan Audenacrde (1969) (Clupeidae) in the Nun river and Taylor Creek of the Niger Delta. Ph.D Thesis University of Port Harcourt

Otway, N.M. and Craig, J. R., (1993**),** Effects of hook size on the catches of undersized snapper, *Pagrus auratus.* Marine Ecology. Prog. Ser 93: 9–15.

Pascoe S. Andersen J. and Dewilde J.W. (2001) The impact of Management regulation on the Technical efficiency vessels in Dutch beam trawl fleet. European Rev. Agricultural Economics 28:187-206

Pendergraft B. (2003),.North American Biomes. Rivers and Streams. Bulletin

Punt, A.E., Pulfrich, A., Butterworth, D.S. and Penney, A.P. (1996) The effect of hook size on the size-specific selectivity of hottentot Pachymetopon blochii (Val.) and on yield per recruit. S. Afr. J. Mar. Sci.17:155-172.

Quinn, T. J. Deriso, R.B. and Hoag, S.H. (1985), Methods of population assessment of Pacific halibut. Int. Pac. Halib. Comm. Sci. Rep.*, 72. 52*

Ralston S. (1982) *Influence of hook size in the Hawaiian deep-sea handline fishery. Canadian Journal of Fishery and Aquatic Science,* 39: 1297–1302.

Reed W. John B. Hopson A. J. Jonathan J. & Ibrahim Y. (1967), *Fish and fisheries of Northern Nigeria.* Ministry of Agriculture, northern Nigeria

Reid G. M. & Sydenham H. (1979), A Check list of the lower Benue River and an ichthyo – geographical review of the Benue River resources of Nigeria (west Africa).*Journal of Natural History*. 13: 41-67

Richardson, T.L. C.E. Gibson and S.I. Heaney.(2000). Temperature, growth and seasonal succession of phytoplankton in Lake Baikal. Siberia *Freshwater Biologia, 44,431-440.*

Sætersdal G. (1963), Selectivity of long-lines. *ICNAF Spec. Publ.* 5: 189–192.

Sagua V.O. and F. O. Otobo (1976) .preliminary observation on experimentary trawling for pelagic fish in lake kainji. Nigeria'. *kainji lake Research project* New Bussa.

Sainsbury J. (1996), *Commercial fishing methods*, 3rd edition Oxford. Fishing News Books

Scurlock, J.M.O, Johnson, K, & Olson, R.J.(2002). Estimating Net Primary productivity from grassland biomass dynamics measurement .*Global change Biology,8-736.*

Sikoki F.D. Hart A.l. & Abowei J.F. (1998). Gill net selectivity and abundance in the Lower Nun river Nigeria. *Journal of Applied Science and Environmental Management* 1(1)

Sikoki, F.D.and Veen, J.V. (2004). Aspects of water quality and the potential for fish production of Shiroro Reservoir, Nigeria, Living system Development

Skeide, R. Bjordal A. & Løkkeborg S. (1986). Testing of a new hook design (E-Z-baiter) through comparative long-line fishing trials. ICES CM 1986/B: 25, 13 (mimeo).

Skud, B.E. (1978). Factors affecting long-line catch and effort: I. General review. Int. Pac. Halib. Comm. *Sci. Rep., 64: 5–14.*

Solarin, B.B. (2003). Fishing gear; hook, line and sinker samuda July 2003 [online] Stickney, A. & Robert, R. (1979). *Principles of warm water Aquaculture*. Oxford University Press, USA, [Accessed 20 thMarch 2007] Available on the World Wide Web:336-400. http://www.icf.net/jsp/publication/samudra/pdf/English/issue_35/art 10.pdf

Takeuchi, S. & Koike, A., (1969).The effect of size and shape of hook on the catching efficiency and selection curve of long-line. *Journal of Tokyo Uni. Fish.,* 55:119–124.

Tejerina-Garro F. L. and B. Merona (2001), Gill-net sampling standardisation in large rivers of French Guiana (South America) Bulletin Franc¸ais de la Peche et de la Pisciculture 357–358:227–240.

Teugel, G.G. Reid G.M. & King R.P., (1992) Fishes of the Cross River Basin (Cameroun-Nigeria), Texonomy Zoogeography, ecology and conservation laboratories d'ichthyologie, mussel roayal de I' Afrique centrale, B-3080 Tervuren, belguin

Udolisa & Solaria (1979) Survey of fishing Gear and techniques in Lagos Lagoon. Annual report of NIOMR, 1978/79 – 38.

United State Environmental Protection Agency (USEPA) (2002), Methods for evaluating wetland conditions: using algae to assessenvironmental conditions in wetlands. Office of water, U.S. Environmental Protection Agency, Washington D.C EPA – 822 – R – 02 – 021.

Vanderpuye C.J. (1973*).* Population of clupeids in the Volta lake. *Ghana journal of science. 33: 16-34*

Victor R. & Tettah (1988). Fish communities of perturbed stream,southern Nigeria. *Journal of Tropical Ecolgy; 3 p118-133*

Wardle, C.S. Cui G. Mojsiewiecz W.R. & Glass C.W. (1991). The effect of colour on the appearance of monofilament nylon under water. *Fishery Resources.* 10: 243–253.

Wetzel, R. G. (1983). *Limnology*. Saunders College Publishing, Philadelphia, Pennsylvania, USA

APPENDICES

APPENDIX I

Observed Weight of Selected Species in Benue River
(In Kilograms)

Species	Gear Used				
	Cn	Dn	Gn	Hl	Total
Alestes baremoze	9.1	17.1	16	18.2	60.4
Auchenoglanis biscutatus	1.5	4.6	6	2.1	14.2
Auchenoglanis occidentalis	1.2	6.3	12	3.1	22.6
Bagrus bayad	5.96	18.3	10.6	6.7	41.56
Bagrus filamentosus	0.4	8.8	5.3	0.8	15.3
Brycynus nurse	3.3	X	6	X	9.3
Citharinus citharus	4.7	12.8	5.5	3.05	26.05
Clarias anguiilaris	0.4	19.7	20.5	4.7	45.3
Clarias garipinus	0.2	21.6	14.6	19.4	55.8
Clarotes laticeps	6.4	1.3	4.6	13.4	25.7
Hemichromis bimaculatus	1.12	X	X	X	1.12
Hepsetus odoe	11.6	14.4	25.1	8	59.1
Heterobranchus bidorsalis	X	10.8	28.7	12	41.5
Hydrocynus brevis	6.2	5.3	37.1	18.7	67.3
Labeo coubie	9.6	56.2	26.4	15.1	107.3
Lates niloticus	12.6	20.0	26.6	28.3	89.5
Mormyrus anguilloides	2.7	1.5	6.1	3.1	13.4
Mormyrus macrophthalnus	1.8	13.5	X	X	15.3
Mormyrus rume	2.3	3.2	9.7	X	15.2
Synodontis batensoda	2.3	12.1	2.4	1.2	18
Synodontis clarias	4.8	6.3	9.3	4.1	24.5
Synodontis courteti	X	X	0.3	2.1	2.4
Tilapia zilli	3.1	3.03	3.7	1.4	11.23

Cn= cast net, Dn= Drag net, Gsn= Gill net, Hlh= Hook and line

APPENDIX II

Frequency of Fish Species Occurance For the 4 Gears Used

---------------------------- Geartype=Cast Season=1* ------------------------------------

The FREQ Procedure

Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	131	8.94	131	8.94
Alestes dantex	14	0.96	145	9.90
Alestes macrolepideth	5	0.34	150	10.24
Auchenoglanis occidentalis	15	1.02	165	11.26
Bagrus bajad	32	2.18	197	13.45
Bagrus filamentosus	9	0.61	206	14.06
Brycinus nurse	114	7.78	320	21.84
Chrysichthys auratus	15	1.02	335	22.87
Chrysichthys nigrodigitatus	16	1.09	351	23.96
Citharinus citharus	72	4.91	423	28.87
Clarias anguillaris	6	0.41	429	29.28
Clarias lazera	6	0.41	435	29.69
Clarotes laticeps	99	6.76	534	36.45
Distichodus brevipinnis	10	0.68	544	37.13
Distichodus rostratus	18	1.23	562	38.36
Haplochromis bloyeti	20	1.37	582	39.73
Hemichromis bimaculatus	18	1.23	600	40.96
Hepsetus odoe	16	1.09	616	42.05
Heterobranchus bidorsalis	14	0.96	630	43.00
Heterotis niloticus	17	1.16	647	44.16
Hydrocynus brevis	39	2.66	686	46.83
Hydrocynus forskalii	52	3.55	738	50.38
Hydrocynus vittatus	10	0.68	748	51.06
Labeo coubie	20	1.37	768	52.42
Labeo parvus	37	2.53	805	54.95
Lates niloticus	48	3.28	853	58.23
Marcusenius mento	35	2.39	888	60.61
Marcusenius senegalensis	27	1.84	915	62.46
Mastercembelus	2	0.14	917	62.59
Mormyrops anguilloides	9	0.61	926	63.21
Mormyrops caballus	54	3.69	980	66.89
Mormyrus macrophthalmus	18	1.23	998	68.12
Mormyrus rume rume	20	1.37	1018	69.49
Nannocharax fasciatus	1	0.07	1019	69.56
Oreochromis aureus	13	0.89	1032	70.44
Oreochromis niloticus	12	0.82	1044	71.26
Pantodon buchholzi	5	0.34	1049	71.60
Phago loricatus	18	1.23	1067	72.83
Schilbe intermedius	25	1.71	1092	74.54
Schilbe mystus	21	1.43	1113	75.97
Synodontis batensoda	107	7.30	1220	83.28
Synodontis budgetti	31	2.12	1251	85.39
Synodontis clarias	83	5.67	1334	91.06
Synodontis sorex	16	1.09	1350	92.15
Tilapia zillii	115	7.85	1465	100.00

Season 1*= Dry season

Season 2*= Wet season

------------------------------------ Geartype=Cast Season=2* ------------------------------------

The FREQ Procedure

Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	104	7.87	104	7.87
Arius gigas	36	2.73	140	10.60
Auchenoglanis biscutatus	33	2.50	173	13.10
Bagrus docmak	8	0.61	181	13.70
Bagrus filamentosus	8	0.61	189	14.31
Barbus ablabes	5	0.38	194	14.69
Brycinus brevis	14	1.06	208	15.75
Brycinus macrolepidotus	16	1.21	224	16.96
Brycinus nurse	4	0.30	228	17.26
Chromidotilapia guentheri	11	0.83	239	18.09
Chrysichthys auratus	37	2.80	276	20.89
Chrysichthys nigrodigitatus	7	0.53	283	21.42
Citharinus citharus	14	1.06	297	22.48
Clarias albopunctatus	5	0.38	302	22.86
Clarias gariepinus	3	0.23	305	23.09
Clarotes laticeps	46	3.48	351	26.57
Cynothrissa mento	16	1.21	367	27.78
Distichodus brevipinnis	5	0.38	372	28.16
Distichodus engycephalus	4	0.30	376	28.46
Distichodus rostratus	4	0.30	380	28.77
Gymnarchus niloticus	3	0.23	383	28.99
Haplochromis bloyeti	18	1.36	401	30.36
Hemichromis bimaculatus	70	5.30	471	35.65
Hepsetus odoe	73	5.53	544	41.18
Heterotis niloticus	41	3.10	585	44.28
Hydrocynus brevis	16	1.21	601	45.50
Hydrocynus forskalii	41	3.10	642	48.60
Hydrocynus vittatus	35	2.65	677	51.25
Labeo coubie	27	2.04	704	53.29
Labeo senegalensis	26	1.97	730	55.26
Lates niloticus	102	7.72	832	62.98
Leptocypris niloticus	19	1.44	851	64.42
Marcusenius abadii	35	2.65	886	67.07
Marcusenius senegalensis	14	1.06	900	68.13
Micralestes humilis	9	0.68	909	68.81
Mormyrops anguilloides	44	3.33	953	72.14
Mormyrops caballus	32	2.42	985	74.56
Mormyrus hasselquistii	3	0.23	988	74.79
Mormyrus macrophthalmus	3	0.23	991	75.02
Mormyrus rume rume	77	5.83	1068	80.85
Protopterus annectens	2	0.15	1070	81.00
Schilbe intermedius	30	2.27	1100	83.27
Synodontis batensoda	31	2.35	1131	85.62
Synodontis budgetti	18	1.36	1149	86.98
Synodontis clarias	57	4.31	1206	91.29
Synodontis eupterus	19	1.44	1225	92.73
Synodontis nigrita	29	2.20	1254	94.93
Tilapia zillii	67	5.07	1321	100.00

Season 1*= Dry season

Season 2*= Wet season

------------------------------------ Geartype=Drag Season=1 -------------------------------
-----

The FREQ Procedure
Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	67	5.01	67	5.01
Arius gigas	6	0.45	73	5.46
Auchenoglanis biscutatus	73	5.46	146	10.93
Auchenoglanis occidentalis	11	0.82	157	11.75
Bagrus bajad	31	2.32	188	14.07
Bagrus filamentosus	1	0.07	189	14.15
Campylomormyrus tamandua	9	0.67	198	14.82
Chrysichthys auratus	4	0.30	202	15.12
Chrysichthys nigrodigitatus	17	1.27	219	16.39
Citharidium ansorgii	3	0.22	222	16.62
Citharinus citharus	7	0.52	229	17.14
Clarias anguillaris	87	6.51	316	23.65
Clarias gariepinus	37	2.77	353	26.42
Clarias macromystax	4	0.30	357	26.72
Clarotes laticeps	4	0.30	361	27.02
Distichodus brevipinnis	20	1.50	381	28.52
Distichodus engycephalus	7	0.52	388	29.04
Distichodus rostratus	21	1.57	409	30.61
Gnathonemus petersii	34	2.54	443	33.16
Gymnarchus niloticus	13	0.97	456	34.13
Hepsetus odoe	34	2.54	490	36.68
Heterobranchus bidorsalis	68	5.09	558	41.77
Heterobranchus longifilis	21	1.57	579	43.34
Heterotis niloticus	26	1.95	605	45.28
Hydrocynus brevis	50	3.74	655	49.03
Hydrocynus forskalii	34	2.54	689	51.57
Hyperopisus bebe bebe	43	3.22	732	54.79
Labeo coubie	66	4.94	798	59.73
Labeo parvus	35	2.62	833	62.35
Lates niloticus	31	2.32	864	64.67
Mormyrops caballus	9	0.67	873	65.34
Mormyrus macrophthalmus	29	2.17	902	67.51
Mormyrus rume rume	35	2.62	937	70.13
Oreochromis aureus	52	3.89	989	74.03
Schilbe mystus	48	3.59	1037	77.62
Synodontis batensoda	3	0.22	1040	77.84
Synodontis clarias	86	6.44	1126	84.28
Synodontis membranaceus	59	4.42	1185	88.70
Synodontis nigrita	32	2.40	1217	91.09
Tetraodon lineatus	2	0.15	1219	91.24
Tilapia zillii	117	8.76	1336	100.00

Season 1*= Dry season

Season 2*= Wet season

------------------------------------ Geartype=Drag Season=2 -------------------------------------

The FREQ Procedure
Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Arius gigas	2	0.31	2	0.31
Auchenoglanis occidentalis	32	5.03	34	5.35
Bagrus bajad	38	5.97	72	11.32
Bagrus filamentosus	93	14.62	165	25.94
Chrysichthys auratus	6	0.94	171	26.89
Chrysichthys nigrodigitatus	25	3.93	196	30.82
Citharidium ansorgii	6	0.94	202	31.76
Citharinus latus	6	0.94	208	32.70
Clarias gariepinus	24	3.77	232	36.48
Clarotes laticeps	2	0.31	234	36.79
Distichodus brevipinnis	4	0.63	238	37.42
Gymnarchus niloticus	5	0.79	243	38.21
Hepsetus odoe	33	5.19	276	43.40
Heterobranchus longifilis	31	4.87	307	48.27
Heterotis niloticus	19	2.99	326	51.26
Hydrocynus brevis	4	0.63	330	51.89
Hydrocynus forskalii	26	4.09	356	55.97
Labeo coubie	19	2.99	375	58.96
Lates niloticus	2	0.31	377	59.28
Mormyrops anguilloides	40	6.29	417	65.57
Mormyrus macrophthalmus	36	5.66	453	71.23
Mormyrus rume rume	2	0.31	455	71.54
Protopterus annectens	12	1.89	467	73.43
Schilbe mystus	30	4.72	497	78.14
Synodontis batensoda	71	11.16	568	89.31
Tilapia zillii	68	10.69	636	100.00

------------------------------------ Geartype=Gill Season=1 -------------------------------------

The FREQ Procedure
Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	41	10.38	41	10.38
Alestes dantex	11	2.78	52	13.16
Auchenoglanis occidentalis	30	7.59	82	20.76
Bagrus bajad	3	0.76	85	21.52
Bagrus filamentosus	5	1.27	90	22.78
Brycinus brevis	2	0.51	92	23.29
Brycinus nurse	2	0.51	94	23.80
Chromidotilapia guentheri	2	0.51	96	24.30
Chrysichthys auratus	5	1.27	101	25.57
Chrysichthys nigrodigitatus	10	2.53	111	28.10
Citharinus citharus	22	5.57	133	33.67
Citharinus latus	4	1.01	137	34.68
Clarias anguillaris	2	0.51	139	35.19
Clarias gariepinus	3	0.76	142	35.95
Clarotes laticeps	10	2.53	152	38.48
Distichodus brevipinnis	11	2.78	163	41.27
Distichodus engycephalus	11	2.78	174	44.05
Gymnarchus niloticus	7	1.77	181	45.82
Hepsetus odoe	14	3.54	195	49.37
Heterobranchus bidorsalis	3	0.76	198	50.13
Hydrocynus brevis	29	7.34	227	57.47
Hydrocynus forskalii	3	0.76	230	58.23
Labeo coubie	11	2.78	241	61.01
Labeo parvus	1	0.25	242	61.27
Lates niloticus	11	2.78	253	64.05
Mormyrops anguilloides	18	4.56	271	68.61
Mormyrops caballus	5	1.27	276	69.87
Mormyrus hasselquistii	1	0.25	277	70.13
Mormyrus rume rume	5	1.27	282	71.39
Protopterus annectens	4	1.01	286	72.41
Schilbe mystus	12	3.04	298	75.44
Synodontis budgetti	12	3.04	310	78.48
Synodontis clarias	31	7.85	341	86.33
Synodontis filamentosus	2	0.51	343	86.84
Synodontis nigrita	13	3.29	356	90.13
Synodontis sorex	2	0.51	358	90.63
Tetraodon lineatus	1	0.25	359	90.89
Tilapia dageti	5	1.27	364	92.15
Tilapia zillii	31	7.85	395	100.00

------------------------------------ Geartype=Gill Season=2 ------------------------------------

The FREQ Procedure
Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	19	4.66	19	4.66
Alestes dantex	3	0.74	22	5.39
Auchenoglanis biscutatus	10	2.45	32	7.84
Auchenoglanis occidentalis	14	3.43	46	11.27
Bagrus bajad	11	2.70	57	13.97
Brycinus nurse	11	2.70	68	16.67
Chrysichthys auratus	8	1.96	76	18.63
Chrysichthys nigrodigitatus	5	1.23	81	19.85
Citharinus citharus	4	0.98	85	20.83
Clarias anguillaris	24	5.88	109	26.72
Clarias gariepinus	7	1.72	116	28.43
Clarias lazera	2	0.49	118	28.92
Clarotes laticeps	13	3.19	131	32.11
Distichodus brevipinnis	8	1.96	139	34.07
Distichodus engycephalus	3	0.74	142	34.80
Gymnarchus niloticus	9	2.21	151	37.01
Hepsetus odoe	14	3.43	165	40.44
Heterobranchus bidorsalis	15	3.68	180	44.12
Heterobranchus longifilis	7	1.72	187	45.83
Heterotis niloticus	15	3.68	202	49.51
Hydrocynus brevis	39	9.56	241	59.07
Hydrocynus vittatus	12	2.94	253	62.01
Labeo coubie	19	4.66	272	66.67
Lates niloticus	27	6.62	299	73.28
Malapterurus electricus	4	0.98	303	74.26
Mormyrops anguilloides	3	0.74	306	75.00
Mormyrus rume rume	11	2.70	317	77.70
Oreochromis niloticus	18	4.41	335	82.11
Schilbe mystus	3	0.74	338	82.84
Synodontis batensoda	15	3.68	353	86.52
Synodontis budgetti	14	3.43	367	89.95
Synodontis clarias	33	8.09	400	98.04
Synodontis courteti	6	1.47	406	99.51
Tilapia zillii	2	0.49	408	100.00

------------------------------------ Geartype=Hook Season=1 ------------------------------------

The FREQ Procedure
Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	6	5.77	6	5.77
Auchenoglanis occidentalis	5	4.81	11	10.58
Bagrus bajad	16	15.38	27	25.96
Chrysichthys nigrodigitatus	2	1.92	29	27.88
Clarias anguillaris	14	13.46	43	41.35
Clarias gariepinus	2	1.92	45	43.27
Clarotes laticeps	6	5.77	51	49.04
Distichodus rostratus	4	3.85	55	52.88
Gymnarchus niloticus	1	0.96	56	53.85
Hepsetus odoe	4	3.85	60	57.69
Hydrocynus brevis	7	6.73	67	64.42
Labeo coubie	6	5.77	73	70.19
Lates niloticus	3	2.88	76	73.08
Mormyrops anguilloides	3	2.88	79	75.96
Protopterus annectens	2	1.92	81	77.88
Synodontis batensoda	3	2.88	84	80.77
Synodontis courteti	20	19.23	104	100.00

Season 1*= Dry season

Season 2*= Wet season

------------------------------------ Geartype=Hook Season=2 --------------------------------
-----

The FREQ Procedure
Fishspecies

Fishspecies	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Alestes baremoze	37	19.68	37	19.68
Auchenoglanis biscutatus	4	2.13	41	21.81
Bagrus bajad	7	3.72	48	25.53
Bagrus filamentosus	2	1.06	50	26.60
Brycinus macrolepidotus	1	0.53	51	27.13
Chrysichthys auratus	4	2.13	55	29.26
Citharinus citharus	11	5.85	66	35.11
Clarias anguillaris	4	2.13	70	37.23
Clarias gariepinus	12	6.38	82	43.62
Clarotes laticeps	9	4.79	91	48.40
Distichodus brevipinnis	1	0.53	92	48.94
Distichodus rostratus	1	0.53	93	49.47
Gymnarchus niloticus	3	1.60	96	51.06
Hepsetus odoe	11	5.85	107	56.91
Heterobranchus bidorsalis	1	0.53	108	57.45
Hydrocynus brevis	22	11.70	130	69.15
Labeo coubie	9	4.79	139	73.94
Lates niloticus	13	6.91	152	80.85
Protopterus annectens	4	2.13	156	82.98
Synodontis clarias	19	10.11	175	93.09
Tilapia zillii	13	6.91	188	100.00

Season 1*= Dry season

Season 2*= Wet season

APPENDIX III

Effects of Physical and Chemical Parameters on the Fish Count

Relationship between fish count and physiochem par

-- Geartype=Cast ---

The CORR Procedure

5 Variables: Fishcount Turbidity Temp PH DO
Freq Variable: Month

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Fishcount	1161	16.86047	18.08232	19575	1.00000	114.00000	Fishcount
Turbidity	1161	37.10853	13.33308	43083	25.00000	69.00000	Turbidity
Temp	1161	25.67786	4.00490	29812	20.00000	32.00000	Temp
PH	1161	7.27054	0.80989	8441	6.40000	8.40000	PH
DO	1161	8.38096	2.33143	9730	5.00000	11.40000	DO

Pearson Correlation Coefficients, N = 1161
Prob > |r| under H0: Rho=0

	Fishcount	Turbidity	Temp	PH	DO
Fishcount Fishcount	1.00000	0.06404 0.0291	-0.40517 <.0001	0.31688 <.0001	0.03654 0.2135
Turbidity Turbidity	0.06404 0.0291	1.00000	-0.08586 0.0034	0.65591 <.0001	-0.03715 0.2059
Temp Temp	-0.40517 <.0001	-0.08586 0.0034	1.00000	-0.61058 <.0001	-0.43133 <.0001
PH PH	0.31688 <.0001	0.65591 <.0001	-0.61058 <.0001	1.00000	0.24980 <.0001
DO DO	0.03654 0.2135	-0.03715 0.2059	-0.43133 <.0001	0.24980 <.0001	1.00000

Relationship between fish count and physiochem par

-- Geartype=Drag ---

The CORR Procedure

5 Variables: Fishcount Turbidity Temp PH DO
Freq Variable: Month

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Fishcount	680	16.58824	17.41264	11280	1.00000	93.00000	Fishcount
Turbidity	680	45.35735	15.23958	30843	25.00000	69.00000	Turbidity
Temp	680	24.79118	4.08170	16858	20.00000	32.00000	Temp
PH	680	7.68544	0.73545	5226	6.40000	8.40000	PH
DO	680	9.11868	1.65755	6201	5.00000	11.00000	DO

Pearson Correlation Coefficients, N = 680
Prob > |r| under H0: Rho=0

	Fishcount	Turbidity	Temp	PH	DO
Fishcount Fishcount	1.00000	-0.06649 0.0832	-0.40885 <.0001	0.35910 <.0001	0.14587 0.0001
Turbidity Turbidity	-0.06649 0.0832	1.00000	0.45451 <.0001	0.29580 <.0001	-0.64547 <.0001
Temp Temp	-0.40885 <.0001	0.45451 <.0001	1.00000	-0.24622 <.0001	-0.36587 <.0001
PH PH	0.35910 <.0001	0.29580 <.0001	-0.24622 <.0001	1.00000	0.00229 0.9525
DO DO	0.14587 0.0001	-0.64547 <.0001	-0.36587 <.0001	0.00229 0.9525	1.00000

Relationship between fish count and physiochem par

--------------------------------------- Geartype=Gill ------------------------------------
-----

The CORR Procedure

5 Variables: Fishcount Turbidity Temp PH DO
Freq Variable: Month

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Fishcount Fishcount	957	5.42006	3.79594	5187	1.00000	23.00000	
Turbidity Turbidity	957	39.53814	15.22103	37838	25.00000	69.00000	
Temp	957	26.10658	4.15308	24984	20.00000	32.00000	Temp
PH	957	7.33981	0.82590	7024	6.40000	8.40000	PH
DO	957	8.02675	2.28805	7682	5.00000	11.40000	DO

Pearson Correlation Coefficients, N = 957
Prob > |r| under H0: Rho=0

	Fishcount	Turbidity	Temp	PH	DO
Fishcount Fishcount	1.00000	-0.14064 <.0001	-0.25717 <.0001	0.09529 0.0032	0.18463 <.0001
Turbidity Turbidity	-0.14064 <.0001	1.00000	0.10294 0.0014	0.61312 <.0001	0.00282 0.9305
Temp Temp	-0.25717 <.0001	0.10294 0.0014	1.00000	-0.49821 <.0001	-0.54178 <.0001
PH PH	0.09529 0.0032	0.61312 <.0001	-0.49821 <.0001	1.00000	0.39183 <.0001
DO DO	0.18463 <.0001	0.00282 0.9305	-0.54178 <.0001	0.39183 <.0001	1.00000

Relationship between fish count and physiochem par

-- Geartype=Hook ---

The CORR Procedure

5 Variables: Fishcount Turbidity Temp PH DO
Freq Variable: Month

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Fishcount	576	4.61979	3.76984	2661	1.00000	20.00000	Fishcount
Turbidity	576	35.83507	9.95567	20641	25.00000	69.00000	Turbidity
Temp	576	24.35417	3.99864	14028	20.00000	32.00000	Temp
PH	576	7.35625	0.76091	4237	6.40000	8.40000	PH
DO	576	8.57951	2.18982	4942	5.00000	11.40000	DO

Pearson Correlation Coefficients, N = 576
Prob > |r| under H0: Rho=0

	Fishcount	Turbidity	Temp	PH	DO
Fishcount Fishcount	1.00000	0.13442 0.0012	-0.32009 <.0001	0.34486 <.0001	0.24916 <.0001
Turbidity Turbidity	0.13442 0.0012	1.00000	-0.37808 <.0001	0.69540 <.0001	-0.02492 0.5506
Temp Temp	-0.32009 <.0001	-0.37808 <.0001	1.00000	-0.80130 <.0001	-0.43088 <.0001
PH PH	0.34486 <.0001	0.69540 <.0001	-0.80130 <.0001	1.00000	0.28196 <.0001
DO DO	0.24916 <.0001	-0.02492 0.5506	-0.43088 <.0001	0.28196 <.0001	1.00000

APPENDIX IV

Effects of Physical and Chemical parameters on fish abundance

Relationship between fish abundance & physiochem parameters by season.

--- Season=1 ---

The CORR Procedure

5 Variables: Fishcount Turbidity Temp PH DO

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Fishcount Fishcount	270	12.22222	14.06896	3300	1.00000	114.00000	
Turbidity Turbidity	270	56.71852	11.49990	15314	41.00000	69.00000	
Temp	270	26.22963	4.18519	7082	20.00000	32.00000	Temp
PH	270	7.85333	0.57910	2120	6.70000	8.40000	PH
DO	270	7.78444	1.01005	2102	5.80000	9.00000	DO

Pearson Correlation Coefficients, N = 270
Prob > |r| under H0: Rho=0

	Fishcount	Turbidity	Temp	PH	DO
Fishcount	1.00000	-0.33308	-0.24981	0.11567	0.22946
Fishcount		<.0001	<.0001	0.0577	0.0001
Turbidity	-0.33308	1.00000	0.79181	-0.32965	-0.41740
Turbidity	<.0001		<.0001	<.0001	<.0001
Temp	-0.24981	0.79181	1.00000	0.18850	-0.38416
Temp	<.0001	<.0001		0.0019	<.0001
PH	0.11567	-0.32965	0.18850	1.00000	0.45254
PH	0.0577	<.0001	0.0019		<.0001
DO	0.22946	-0.41740	-0.38416	0.45254	1.00000
DO	0.0001	<.0001	<.0001	<.0001	

Relationship between fish abundance & physiochem parameters by season.

--- Season=2 ---

The CORR Procedure

5 Variables: Fishcount Turbidity Temp PH DO

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Fishcount Fishcount	250	10.21200	12.57360	2553	1.00000	93.00000	
Turbidity Turbidity	250	30.40400	6.24795	7601	25.00000	41.00000	
Temp	250	26.32800	3.34922	6582	21.00000	30.00000	Temp
PH	250	7.02800	0.80989	1757	6.40000	8.40000	PH
DO	250	8.26320	2.72339	2066	5.00000	11.40000	DO

Season 1*= Dry season

Season 2*= Wet season

Pearson Correlation Coefficients, N = 250
Prob > |r| under H0: Rho=0

	Fishcount	Turbidity	Temp	PH	DO
Fishcount	1.00000	0.33186	-0.30092	0.33649	0.10206
Fishcount		<.0001	<.0001	<.0001	0.1074
Turbidity	0.33186	1.00000	-0.96250	0.99396	0.42206
Turbidity	<.0001		<.0001	<.0001	<.0001
Temp	-0.30092	-0.96250	1.00000	-0.96429	-0.63446
Temp	<.0001	<.0001		<.0001	<.0001
PH	0.33649	0.99396	-0.96429	1.00000	0.43786
PH	<.0001	<.0001	<.0001		<.0001
DO	0.10206	0.42206	-0.63446	0.43786	1.00000
DO	0.1074	<.0001	<.0001	<.0001	

Season 1*= Dry season

Season 2*= Wet season

APPENDIX V

Maximum and Minimum lengths Observed for Gears (Using Powell Wetherall Plot)

Cast net

FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:41:25 PM

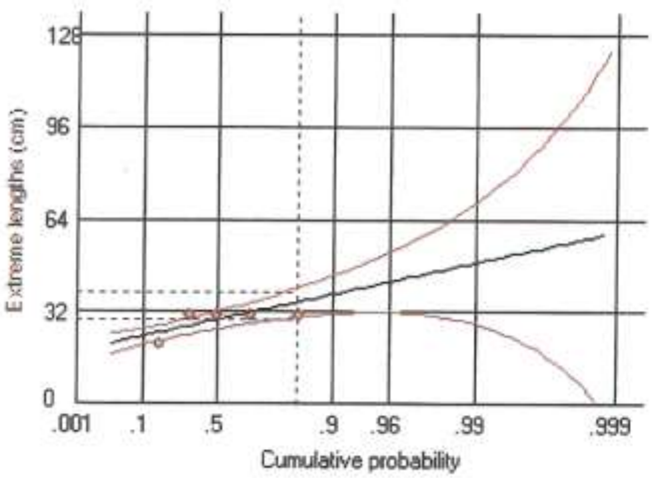
File ----------------

Filename:	C:\Program Files\FiSAT II\Latcast.lfq
Species name:	Lates niloticus
Other identifier:	Cast net, Benue R.
Number of samples:	5
Unit of measurement:	cm

Results ---------

Observed extreme length:	31.00 cm
Predicted extreme length:	34.45 cm
Range at 95% confidence interval:	29.74 - 39.17 cm

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:42:40 PM

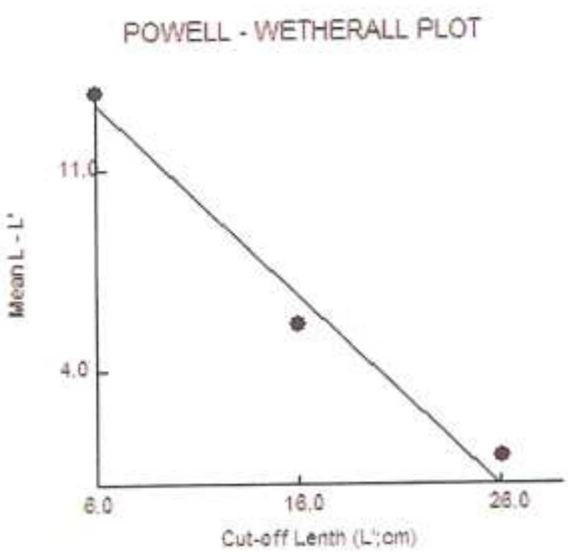
File ----------------

Filename:	C:\Program Files\FiSAT II\Latcast.lfq
Species name:	Lates niloticus
Other identifier:	Cast net, Benue R.
Number of samples:	5
Unit of measurement:	cm

Results ---------

Estimate of Loo:	31.90
Estimate of Z/K:	0.499
Function:	Y =21.28 + (-0.667)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:54:42 PM

File ----------------

Filename:	C:\Program Files\FiSAT II\Tilcast.lfq
Species name:	Tilapia zilli
Other identifier:	Cast net, Benue R.
Number of samples:	6
Unit of measurement:	cm

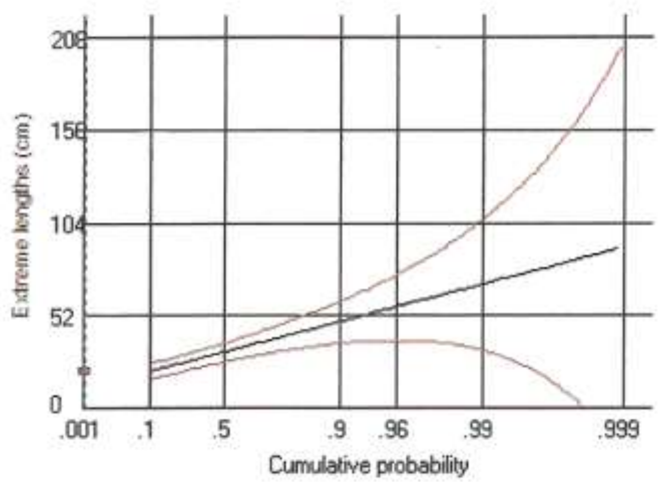
Results ---------

Observed extreme length:

Predicted extreme length:

Range at 95% confidence interval:

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:53:58 PM

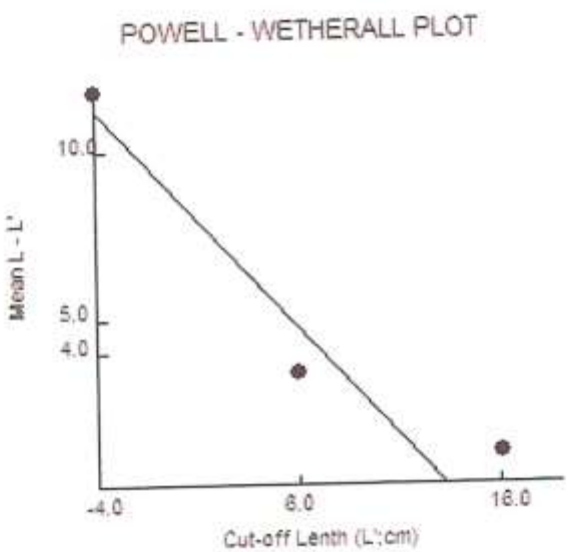
File ----------------

Filename:	C:\Program Files\FiSAT II\Tilcast.lfq
Species name:	Tilapia zilli
Other identifier:	Cast net, Benue R.
Number of samples:	6
Unit of measurement:	cm

Results ---------

Estimate of Loo:	19.44
Estimate of Z/K:	0.539
Function:	Y =12.63 + (-0.650)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:45:37 PM

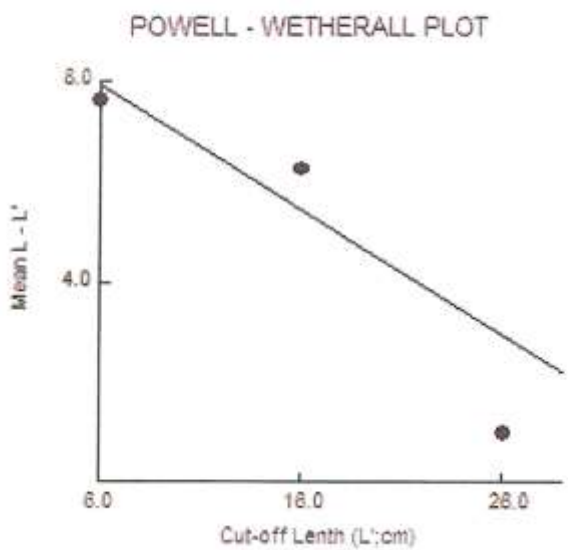
File ----------------

Filename:	C:\Program Files\FiSAT II\Clarocast.lfq
Species name:	Clarotes laticeps
Other identifier:	Cast net
Number of samples:	4
Unit of measurement:	cm

Results ---------

Estimate of Loo:	47.50
Estimate of Z/K:	2.488
Function:	Y =13.62 + (-0.287)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:45:37 PM

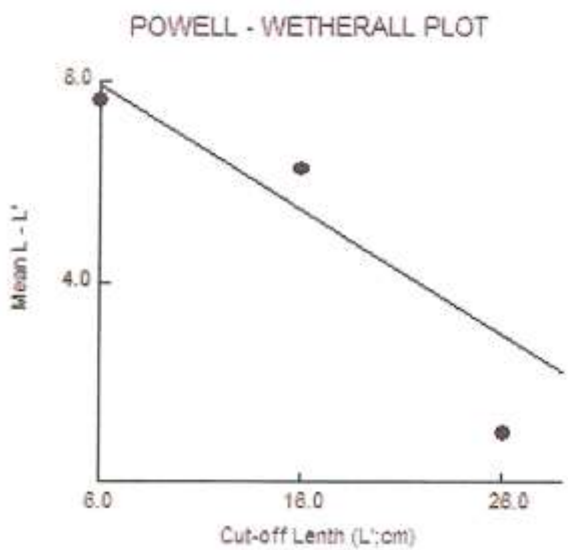
File ----------------

Filename:	C:\Program Files\FiSAT II\Clarocast.lfq
Species name:	Clarotes laticeps
Other identifier:	Cast net
Number of samples:	4
Unit of measurement:	cm

Results ---------

Estimate of Loo:	47.50
Estimate of Z/K:	2.488
Function:	Y =13.62 + (-0.287)* X

Plot ---------------



Drag Net

FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:36:23 PM

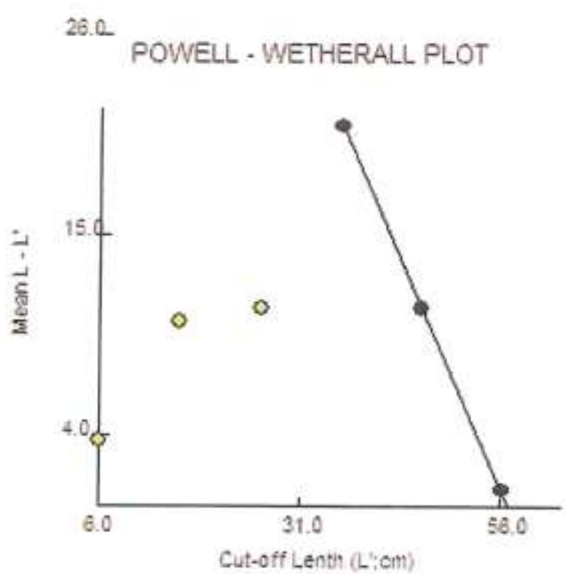
File ----------------

Filename:	C:\Program Files\FiSAT II\Bagdra.lfq
Species name:	Bagrus filamentosus
Other identifier:	Drag net, Benue R.
Number of samples:	2
Unit of measurement:	cm

Results ---------

Estimate of Loo:	61.00
Estimate of Z/K:	0.000
Function:	Y =61.00 + (-1.000)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:12:58 PM

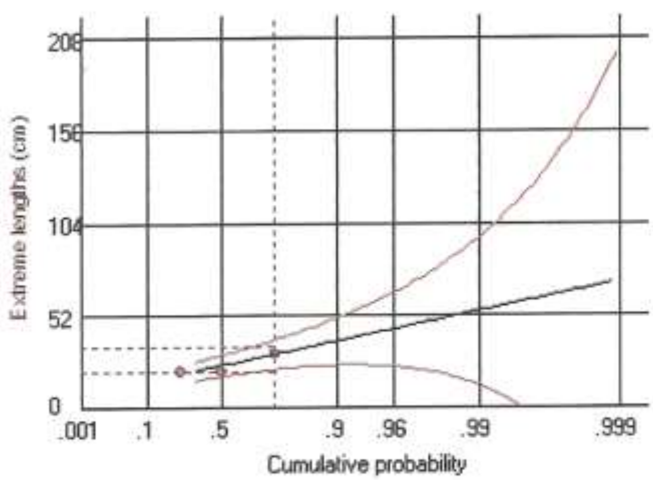
File ----------------

Filename:	C:\Program Files\FiSAT II\Synodra.lfq
Species name:	Synodontis clarias
Other identifier:	Drag net, Benue R.
Number of samples:	3
Unit of measurement:	cm

Results ---------

Observed extreme length:	31.00 cm
Predicted extreme length:	27.86 cm
Range at 95% confidence interval:	20.58 - 35.13 cm

Plot ----------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:20:37 PM

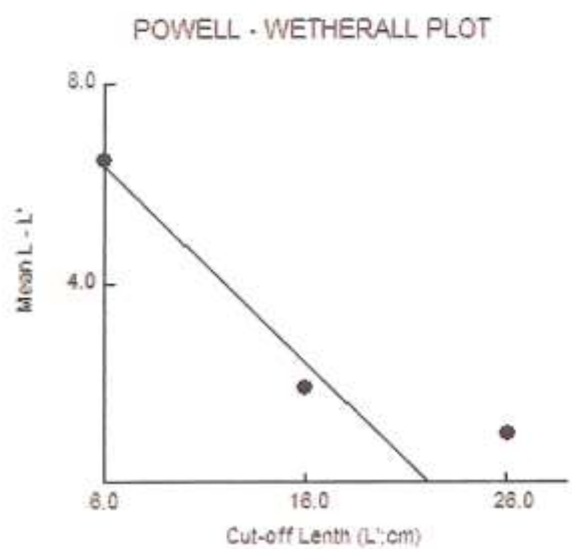
File ----------------

Filename:	C:\Program Files\FiSAT II\Synodra.lfq
Species name:	Synodontis clarias
Other identifier:	Drag net, Benue R.
Number of samples:	3
Unit of measurement:	cm

Results ---------

Estimate of Loo:	32.23
Estimate of Z/K:	1.536
Function:	Y =12.71 + (-0.394)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:32:37 PM

File ----------------

Filename:	C:\Program Files\FiSAT II\Cladra.lfq
Species name:	Clarias anguillaris
Other identifier:	Drag net, Benue R.
Number of samples:	2
Unit of measurement:	cm

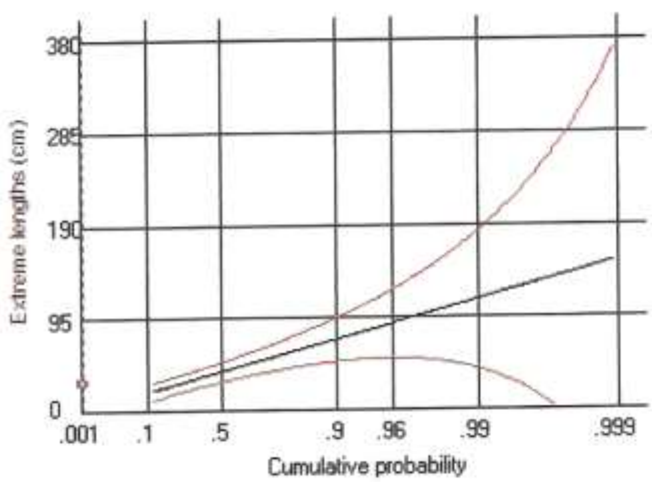
Results ---------

Observed extreme length:

Predicted extreme length:

Range at 95% confidence interval:

Plot ----------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:39:13 PM

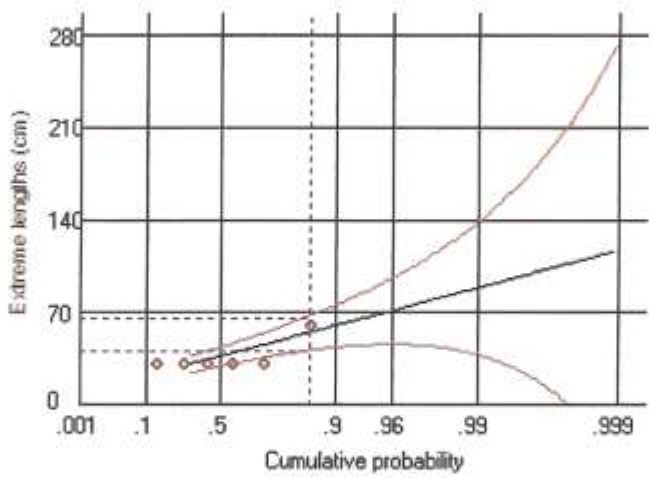
File ----------------

Filename:	C:\Program Files\FiSAT II\Hydrogil.lfq
Species name:	Hydrocynos brevis
Other identifier:	Gill net Benue R.
Number of samples:	6
Unit of measurement:	cm

Results ---------

Observed extreme length:	61.00 cm
Predicted extreme length:	53.10 cm
Range at 95% confidence interval:	40.78 - 65.42 cm

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:40:20 PM

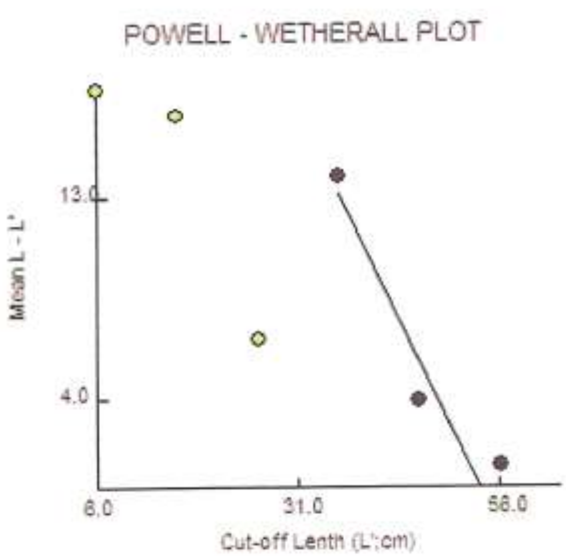
File ----------------

Filename:	C:\Program Files\FiSAT II\Hydrogil.lfq
Species name:	Hydrocynos brevis
Other identifier:	Gill net Benue R.
Number of samples:	6
Unit of measurement:	cm

Results ---------

Estimate of Loo:	58.94
Estimate of Z/K:	0.337
Function:	Y =44.09 + (-0.748)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:47:40 PM

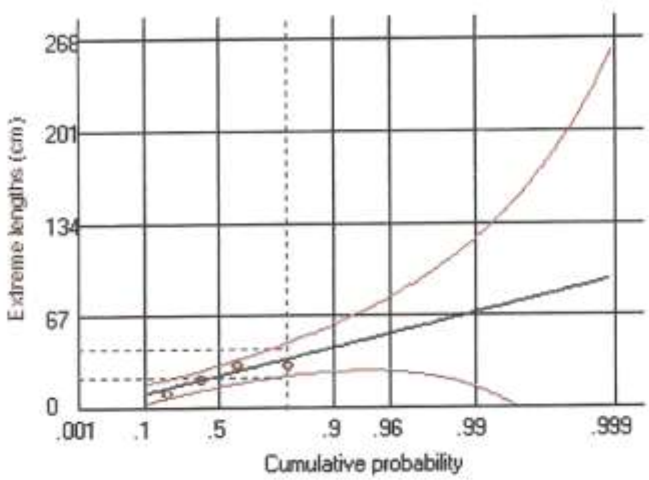
File ----------------

Filename:	C:\Program Files\FiSAT II\Augil.lfq
Species name:	Auchenoglanis occidentalis
Other identifier:	Gill net, Benue R.
Number of samples:	4
Unit of measurement:	cm

Results ---------

Observed extreme length:	31.00 cm
Predicted extreme length:	32.88 cm
Range at 95% confidence interval:	22.07 - 43.68 cm

Plot ----------------



Set Gill Net

FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:39:13 PM

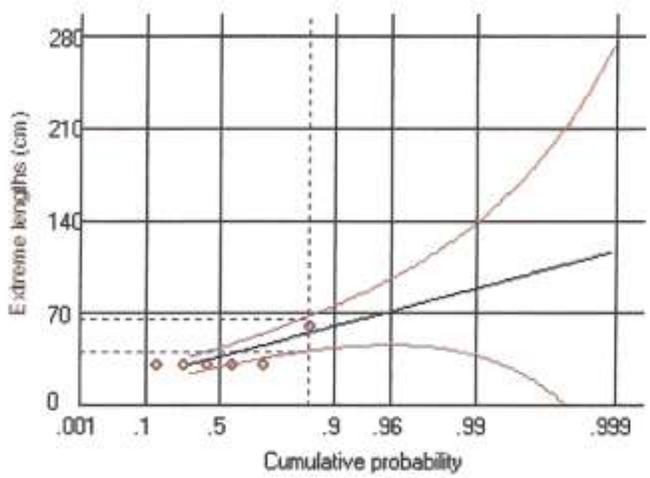
File ----------------

Filename:	C:\Program Files\FiSAT II\Hydrogil.lfq
Species name:	Hydrocynos brevis
Other identifier:	Gill net Benue R.
Number of samples:	6
Unit of measurement:	cm

Results ---------

Observed extreme length:	61.00 cm
Predicted extreme length:	53.10 cm
Range at 95% confidence interval:	40.78 - 65.42 cm

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:47:01 PM

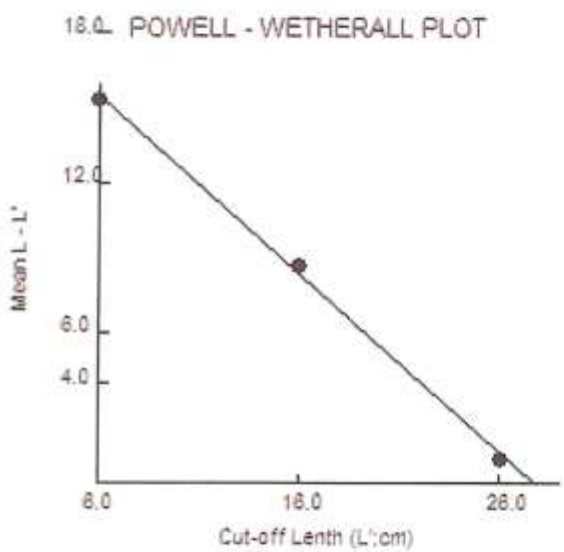
File ----------------

Filename:	C:\Program Files\FiSAT II\Augil.lfq
Species name:	Auchenoglanis occidentalis
Other identifier:	Gill net, Benue R.
Number of samples:	4
Unit of measurement:	cm

Results ---------

Estimate of Loo:	33.32
Estimate of Z/K:	0.404
Function:	Y =23.73 + (-0.712)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:48:26 PM

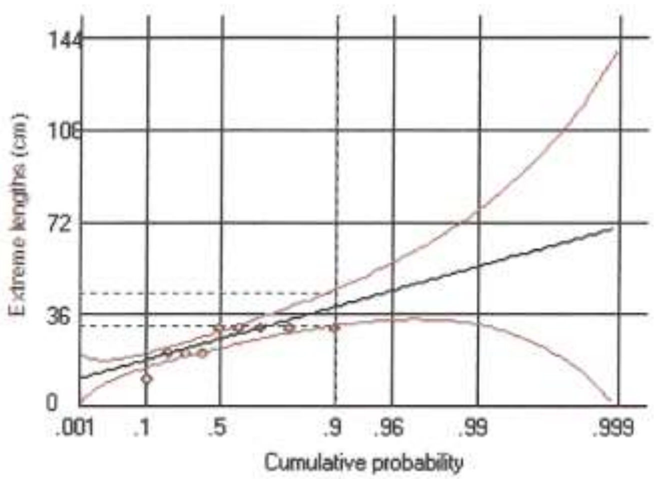
File ----------------

Filename:	C:\Program Files\FiSAT II\Alesgil.lfq
Species name:	Alestes baremoze
Other identifier:	Gill net, Benue R.
Number of samples:	9
Unit of measurement:	cm

Results ---------

Observed extreme length:	31.00 cm
Predicted extreme length:	38.13 cm
Range at 95% confidence interval:	31.41 - 44.85 cm

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:49:17 PM

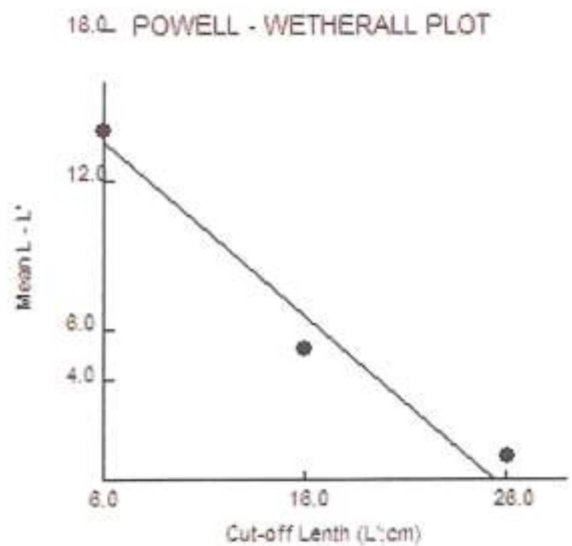
File ----------------

Filename:	C:\Program Files\FiSAT II\Alesgil.lfq
Species name:	Alestes baremoze
Other identifier:	Gill net, Benue R.
Number of samples:	9
Unit of measurement:	cm

Results ---------

Estimate of Loo:	31.16
Estimate of Z/K:	0.439
Function:	Y =21.65 + (-0.695)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:49:17 PM

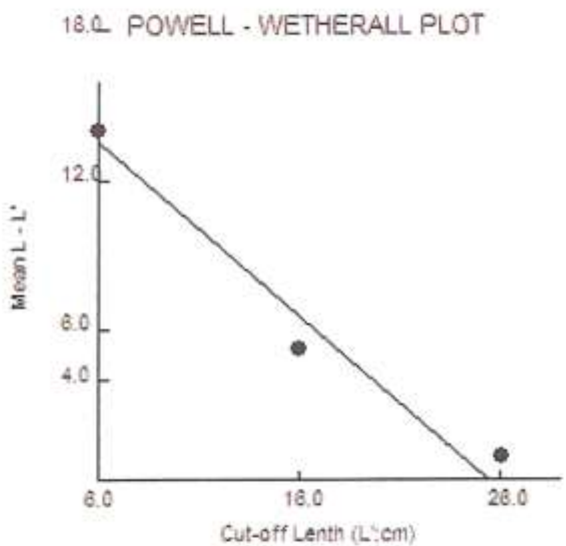
File ---------------

Filename:	C:\Program Files\FiSAT II\Alesgil.lfq
Species name:	Alestes baremoze
Other identifier:	Gill net, Benue R.
Number of samples:	9
Unit of measurement:	cm

Results ---------

Estimate of Loo:	31.16
Estimate of Z/K:	0.439
Function:	Y =21.65 + (-0.695)* X

Plot ---------------



Line Hooks

FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:50:31 PM

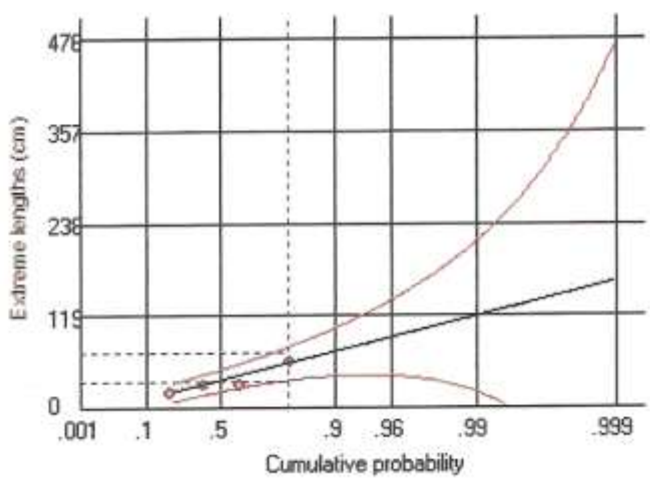
File ----------------

Filename:	C:\Program Files\FiSAT II\Hydrohoo.lfq
Species name:	Hydrocynusbrevis
Other identifier:	Hook and line, Benue R.
Number of samples:	4
Unit of measurement:	cm

Results ---------

Observed extreme length:	61.00 cm
Predicted extreme length:	52.96 cm
Range at 95% confidence interval:	33.42 - 72.51 cm

Plot ----------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:52:14 PM

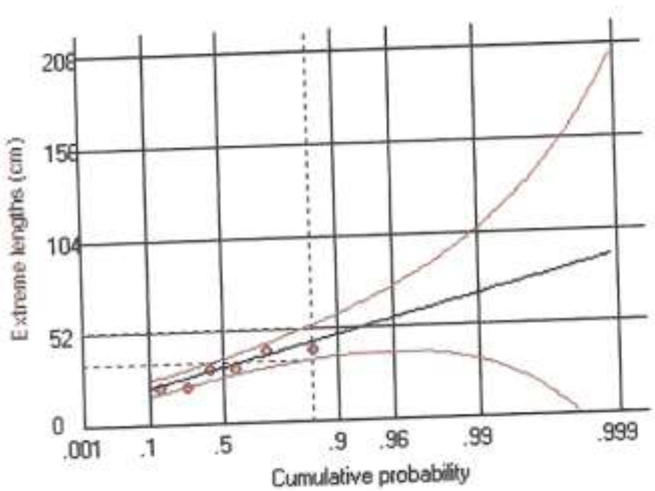
File ----------------

Filename:	C:\Program Files\FiSAT II\Aleshoo.lfq
Species name:	Alestes baremoze
Other identifier:	Hook and line, Benue R.
Number of samples:	6
Unit of measurement:	cm

Results ---------

Observed extreme length:	41.00 cm
Predicted extreme length:	43.49 cm
Range at 95% confidence interval:	34.49 - 52.48 cm

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Powell - Wetherall's Plot
Report Generated: 9/7/2010 3:53:01 PM

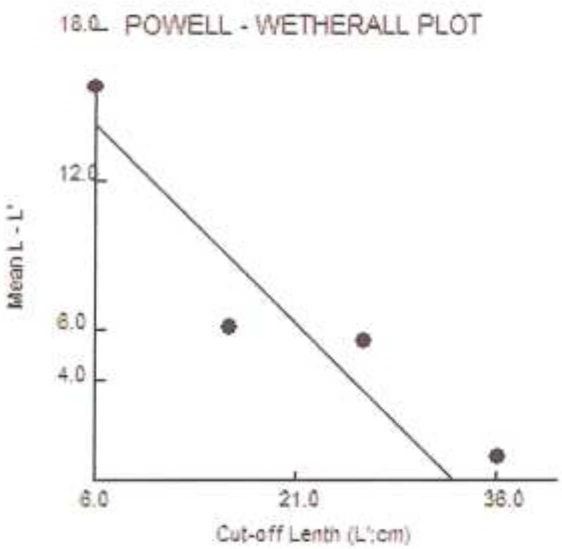
File ----------------

Filename:	C:\Program Files\FiSAT II\Aleshoo.lfq
Species name:	Alestes baremoze
Other identifier:	Hook and line, Benue R.
Number of samples:	6
Unit of measurement:	cm

Results ---------

Estimate of Loo:	40.31
Estimate of Z/K:	0.887
Function:	Y =21.36 + (-0.530)* X

Plot ---------------



FiSAT 2: FAO-ICLARM Stock Assessment Tools
Prediction of the Maximum Length from Extreme Values
Report Generated: 9/7/2010 3:51:31 PM

File ----------------

Filename:	C:\Program Files\FiSAT II\Baghoo.lfq
Species name:	Bagrus bayad
Other identifier:	Hook and line, Benue R.
Number of samples:	5
Unit of measurement:	cm

Results ---------

Observed extreme length:	31.00 cm
Predicted extreme length:	34.45 cm
Range at 95% confidence interval:	29.74 - 39.17 cm

Plot ---------------