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ASPECTS OF THE STRUCTURE AND SUSTAINABILITY OF THE FISHERIES IN THE CROSS RIVER ESTUARY OF NIGERIA-THE ROLE OF COMMUNITY-BASED MANAGEMENT

BY

AMBO ANTIGHA ANTIGHA
(10509636)

THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN COASTAL MANAGEMENT

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DECLARATION

This thesis is the result of research work undertaken by me, Ambo Antigha Antigha, in the Department of Marine and Fisheries Sciences, University of Ghana under the supervision of Mr. A. K. Armah and Prof. Elvis Nyarko both of the Department of Marine and Fisheries Sciences, University of Ghana. I hereby declare that except for references to work of other scholars who have been duly acknowledged, this thesis is entirely my original research which has neither been presented in whole nor in part to any other university for the award of a degree.

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Ambo, Antigha Antigha (Student) Date

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Mr. A. K. Armah (Principal Supervisor) Date

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Prof. Elvis Nyarko (Co-Supervisor) Date

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DEDICATION

This work is dedicated to my late mother, Deaconess (Mrs.) Uso Antigha Ambo who passed on during this study period, may her gentle soul rest in peace, my wife, Mrs. Esther Antigha Ambo, my children Anna, Anita, Amanda, and my entire family.

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TABLE OF CONTENTS

Content **Page**

University of Ghana http://ugspace.ug.edu.gh

University of Ghana http://ugspace.ug.edu.gh

LIST OF TABLES

University of Ghana http://ugspace.ug.edu.gh

LIST OF FIGURES

University of Ghana http://ugspace.ug.edu.gh

LIST OF PLATES

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LIST OFABBREVIATIONS AND ACRONYMS

a	Multiplicative factor generally used in exponential relationships linking L and W ($W=aL^b$)
b	Exponent of a length-weight relationship; slope of a linear regression.
C/F	Catch per unit effort Exponential rate Instantaneous rate of fishing mortality
K	Curvature parameter of the Von Bertallanfy Growth Function (VBGF), rate of Dimension time at which L_∞ is approached.
L_∞	Parameter of VBGF expressing the asymptotic length (i.e. the mean length, the fish in the population or stock) will reach if they were to grow indefinitely.
M	Instantaneous rate of mortality (due to all causes except fishing).
TL	Total Length
Wt.	Live weight of an individual fish, mean weight of fish caught in samples.
WP	Winter Point (time of the year when growth rate is slowest).
Z	Instantaneous rate of total mortality.
CPUE	Catch per Unit Effort
CBCRM	Community-Based Coastal Resource Management
FCA	Fishery Community Association

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ABSTRACT

This study focused on aspects of the structure and sustainability of the fisheries in the Cross River estuary with a view to addressing the unsustainable fishing activities in the Cross River estuary. The physicochemical characteristics of water were analyzed in order to determine the quality of water and health status of fishes in the study area. These included surface temperature, pH, DO, turbidity, salinity, alkalinity, phosphate and nitrates. The catch rates and catch composition of the multispecies gillnet fishery in the estuary, exploitation rates, sizes of fishes and socioeconomic factors were also investigated in order to determine their vulnerability to human and environmental factors. The water quality of the area showed a significant variation in turbidity at the locations of study, 52.2 NTU at Esuk Anansa, 30.3 NTU at Esuk Okon, and 21.8 NTU at Esuk Anantigha, with a range of 21.8 - 52.2. However, the general water quality was within the tolerable limit of fish during the study period. The mean weight of monthly catches sampled averaged 21.2 kg (range 15.3 kg to 27.0 kg).The mean CPUE was 7.1 kg/boat/trip. The catch composition revealed that *Pseudotolithus elongatus* accounted for 56.69%, by weight, *Ethmalosa fimbriata* was 30.28% by weight, while *Chrysicthys nigrodigitatus* was 7.53% by weight. The results of the study showed that these species are being threatened as a result of unsustainable fishing methods leading to harvesting of small fishes mostly between 10 and 15cm of length. The socioeconomic status of artisanal fishermen, traders and mangrove loggers in the estuary was determined with the view of updating knowledge on the socioeconomic indices, fishing gears, prime catches of the fishes in the area, in order to suggest management measures for the fishery and ecosystem of the area. The study recommends the introduction of community-based coastal resource management approach for the sustainability of the fisheries and the ecosystem of the area.

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CHAPTER ONE

INTRODUCTION

1.0 Background

Estuarine environments are among the most productive on earth, creating more organic matter each year than comparably-sized areas of forest, grassland, or agricultural land. The tidal, sheltered waters of estuaries also support unique communities of plants and animals especially adapted for life at the margin of the sea. Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, swamps, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, and sea grasses (USEPA, 1998).

Estuaries rank along with tropical rainforests and coral reefs as the world's most productive ecosystems, more productive than both the rivers and the ocean that influence them from either side (Harvey *et al.*, 1998). A healthy estuary has a very important structural biodiversity due to the many gradients (fresh-salt; sand - silt; deep channels-irregular flooded marshes). Tidal flats and tidal marshes are essential habitats for many birds, fish, benthos and plants (Maris *et al.*, 2007) and they give protection against floods. Estuarine and coastal ecosystems carry out many important functions such as storm protection, erosion and deposition control, habitat creation for species, and biogeochemical processing (Kennedy 1984, Costanza *et al.*, 1993).

These ecosystems are often physically variable, sometimes to the extreme (e.g. exposed to high or low salinity, temperature, oxygen, or moisture), that they are subject to continuous or periodic external forcing (e.g., tides, storms, river discharges), and are markedly impacted by

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human activities both now and in the future via human-induced climate change (Officer, 1976; Kennedy, 1984; Hobbie, 2000; Valiela, 2006). They are by nature a focal point of impacts both from the landward and the seaward side, because they form a major transition zone with steep gradients in energy and physicochemical properties at the interface between land and sea. During times of global change they are also a focal point of the pressures that global climate change and human activities impose on the oceans and the continents. Consequently, any organism or activity that depends on estuarine stability is most vulnerable to environmental change; hence ecosystem services and economic potential can be greatly impaired (Jennerjahn *et al.*, 2013).

Estuaries have long been regarded as important areas for fish, acting mainly as nursery areas, migration routes, feeding and shelter areas, providing an alternative habitat to the marine environment that supports large numbers of fish (Mc. Lusky and Elliot, 2004). An understanding of the ecosystem process (i.e. the functioning of these transitional environment is necessary to enable their protection and sustainable management (Franco *et al.*, 2008).

Fish is a renewable aquatic resource. The benefits being that at the verge of over exploitation, the trend can be turned by applying good management and conservative strategies to recover a diminishing stock. The renewability concept of the stock affords aspects of dynamism to the population of fish. Population dynamics is a very important aspect of fisheries, which becomes a welcome tool for management and conservatory measures (Mosepele, 2000).

The primary objective of population dynamics is to provide advice on the optimum exploitation of aquatic living resources such as fish and shrimps. Since living aquatic resources are limited but renewable, a fish stock assessment may be obtained as a search for the exploitation level, which in the long run gives the maximum yield. (Mosepele, 2000).

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The role played by estuaries in the life cycles of many species of fish and crustaceans is so important that these species have been considered to be estuarine dependent (Potter *et al.*, 1990). Since many of the larger marine species which use estuary as nursery areas are of commercial and recreational importance, much emphasis have been placed on the need to preserve estuarine environments as nursery areas in order to ensure the survival of important fisheries (Elliot *et al*., 1990; Pomfret *et al*., 1991).

Generally, few attempts have been made to restore the ecological functions of degraded tropical estuaries (Twiley *et al*., 1996). Not many attempts have been made to restore habitats such as mangroves, but much attention is given to improving water quality by controlling pollution. However, as destruction continues and fisheries yields fall, issues on management and conservation of tropical estuaries are being recognized. A number of countries have begun trials investigating the possibility of replanting mangroves (Blaber *et al*., 2000). In the absence of insignificant amounts of rehabilitation, the conservation of tropical estuaries is more important than ever.

However, Cross River estuary is subjected to heavy human usage, the frequent proximity to population centres, biological diversity, high fisheries productivity and recreational value of this estuary ensure that humans are now very much part of the ecology of the estuary, which must be managed accordingly (Oribhabor *et al*., 2013). Human activities leading to degradation of the ecosystem of the estuary include indiscriminate exploitation of mangroves, refuse disposal, pollution of various dimensions and unsustainable fishing methods.

This study seek to investigate the need for the adoption of community-based coastal resource management approach based on the premise that local populations have a greater interest in the sustainable use of natural resources around them than more centralized or distant

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government or private management institutions. Here, the local community is seen as having a greater understanding of, as well as vested interest in, their local environment and are thus seen as more able to effectively manage natural resources through local or 'traditional' practices (: Tsing *et al*., 1990:Leach *et al*., 1999). There is increasing recognition that effective resource management must be linked with issues of equitable access to natural resources, the promotion of sustainable livelihoods and the alleviation of poverty through participatory and empowering processes of development (Forsyth and Leach, 1998).

The goal of this study is to demonstrate the importance of the Cross River estuarine habitats to subsistence and commercial fisheries, and the need for the development of a Community Based Coastal Resources Management strategy for the management of fisheries and the ecosystem for sustainability in the Cross River estuary.

1.1 Objective of the study

The main objective of the study is to examine the structure of the fisheries with a view to evolving a sustainable management strategy for the fisheries and the ecosystem of the estuary.

1.2 Specific Objectives

*To assess the physicochemical characteristics of water of the study locations within the Cross River estuary in order to determine its quality and the health status of fishes.

*To ascertain species composition and catch rate of fish, and their vulnerability to human and environmental factors.

*To examine the exploitation rate and sizes of the target species caught in the estuary.

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1.3 Justification

The functioning of the Cross River estuary ecosystem is influenced by human modification such as habitat destruction for construction and agriculture, indiscriminate refuse disposal, over exploitation of mangrove vegetation, pollution and unsustainable exploitation of fishes. These changes in the ecosystem processes influence biodiversity, and change the ecological state of the ecosystems, and impact both on society and the economy. This underlines the need for the development of a sustainable fisheries resources and ecosystem management strategy for the estuary.

The Cross River estuary is the largest estuary along the Gulf of Guinea. It has an area of about 1500 km^2. The estuarine coastal plain is characterized by mangroves, river tributaries and creeks. *Rhizophora racemosa* and *Avicenna africana* are the main mangrove species. The mangroves of the estuary serve as spawning and feeding ground for shrimps, crabs, clams, periwinkles and fish. The estuary is inhabited by over 232 fishing settlements. The residents of the fishing settlements exploit the fish, shrimp stock and the mangrove resources of the estuary both for commercial purpose and for subsistence. Esin, (2012) had reported that the biodiversity of the Cross River estuary has been endangered by unregulated anthropogenic activities which are increasing the stock of nypa palm.

Studies on fisheries of the Cross River estuary over the years have shown that little attention had been given to its fisheries management. This is as a result of the fact that freshwater fish biologists tend to regard them as primarily marine, while their marine counterparts have concentrated more on other habitats.. The major challenge for the management of fisheries resources in the estuary is the widespread lack of community organization and capacity for

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carrying out basic management functions. Hence, there is the need to establish a bottom-up community-based sustainable coastal resource management strategy in the area.

Community-Based Coastal Resource Management CRBCM is people-centred, community-oriented and resource-based (Ferrer, 2001). It starts from the basic premise that people have the innate capacity to understand and act on their own problems. It strives for more active people's participation in the planning, implementation and evaluation of coastal resource management programmes. It involves an iterative process where the community takes responsibility for the assessment and monitoring of environmental conditions and resources and the enforcement of agreements and laws. Since the community is involved in the formulation and implementation of management measures a higher degree of acceptability and compliance can be expected. People's participation in the management of resources also provides a sense of ownership over the resource which makes the community far more responsible for long-term sustainability of resources.

Community-based coastal resource management can be more economical in terms of administration and enforcement than a national centralized system. A typical illustration is the centralized natural coastal resource management system by the Cross River State Government which is characterized by a very weak administration and enforcement due to non-compliance to government policies on management by coastal communities on one hand, and the lukewarm attitude of the government administrators and enforcement agents on the other hand.

Community-based coastal resource management involves an iterative research process of

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conceptualization, implementation, documentation and evaluation involving both the community and development workers and researchers in a dynamic partnership to realize coastal resource management (Ferrer, 1992). Throughout this process, the community and the researchers teach and learn from one another. The key concepts revolve around seven major components, community organizing and leadership formation, enhancement of cultural integrity participatory research, education and training, resource management, livelihood development, networking and advocacy. Community-based coastal resource management approach has been successfully demonstrated in the Philippines, Indonesia and Mexico (Ferrer, 1992).

The last two decades have been marked by an increasing number of institutions, agencies and organizations which have focused attention on coastal zone. This participatory, integrated and multi-sectoral approach is fast becoming an accepted and viable approach to coastal zone management. However, it is important to note that community participation and empowerment of local communities are crucial to CBCRM. The results and concrete benefits of this approach to the community must be disclosed early in order to convince people about the relevance of the programme. Coastal management should be integrated and community based, knowledge production must genuinely involve the members of the community/stakeholders.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Review of Fisheries in Tropical Estuaries

Tropical estuaries and associated coastal waters support many essential fisheries, a fact which contributes to their disproportionately high economic value. They are, however, also among the most extensively modified and threatened aquatic environments, and have been strongly affected by human beings, and fisheries are an integral part of human activities on the coast (Blaber *et al*., 2000).

A global perspective in synthesizing the effects of fishing on estuaries and coastal waters was taken by (Blaber *et al*., 2000) in reviewing eight process-orientated categories affected by fishing, with case studies for each of them: target organisms, non-target organisms, nursery functions, trophic effects, habitat change, reduced water quality, human environment, and potential for local extinctions. The investigation revealed that fishing in the estuarine and near-shore environment has clear impacts on the structure and functioning of these ecosystems, although other, non-fishing issues also affect these ecosystems. This creates multiple interactions and reinforces the need for an integrated approach to coastal zone management. Nonetheless, some form of fish-based action plan could be created, especially within estuaries, which would provide management objectives for a particular system.

Since 2002 there has been an increase in knowledge of many aspects of the biology and ecology of tropical estuarine fishes, as well as significant changes to many estuarine fisheries. Analyses of literature databases by Blaber from 2002–2012 showed that of the 600 relevant

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papers, 52% were primarily related to ecology, 11% to conservation, 11% to anthropogenic and pollution effects on fishes, 9% to fisheries, 7% to aquaculture, 4% to study techniques, and 1% each to fish larvae, effects of fishing, taxonomy, climate change, evolution and genetics. In terms of geographic spread 17% were from North America, 15% from south Asia, 14% from the Caribbean, 13% from Australasia, 12% from Africa and 9% each from South America and SE Asia (Blaber, 2013). According to Blaber (2002), tropical estuarine areas comprise small systems of a few kilometers, larger estuaries, coastal lakes of hundreds of kilometers and vast shallow coastal waters that are contiguous with estuaries and have similar reduced salinities. He reported that many of the world's great estuaries are in the tropics, e.g. the Amazon, Orinoco, Congo, Zambezi, Niger, Ganges and Mekong.

The aquatic environment and fish communities of the Gambia estuary (about 250 km long) were studied by Albaret *et al*. (2004). In his study, purse seines sampling at different periods in the river cycle, covering all hydro-climatic seasons that are characteristic of West African estuaries were investigated. Emphasis was placed on the diversity, composition, structure and distribution of fish assemblages in relation to fluctuations in physicochemical factors such as water temperature, salinity and turbidity. Results on the aquatic environment, mainly the salinity range (from freshwater to 39) and dissolved oxygen (never a limiting factor for fish in the estuary) and on the main characteristics of the fish fauna (high diversity of life cycles, all the ecological categories represented) indicated that the Gambia estuary was free of major climatic perturbation reinforced the choice of this system as a reference for the study of the effects of major perturbations on estuarine tropical fish communities.

Boko *et al*. (2007) stated that the expected impacts of climate change in Africa are changes of sea surface temperatures that may lead to the disruption of ecosystems and threaten entire

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food chains. This could also have an impact on the migration of species and therefore on catches in the zone. Aryeety (2002), reported that artisanal fisheries in West Africa including the Gulf of Guinea are facing serious challenges due to the virtually open access nature of the industry and the fact that the natural resources supporting this industry are beginning to show serious signs of stress, linked to overexploitation and natural environmental variability.

In the assessment of the contribution of small-scale fisheries to rural livelihood in developing countries, Bene (2006) noted that traditionally, the contribution, role and importance of small-scale fisheries have often been described in thematic terms such as economic, social, employment and source of food. However, the contributions of small-scale fisheries are often interlinked and interdependent and some of their major contributions lie at the interface between these themes/sectors rather than within each. Also some of the major contributions to small-scale fisheries result from the synergies between various domains particularly economic and social aspects as conventionally recognized.

Chrysichthys nigrodigitatus and *Ethmalosa fimbriata* are important components of the ecology of rivers and estuaries along the coast of West Africa, from Senegal to Angola. Geographically, *E. fimbriata* occurs throughout tropical West Africa from Mauritania to Angola (FAO, 1996).

The fish inhabits waters ranging in salinity from 2 to 35‰. It prefers warm water and its abundance is not limited by high turbidity. Small-scale fisheries account for about 90 percent of the total fish catch in West Africa. Small pelagics, including the bonga (*Ethmalosa fimbriata*), contribute a significant part of this catch. Gill net fishing technique is the most

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selective fishing method used in these fisheries worldwide (Brandt, 1975).

2.1 Fisheries in the Cross River estuary

Fisheries in the Cross river estuary are predominantly artisanal. It is well known that only about 5% of the total landings are attributed to industrial marine fisheries using trawlers, the remaining 95% being landed by local or artisanal fishers. Yet there is no provision in the Fisheries Decrees for operation of coastal canoe fishers (beside restriction to near-shore waters not beyond 5 nautical miles), even though this class of fisher folks operate in the most productive coastal waters where the probability for exploiting undersized fishes are highest (Holzlohner *et al*., 2004).

Nwosu *et al.* (2011) reviewed the marine fisheries laws as contained in the Sea Fisheries Decrees of Nigeria promulgated in 1971, 1972 and revised in 1992. They found out that these decrees were lacking in scientific data needed to effectively enforce the laws, both for industrial and artisanal fisheries. The major habitats of the different species, their breeding and nursery grounds; the migratory movements and seasons for different species; size selection of the fishing gears for different species caught simultaneously by relevant gears; sizes at first maturity of the different species; feeding/trophic relationships of the various species; maximum and optimum sustainable yields of the resource, and the corresponding effort, were some of the missing scientific information.

Landings of these small scale fisheries operations contributes a large proportion of Nigeria's marine/brackish water fish output. Akpan (1993, 1994) processed the seasonal variability of the phytoplankton biomass in relation to physicochemical changes in the Cross River Estuary.

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He also provided data on the seasonal variations in temperature, salinity, dissolved oxygen, biochemical oxygen demand, ammonium, nitrite, nitrate, phosphate, silicate, secchi disc transparency and pH. Some statistical data sampling and stock assessments have been done by Bisong (1994) based on landings from the bottom trawl fishery in the outer Cross River estuary and adjacent region. The catch consisted of 65 fish species representing 30 families, mainly *Clupeidae, Mugilidae, Lutjanidae, Carangidae, Sciaenidae, Polynemidae, Pomadasidae, Sphyraenidae and Bagridae*.

Holzlohner *et al*. (2007) also investigated the species composition and catch rates of gillnet fisheries in the central Cross River estuary, Nigeria. They reported 21 fish species, three shrimp species and one crab species. The dominant fish species were bobo croaker (*Pseudotolithus elongatus*), bonga (*Ethmalosa fimbriata*), and the estuarine catfish (*Chrysichthys nigrodigitatus*). In the annual fish species abundance, from the 21 fish species found, 81% were of marine and 19 % of freshwater origin respectively. Bassey (1988) in a related study, also on gillnet fishery listed 28 fish taxa, 12 of which were identified to species level, 8 to genus and others to family level at two landing sites in the estuary. Nwosu *et al*. (2010) studied the status of an exploited stock of *Pseudotolithus elongatus*, using von Bertalanffy growth model. His investigation indicated that the fishery is overexploited in the estuary.

Moses (1990) contributed to the growth, mortality and potential yield of the bonga, *Ethmalosa fimbriata*. Nawa (1985) studied the growth of the croaker, *Pseudotolithus elongatus*, and the estuarine catfish, *Chrysichthys nigrodigitatus* and of the sole, *Cynoglossus goreensis*. Ajang *et al*. (2011) studied the population dynamics and the selectivity of gillnets for the

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exploitation of *Chrysichthys nigrodgitatus* and *Ethmalosa fimbriata* in the Cross River estuary. He reported growth curves of L_∞= 30.17cm; K=1.5yr^{-1}; C = 0.25; and WP= 0.3 for *E. fimbriata*, and L_∞ =98.25cm; K= 0.96y^{-1}; C = 0.15 and WP=0.15 for *C. nigrodigitatus*. Abowei *et al.*, (2009) in Nkoro River, Niger Delta reported a condition factor range from 0.917 (*Ilisha africana*) to 0.985 (*C. senegalensis*), *E. fimbrata*, *I. africana*, and *E. senegalensis* were isometric in their growth, while *S. maderensis* and *C senegalensis* were positively allometric. The respective exponential equations were: *E. fimbrata* (Wt = 0.0162 (TL) 3.199); *I. africana* (Wt = 0.5998 (TL) 2.719), *S. maderensis* (Wt = 0.0478 (TL) 3.580) and *C. senegalensis* (Wt = 0.0326 (TL) 3.508). Ama-Abasi *et al*. (2014) reported in the lower Cross River that the fecundity of the *C. nigrodigitatus* ranged from 3,730.5 to 41,535.9 eggs. There was a positive correlation between the total fecundity and fish weight (p = 0.01, r = 0.80, n = 44) in the study. The regression model for the relationship was expressed as, fecundity = 4660.8 + 4.76 weight. The gonadosomatic index was highest in the month of May and dropped sharply in June, signifying that spawning in *Chrysichthys nigrodigitatus* starts around this period.

The nutritive value and the content of some minerals were investigated in three commercially important marine fish species of the Cross River estuary, Nigeria by Udo *et al*. (2012). The fishes studied using standard procedures as recommended by AOAC were *Ethmalosa fimbriata*, *Mugilcephalus* and *Cynoglosus senegalensis*. The investigation of the status of an exploited stock of West African croaker (also known as the giant captain fish) *P. elongatus* using von Bertalanffy growth models by Nwosu *et al*. (2010) revealed that the asymptotic length was 61.5 cm, the curvature parameter was 0.40 per year, the oscillation constant was 0.3, the winter point was 0.40 and the goodness-of-fit index was 0.515. The instantaneous

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rates of total, natural and fishing mortality were 3.71, 0.78, and 2.93 per year, respectively. The distribution, biology and artisanal fishery of *C. nigrodigitatus* and *E. fimbriata* in the Cross River estuary were studied by Moses (1987). The study revealed that the fishes constitute about 60% of all fisheries landings in the coastal area and fishery catches during the rainy season. They constitute 66% by weight and 81% by number in the landings of the artisanal fishery in the Cross River estuary, confirming their dominant position as the target species of the fishery.

Moses (1993) also studied the artisanal fishing gears in the estuary. He identified the gill nets as the most popularly used and stated that they contributed about 33.7% and 5.0% respectively of the total fish production in the Cross River State. Species tend to move in shoals where gill nets were effective in catching the migratory E. *fimbriata* species during May to June, and C. *nigrodigitatus* all through the season. Ayotunde *et al*., (2013) reported that *Chrysichthys nigrodigitatus* inhabit brackish water, small and large fresh water bodies of Africa. (Ajang, 2011) reported that a large meshed net permits young fishes to escape which result in the reduction of harvesting undersized and immature ones and hence allowing time for them to grow and thereby contributing to the biomass of the fish stock in subsequent years.

Environmental parameters and ichthyofauna were investigated over a two years period in three regions along the 200 km length of Cross River by Offem *et al.* (2009). The objective of the study was to quantify the relative importance of local environmental conditions prevailing within sampling sites and the composition and abundance of the principal fish species in the upper, middle and lower reaches of the river. Vegetation cover, size of river, flow velocity, water level, temperature, transparency, and food availability explained the observed seasonal

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and spatial changes in fish abundance. Forty-six species and 28 genera of fish belonging to 16 families were recorded among the 14,466 fish caught. Three fish families (Cichlidae, Bagridae, and Clariidae) yielded highest number (41.3%) of species while Denticeptidae, Protopteridae, and Osteoglossidae had the least. *Oreochromis niloticus*, *Chrysichthys nigrodigitatus*, and *Clarias anguillaris* numerically dominated (46.4%) catch composition. Species richness was higher for the river stretch in forest area than in savanna, and it was correlated significantly with width of the reach, water transparency, depth, and flow velocity ($P < 0.001$) of the river. Wet season samples were more diverse (>0.6) and had higher richness (>9.7) than those for dry season. Wet season and forest regions were therefore critical in maintaining fish stock of Cross River.

The fresh water crayfish *Macrobrachium vollenhovenii* lives in the brackish waters of the estuary as larva and in fresh water of the rivers as adult animal. These shrimp species are the largest in West Africa and therefore a potential candidate for aquaculture. Udo and Taege (1991) compared the body size with the metabolic rate and the respiratory responses to various salinities. The dynamics of the exploited population *of Macrobrachium macrobrachion* in the Cross River estuary, Nigeria, were studied based on monthly length-frequency data collected from the landings of the artisanal *Macrobrachium* fishery by Nwosu *et al.* (2007). Sexual dimorphism was indicated in the growth and mortality parameters. For the males, the von Bertalanffy growth parameters were estimated as $L\infty$ = 141.35 mm, K = 1.21 year^{-1}, C = 1.0 and WP = 0.15. For the females, they were $L\infty$ = 117.55 mm, K = 1.60 year-1, C = 0.81 and WP = 0.51. The instantaneous rate of total mortality (Z) was estimated to be 9.53 year^{-1}(males) and 9.14 year^{-1}(females). The exploitation rate (E) obtained was 0.74 for the males and 0.66 for the females, suggesting that the prawn population was over-fished

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for both sexes.

Holzlöhner (1996) derived the objective demands for short- and long-term biological-oceanological and fishery investigations in the Cross River estuary and environs to the Institute of Oceanography of the University of Calabar, Nigeria. While Antia and Holzlöhner (1986) produced a bibliography of a decade (1975-1985) of coastal studies in the Cross River estuary and environs by the Institute of Oceanography, University of Calabar, Nigeria. Antai *et al*. (1993) performed surveys in the fishing villages of the Akwa Ibom, Cross River and Rivers States for sampling of information on the population structure and fishery. Alone in the Cross River system they counted 59,714 artisanal fishermen in a population of 246,011 dwellers in 232 fishing settlements exploiting with 17,706 canoes the fish and shrimp stocks of the Cross River estuary.

Adebegbin and Nwaigo (1990) discussed the uses and management perspectives of the mangrove. Eni *et al*. (2011) studied the exploitation impact on flora and fishes within the Cross River estuary in fifteen (15) villages. The study revealed that trees such as *Elaeis guineensis* and *Combrectum hispidum* were located close to villages like Asiak Obufa and Affiah Aduting thereby encouraging high exploitation for palm oil production and construction purposes.

Okpiliya *et al*. (2013) examined the various ways in which mangrove forest ecosystem is being utilized and depleted and the implications for occupational changes in the southern Cross River area. Five communities based on observation that are actively involved in the mangrove exploitation were sampled for the study. The result showed that mangrove

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ecosystem destabilization in the coastal communities of Calabar south area of Cross River State has been increasing rapidly over the years, and the deleterious effect of mangrove depletion on human and the environment remained unnoticed. This has led to the prevalence of flood, coastal erosion, and the invasion of the nypa palm leading to habitat alteration and the reduction in fish productivity. A study by Akpan-Idiok *et al.* (2012) on the bacterial isolates of the mangrove swamp soils in the Cross River estuary identified six genera based on their morphological, biochemical and physiological characteristics for the mangrove swamp soils supporting tall mangrove, short mangrove and Nypa palms. The bacteria were *St*sp., *Micrococus* sp., *Bacillus* sp., *Pseudomonas* sp., *Staphylococcus* sp. and *Streptococcus* sp. *Micrococcus* sp., *Bacillus* sp. and *Pseudomonas* sp. were classified as indigenous (authochthonous) bacteria responsible for the decomposition of leaf litter in the mangrove swamp soils. The bacterial isolates, *Staphylococcus* sp. and *Streptococcus* sp. were regarded as foreign (allochthonous) and such bacteria lack potentials to degrade leaf litter and are contaminants introduced by human activities in the mangrove swamp forest area.

A further review of the Sea Fisheries Laws of Nigeria in order to accommodate the aforementioned scientific data for artisanal and industrial fisheries is very essential for the sustainable management of the fisheries and the ecosystem of the estuary. The marine and coastal ecosystems of the estuary which include mangroves and sea grass beds are threatened by a number of factors including pollution, unsustainable exploitation and fishing practices. One of the most holistic approaches to protecting such marine and coastal ecosystems is Ecosystem-Based Management (EBM) which recognizes the need to protect the entire ecosystems instead of individual species. On this note, it is important that the CB-CRM system assist in the management of the marine and coastal ecosystems of the estuary on a

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sustainable basis through sustainable practices; mobilize the political will and action of governments and other partners for the management and sustainable use of resources such as fish, and their associated ecosystems including mangrove swamps and sea grass beds; effectively communicate the value and importance of mangroves and sea grass beds, including their ecosystem services, the threats to their sustainability, and the actions needed to protect them; and promote the ecosystem management approach for the conservation and management of marine and coastal ecosystems of the estuary.

2.2 Community-Based Coastal Resource Management

"Community-Based Coastal Resource Management does not adhere to a predetermined, exact and indispensible model but rather, a flexible one that works to achieve the inclusion of those currently excluded and marginalized from the institutional political processes. CBCRM works because it inspires people to search for their meaning and worth in their own context. CBCRM works because it continues to innovate and re-invent itself" (Ferrer *et al.*, 2001).

Community-Based Coastal Resource Management (CBRCM) initiatives in Southeast Asia emerged from a range of donor-funded projects, government programmes and civil society initiatives. Numerous social, political and cultural factors contribute to how CBCRM efforts unfold. Community-based management may be endorsed at different scales i.e. by local communities or at a national level, leading to different types of resource management institutions and policies. Impacts therefore vary within and across scales. Rivera-Guieb *et al.* (2006) examined the experiences of CBCRM in the Philippines, Viet Nam and Cambodia. They noted that key factors contributing to the success of CBRCM include working at multiple scales, nurturing local initiatives and a political commitment to this type of approach.

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However, they stated that successes are modulated by each social and cultural context, which are perhaps even locally specific.

The Community-based Coastal Resource Management Project in Orion, Bataan, Philippines was started in 1991. The village level fishers organization formed a municipal-wide association called the Samahan at Ugnayan, Pangisdaan in Orion. It represents 70% of the small-scale fishers in Orion and has taken the task of rehabilitating the degraded fishing grounds. The experience in Orion indicates that coastal management can be successful if the fishers have ownership of the programme and the cost benefit of the programme is distributed equally in a manner acceptable to them (Mulekom, 1995).

Cudney *et al*. (2009) studied the evolution and effectiveness of a community-based management effort to establish, monitor, and enforce a marine reserve network in Gulf of California, Mexico. The study revealed that locally crafted and enforced harvesting rules led to a rapid increase in resource abundance. As described by Pinkerton and Weinstein (1995), Japan's management of its near shore fisheries represents an instructive exception to management in industrialized countries and provides perhaps the purest example of community-based fisheries management in the world. Briefly, prefectural governments grant tens of thousands of exclusive territorial rights for sedentary fishery resources for ten years period to Fisheries Cooperative Associations (FCAs).

There are signs that fisheries in many places are not driven solely by individual motives but rather are the sites of community organization and cooperative management of common property (Mc. Goodwin, 1990). Unfortunately, examples of community management of

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fisheries have seldom been documented in the industrialized fisheries of the first world (Pinkerton, 1995); communal forms of resource management are undermined as an option. Bulayi (2001) reported that community-based cooperative fisheries management was proposed for Lake Victoria fisheries in Tanzania in order to improve fisheries management. This system recognizes the sharing of management responsibilities between fishing communities through beach fisheries management units (BFMUs) and the Fisheries Division in the Ministry of Natural Resources and Tourism. The community-based cooperative fisheries management is likely to reduce the problem of over-exploitation of fisheries resources in Lake Victoria by allocating exclusive fishing rights to the fishing communities through BFMUs in their respective villages.

Typically, fisheries management in East Africa had followed the traditional top-down method, where the government makes decisions that the people follow. But in 2006, the Kenyan government implemented a pilot programme to do just the opposite, giving communities the ability to develop and enforce their own fisheries regulations. Emily (2014) reported that the strategies implemented by these communities benefited not only their fishery, but also the local corals, and the people's livelihood.

Community organizing is a core strategy of CBCRM. The CBCRM approach is based on the premise that resources management approaches should build on the inherent capacities and practical experience of communities. Organizing facilitates the creation of community institutions, structures, programmes and systems. For example; In the Philippines, organizing efforts led to the formation of a community structure called people's organization (PO). A PO is an organized group of community residents whose members take the lead in local resource management initiative. A PO can also be a multipurpose cooperative, a savings and credit

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organization, a resource management cooperative, some other form of resource protection association (Heinen, 2003). It is noteworthy that a PO is not a formal village organization, which is viewed as government organization. Community organizers are usually Non-Governmental Organization workers or fisher folk leaders and not staff of government departments or academic institutions. The government agency usually partners with a local NGO to organize the communities. The PO becomes the representative of the community in decision-making process such as negotiating with the government on the access and use of resources. It is frequently involved in making decisions on regulations and restriction on resource use. The PO could be the legal holder of a tenurial instrument as in the case of mangrove stewardship agreement or a declared marine reserve. It is therefore a negotiating body, a resource tenure holder, and overall community representative (Gollin and Kho, 2002).

Community-based management (also known as community fisheries, community forestry or co-management) has emerged in Cambodia as a response to declining access to natural resources (Marschke, 2003). Although approaches can vary, communities are actively establishing their own management areas and plans often with support from NGOs or governmental institutions. In 2002, there were an estimated 162 community fishery sites and 237 community forestry sites in Cambodia (Mc. Kenney and Tola, 2002). Many of the community forestry and fishery sites in Cambodia have an elected resource management committee that is responsible for guiding resource management activities. In Koh Kong province, a project on Participatory Mangrove Management Resources (PMMR) began in 1997 to better understand livelihood and management issues in one protected area (Marschke and Nong, 2003).

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Community-based coastal resources management approaches are associated with a goal to address issues of social injustice that have to do with unequal resource access and wide gap in benefits-sharing from resource use. In Philippines, it is seen as a resource management tool but more so as a response to the need for social and political reform (Batongbacal, 1997; Rivera, 1997). The two Philippine government implemented Fisheries sector programmes, and the USAID/ World Bank funded Coastal Resource Management Project are examples of large scale institutionalized CBCRM programmes. Though they use similar language of “participation” and “Community-based management” to describe their efforts, these donor driven programmes do not spring from the soil as the NGO and PO led efforts that have emerged to respond to social justice issues. Many of the larger CBCRM programmes focus mostly on resource conservation and use of local participation to increase the efficacy of their program delivery, rather than as a real means for local empowerment.

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CHAPTER THREE

MATERIALS AND METHODS

3.0 Survey of Study Area

A reconnaissance survey of the area preceded the data collection. Each location of study in the Cross River estuary was captured with its proper coordinates using the Global Positioning System (GPS). Observational walks and boat trips were made in order to identify social, environmental and livelihood issues.

3.1 Description of Study Area

The Cross River estuary is in south eastern Nigeria. It is a coastal zone lying within the Cross River State at the Cameroun border, encompassing Akwa Ibom State as a fraction and the Rivers State, east of the Niger Delta, located between latitudes $04^0 10'$ and $05^0 10'$N and longitudes $08^0 15'$ and $08^0 35'$E. The estuary is known as the biggest in the Gulf of Guinea. Three main rivers, namely Cross River, Great Kwa and Akpa Yafe Rivers, empty into this estuary. The estuary is shared between Nigeria and Cameroun (Nwosu *et al*., 2005). It takes its source from the Cameroun Mountains. It meanders westwards into Nigeria and then southwards through high rainforest formations before discharging into the Atlantic Ocean. Within the lower brackish water reaches of the river, the vegetation changes to mangrove forest. (Ama-Abasi, 2002).

3.2 Climate and Vegetation

The climate of the study area is characterized by a long wet season from April to October and a dry season from November to March. Mean annual rainfall is about 2000 mm. A short

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period of drought occurs in the wet season around August/September, which is called the August drought. There is usually a cold, dry and dusty period between December and January referred to as the harmattan. Temperatures generally range from 22^{0}C in the wet to 35°C in the dry season, relative humidity is generally above 60% at all seasons with close to 90% during the wet season (Akpan, 1993). Changes in the hydrodynamic conditions affect both the marine and fresh water fisheries of the area (through the lowering of salinity of the coastal waters and the inundation of the floodplain respectively) (Moses, 1990). Five mangrove species are known in the area, they are *Rhizophora racemosa*, *Rhizophora mangle, Rhizophora harrissonii, Languncularia racemosa and Avicennia marina (africana)* in association with exotic nippa palm *(Nypa fruticans*). A wide range of biodiversity exists in the area: plankton, crustaceans, molluscs, fin fishes, reptiles, birds and mammals (Nwosu, 2005).

3.3 Locations of Study

The study was carried out in the estuary area of the Cross River in Nigeria, in Bakassi Peninsula and Calabar South Local Government Area both within the Cross River estuary. The locations were selected because of the high concentration of fish landings in the area.

Bakassi is a peninsula on the Gulf of Guinea. It lies between the Cross River estuary, near the City of Calabar in the West, and the Rio del Ray estuary on the east. The peninsula lies between latitudes 04º 25´N and 05º 10´N and longitudes 08º 20´ and 09º 08´E. It consists of a number of low-lying, largely mangrove covered islands covering an area of around 665 km^2. The population of Bakassi is generally put at between 150,000 and 300,000 people. Bakassi is situated at the extreme eastern end of the Gulf of Guinea, where the warm east-flowing Guinea current (called Aya Efiat in Efik) meets the cold north-flowing Benguela current

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(called Aya Ubenekang in Efik). These two ocean currents interact creating huge foamy breakers which constantly advance towards the shore, and building submarine shoals rich in fish, shrimps and wide variety of other marine forms. This makes Bakassi area a fertile fishing ground. Most of the population makes their living through fishing (Gill *et al*., 2003). Calabar South Local Government Area is situated at latitudes 04º 95´ and 05º 15´N longitudes 08º 32´ and 08º 45´E. Its headquarters are in the town of Anantigha. It has an area of 264 km^2 and a population of 191,630 as at 2006 Census. The inhabitants are predominantly engaged in fishing and mangrove logging.

The study was carried out in three stations as follows:

Station 1: Esuk Anansa is located in Ikang town, between latitudes 04^0 47´ and 05º 20´N and longitude 08^0 30′ and 08º 42´ E. The town is about 1km away from Station 2 (Esuk Okon), and about 5 km from the state capital, Calabar. This station is characterized by clustered settlement with a dense human population resulting in intense deforestation, indiscriminate refuse disposal, pollution from surface run-off inputs from domestic wastes especially during wet season. The dominant vegetation in this location are palm trees (*Elaeis guineensis*), bamboo (*Bambusa africana*), plantain and banana (*Musa spp*), mangroves (*Rhizophora racemosa, R. mangle and Avicenna africana*). The dominant crops cultivated in the riparian areas are okra (*Abelmoschus esculentus*), water leaf (*Talinum triangulare*), fluted pumpkin (*Telfairia occidentalis*), and maize (*Zea mays*). The location is characterized by a biotope or beach with muddy sediment made up of silt.

Station 2: Esuk Okon is located on the outskirt of Ikang, in the Bakassi Local Government Area of Cross River State, Nigeria, between latitudes 04^0 49′ and 05º 22´ N and longitudes

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08^0 33 ′ and 08º 40´ E. The village is about 6 km from the Calabar Municipality, the Cross River State Capital. It is characterized by a very small and clustered human settlement with a population of about 200 households predominantly fishers, without basic amenities and infrastructure such as school, hospital, potable water, access road, electricity, hotels, and market. The inhabitants of this village depend on Ikang main town, about 1km away for such facilities. The dominant vegetation and crops in this location are similar to that of station 1. This station is also characterized by a beach with muddy sediment made up of silt.

Station 3: Esuk Anantigha is located in the Southern part of the Cross River State capital (Calabar South) between latitudes 04^0 55′ and 05º 10´N and longitudes 08^0 22′ and 08º 34´E. The station is characterized by a highly clustered human settlement with a denser population than station 1, with the associated human impact on the environment such as deforestation, erosion, flood, and pollution of all sorts, ranging from domestic waste to urban and agricultural run-off during wet season. The vegetation and cultivated crops are alike with other stations, but there is more concentration of nipper palm and scattered fish and poultry farms around this location than in the others. The station is known as the largest landing site/market for mangrove wood, used as domestic fuel for fish smoking, cooking, bakery, building and other purposes. It is characterized by a muddy substratum and bank root biotope. (See, Figure 3.1. Map of study area showing the three stations)

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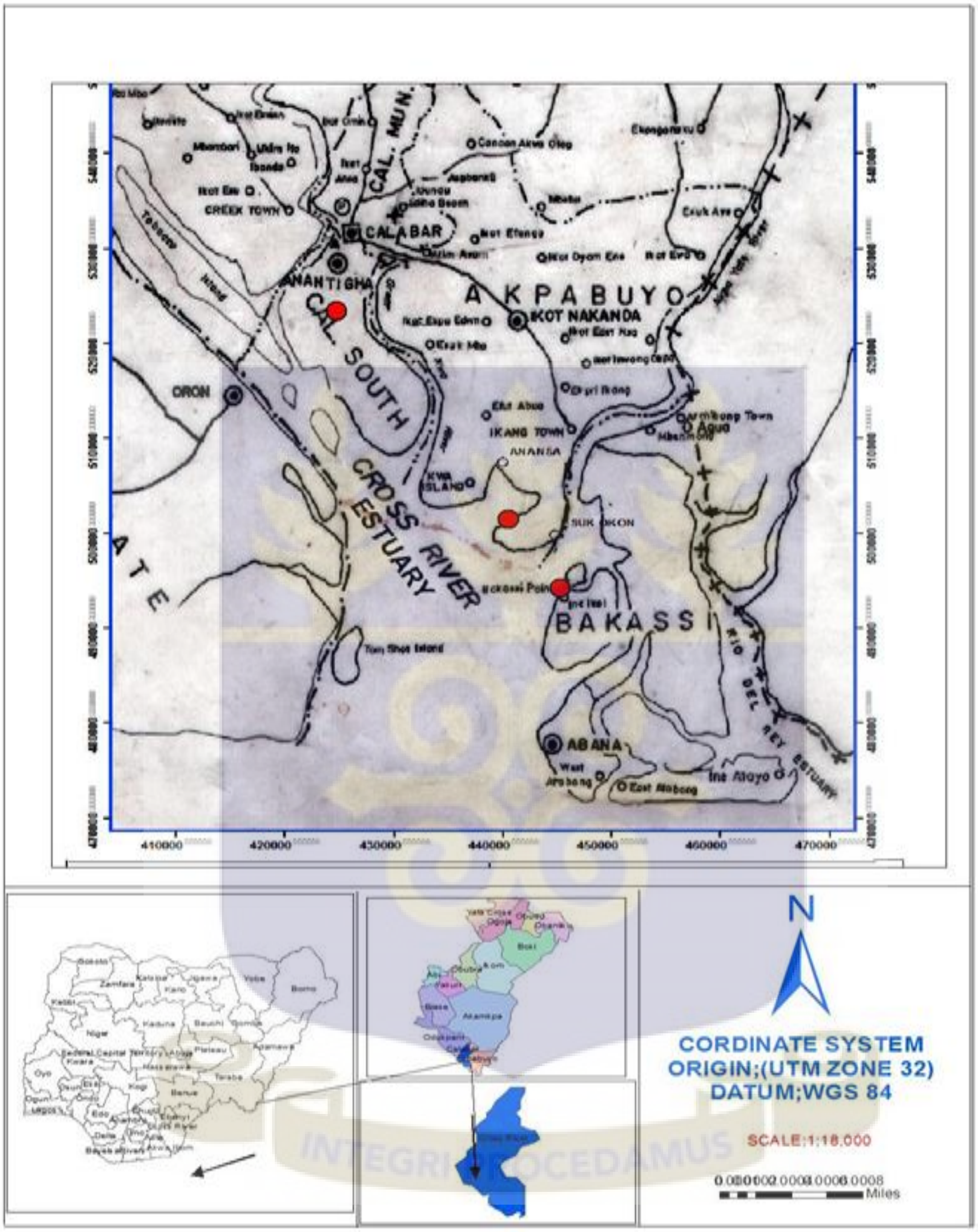

Figure, 3.1: Map of the study area showing the three stations

LEGEND

Anansa O ,OkonO

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3.4 Research Design and Sampling Methods

The study employed primary and secondary data. The primary data were obtained from monthly water samples in each station for laboratory analysis. The water quality parameters analyzed included pH, Dissolved Oxygen (DO), turbidity, salinity, alkalinity, phosphate (PO_4-P) and nitrate (NO_3-N) during the study. Water temperature and turbidity were measured *insitu*. This was done at a distance of 100 m away from the shore and 1m deep; water samples were collected in two replicates for each station monthly with one litre polyethylene bottle, previously washed, rinsed, and dried in the laboratory. Water samples were preserved in a cooler filled with ice chips to maintain its status. The water quality parameters were analyzed in the laboratory of the Institute of Oceanography, University of Calabar, Nigeria using American Public Health Association (APHA, 2005) standard method of examining water and waste water.

The landings of artisanal multi-species gillnet fishery in the study area were investigated during the study. The length measurements of 1814 fishes were taken according to the conventional method, which is nearest unit below 0.1cm precision for total length measured from the tip of the snout to the end of the caudal fin using a ruler. The boats that landed were selected at random for sampling to avoid sampling bias. This was achieved by sampling different boats in the various stations on each of the day. Sampling was conducted once monthly in each station on different landing days during flow tide (landing periods). The main fishing gears used in the area were near-surface and near bottom gillnets of about 100m in length and of stretched mesh size varying from 2.9 cm to 5.0 cm (average 3.8 cm) for near surface gillnets for bonga, and 4.0 cm to 6.6 cm (average 5.5 cm) for near bottom drift nets for demersal fishes (Holzlohner *et al.*, 2007). Others were hook-and-line, and traps of

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different types including artificial shelters, basket traps and fish fences (Figure 2).

Socioeconomic data were collected from one hundred and forty two respondents across the three study stations. The respondents included; fishermen, mangrove loggers, fish processors / traders and farmers: 50 at Esuk Anansa, and 22 at Esuk Okon while 70 was collected at Esuk Anantigha. This information was collected based on the population of each station. Esuk Anantigha being the most populated, followed by Esuk Anansa. The secondary data included the map of the study area obtained from the Geography and Regional Planning Department of the University of Calabar, Nigeria and modified by the Cross River State Geographical Information System (CRSGIS) Department and rainfall data obtained from the Department of Meteorology of the Nigerian Airport Authority, Calabar, Cross River State.

Fish sampling was done by obtaining the total weight of all fish landed by a canoe from one fishing trip as described by Holzlohner *et al*. (2007). This was achieved by measuring the weight of each basket of fish from the canoe using an artificial weighing balance, and the weight of each basket was summed to establish the catch rate in kg/canoe/trip. A total of 6 canoes were sampled in each station, one canoe monthly for six months during the study period. Eighteen out of 149 canoes were sampled in all the stations. The total numbers of canoes in each station were 62 at Esuk Anantigha, 34 at Esuk Okon and 53 at Esuk Anansa. Due to logistics constraints, the total landing of each canoe sampled was sorted for the 3 main dominant species in the area which *Pseudotolithus elongatus* (West African croaker), *Ethmalosa fimbriata* (Bonga) and *Chrysichthys nigrodigitatus* (estuarine catfish). This is because these species were the most targeted by the fishers as a result of the market demand. A few other species in the landings were treated as by-catches as a result of their insignificant

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market value.

The catch per unit effort was calculated using the formula below:

CPUE = $\frac{Catch\ per\ Trip}{Effort}$ ……………………………………………………........... (1)

Where CPUE is the Catch per unit effort (Catch/ canoe/ trip), which represents the mean catch divided by the mean effort during the study period.

The data for each month were added together, and the proportion for each species was expressed as a percentage by weight of the total landings for that month as follows:

Percentage Weight (%) = $\frac{Species\ weight}{Total\ Weight}$ × 100……………………….............. (2)

The mean length, variance and standard deviation were calculated using Sokal and Rohlf (1981) and Cochran (1977) biostatistics.

The mean length of each sample was given by the following equation:

$\times = [x(1) + x(2) + \cdots + x(n)] = \frac{1}{n} * \sum_{i=1}^{n} x(i)$ … … … … … … … … … … … … … … … … … …. (1)

Where n = sample of a particular fish species caught from one canoe and

x(i) = length of fish no i., and I = 1,2,……..,n.

The variance, which is the variability about the mean value, is given by the following equation:

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$$S^2 = \frac{1}{n-1} * [(x(1) - \times)^2 + (x(2) - \times)^2 + \cdots + (x(n) - \times)^2] = \frac{1}{n-1} * \sum_{i-1}^{n} [x(i) - \times]^2 \ldots\ldots\ldots\ldots\ldots (2)$$

Thus the variance, S^2, is the sum of the squares of the deviation from the mean divided by the number, minus one.

$$S^2 = \frac{1}{n-1} * [\sum_{i=1}^{n} x(i)^2 - \frac{1}{n} * [\sum_{i=1}^{n} x(i)]^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The square root of the variance is the standard deviation. The relative standard deviation or coefficient of the mean is the standard deviation divided by the mean i.e. $\frac{S}{X}$ .... (4)

The growth parameters L∞ (asymptotic length) and K (stress factor) of the species were examined with FISAT II software package. The total mortality Z was calculated as follows:

Z = F + M.. (5)

Where F = Fishing mortality and M = Natural mortality.

The exploitation rate (E) was calculated as follows:

$E = \frac{F}{Z}$.. (6)

3.5 Data Sources

The field sources used to gather information from the area included focused group discussions which is a semi-structured discussion with group of fishermen, mangrove loggers and traders separately in order to identify their perception of the environment , questionnaire, water samples for physicochemical parameters analysis and catch composition of gillnet fishery in the study locations between December 2014 and May 2015. Rainfall data for the period of study were obtained from the Department of Meteorology of the Nigerian Airport Authority

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(NAA), Calabar. Information from previous studies was also used in this work.

The questionnaire (Appendix I) consisted of both open-ended questions which gave the respondents the opportunity to express themselves, and avoid the bias that may result from suggesting response to individuals, and closed-ended questions that gave the respondents pre-coded responses in which the respondents selected the options.

The questionnaire was categorized into six sections including socio-demographic background information of respondents, information on traditional fisheries management, other estuarine resources management, socio-ethnic information, social information and governance in each location of study. The administration of the questionnaires was preceded by focal group discussions with fishermen and women, shellfish harvesters, mangrove loggers, fish and shellfish processors and traders. The focal group discussions were held twice in each of the stations prior to the administration of questionnaires.

3.6 Data Analysis

The physicochemical analysis of water samples was done using the methods in American Physical Health Association (APHA, 2005). The fish samples were analyzed for catch per effort and catch composition, length frequency using relevant statistics which included mean, variance and standard deviation, while the growth parameters was analyzed using FISAT II fish statistics software package. Simple analysis of variance (ANOVA) was used for statistical test of significance of the physicochemical characteristics of water and the catch per unit effort of fishes. The questionnaire data were analyzed using descriptive statistics (Statistical Package for Social Science software). Tables, charts, graphs and photographs were also used.

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CHAPTER FOUR

RESULTS

4.0 Physicochemical Characteristics of Water in the Study Area

Table 4.1 shows the mean surface temperature, pH, dissolved oxygen, turbidity, salinity, alkalinity, and nutrients ($PO4^-P$ and $NO3^-N$) of the study locations, during the study period. There was no consistent trend in water temperature. The mean surface temperature ranged from 29.25^{0}C to 29.50^{0}C at all locations. The hydrogen ion concentration (pH) ranged from 6.25 to 6.47.

Table 4.1: Physicochemical characteristics of water in the study area (Mean±S.D)

LOCATION	Temp. (°C)	pH	DO (mg/l)	Turbidity (NTU)	Salinity (ppt)	Alkalinity (mg/l)	$PO4^-P$ (mg/l)	$NO3^-N$ (mg/l)
Anansa	29.5±0.2	6.25±0.2	5.90±0.3	52.20±1.2	10.63±0.8	36.25±0.25	0.0016±0.002	0.0048±0.003
Okon	29.7±0.1	6.47±0.2	5.80±0.5	30.33±0.7	7.65±1.5	35.00±1.25	0.0048±0005	0.0023±0.002
Anantigha	29.25±0.25	6.27±0.3	5.15±0.4	21.80±2.2	10.20±0.6	42.50±1.0	0.0018±0.001	0.0046±0.003

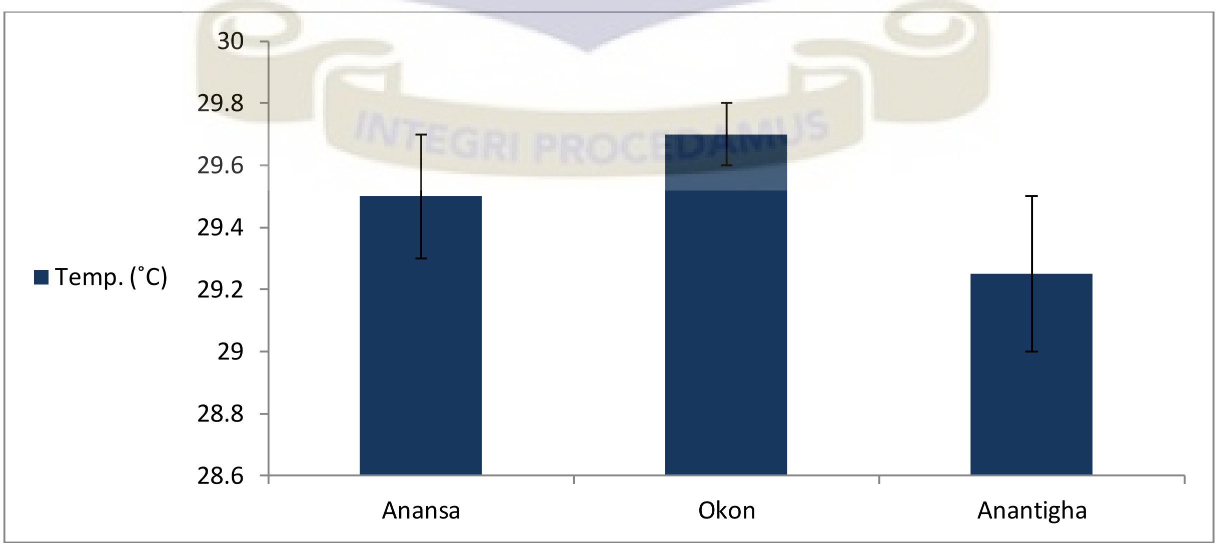

Figure 4.1: Mean temperature for the study locations

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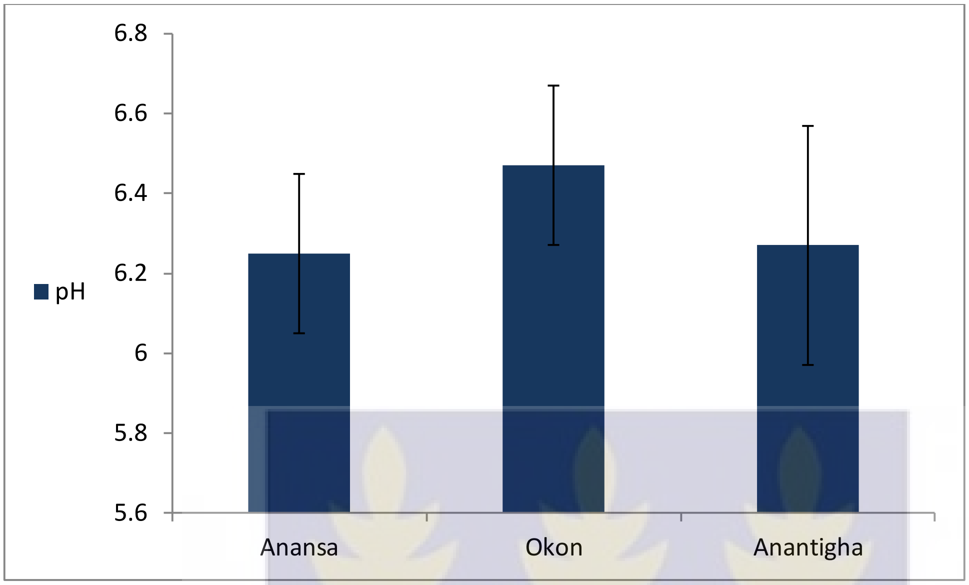

Figure 4.2: Mean pH for the study locations.

The mean dissolved oxygen ranged from 5.15 mg/L. The range was 5.20 to 5.90 mg/L. Higher dissolved oxygen values were recorded from December 2014 to January 2015.

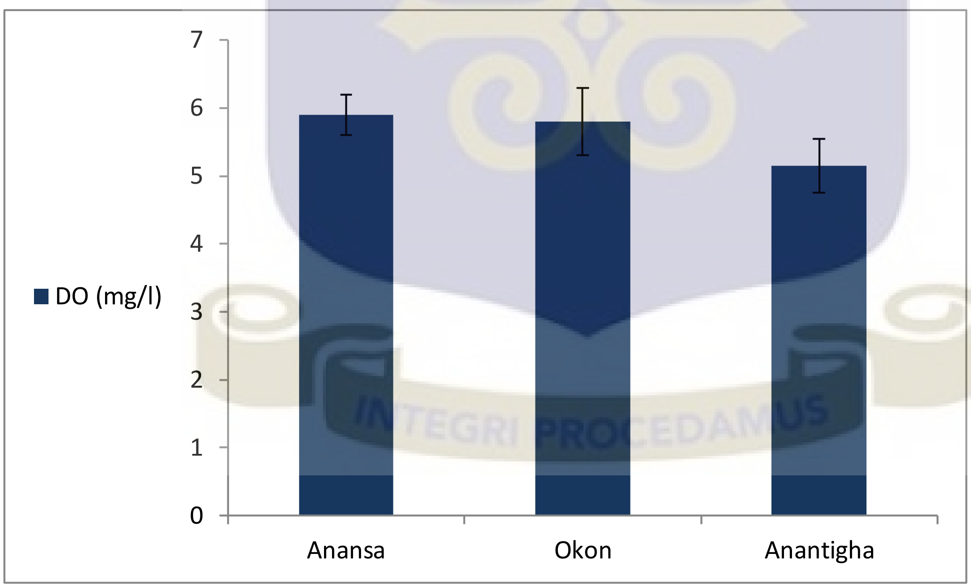

Figure 4.3: Mean DO level for the study locations.

The mean turbidity for all the stations ranged from 21.80 to 52.50 NTU while that of salinity was from 7.65 to10.63 ppt.

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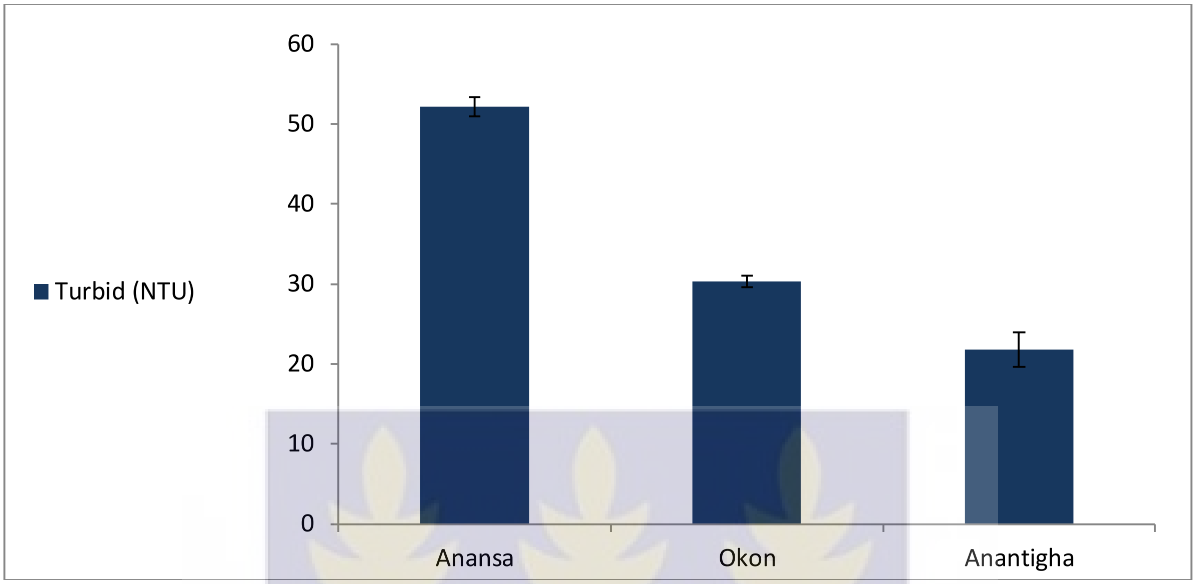

Figure 4.4: Mean turbidity for the study locations

Figure 4.5: Mean Salinity for the study locations.

The mean alkalinity for the stations, Anansa, Okon and Anantigha ranged from 35.0 to 42.50 Mg/L, while the mean phosphate and nitrate were from 0.0016 to 0.0048 and 0.0023 to 0.0048 Mg/L, respectively.

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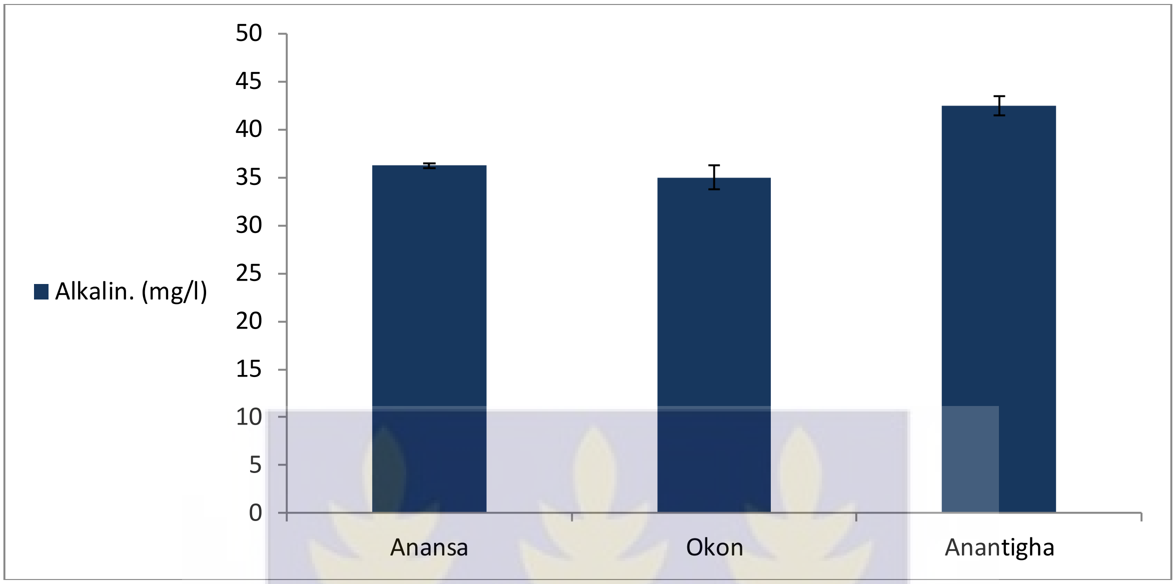

Figure 4.6: Mean Alkalinity for the study locations.

Phosphate and nitrate at all the stations followed similar trend of higher values in the drier period of the study and was higher at Anantigha in April when the wet season was approaching. They ranged from 0.016 to 0.048 mg/L, and 0.023 to 0.048 mg/L, respectively.

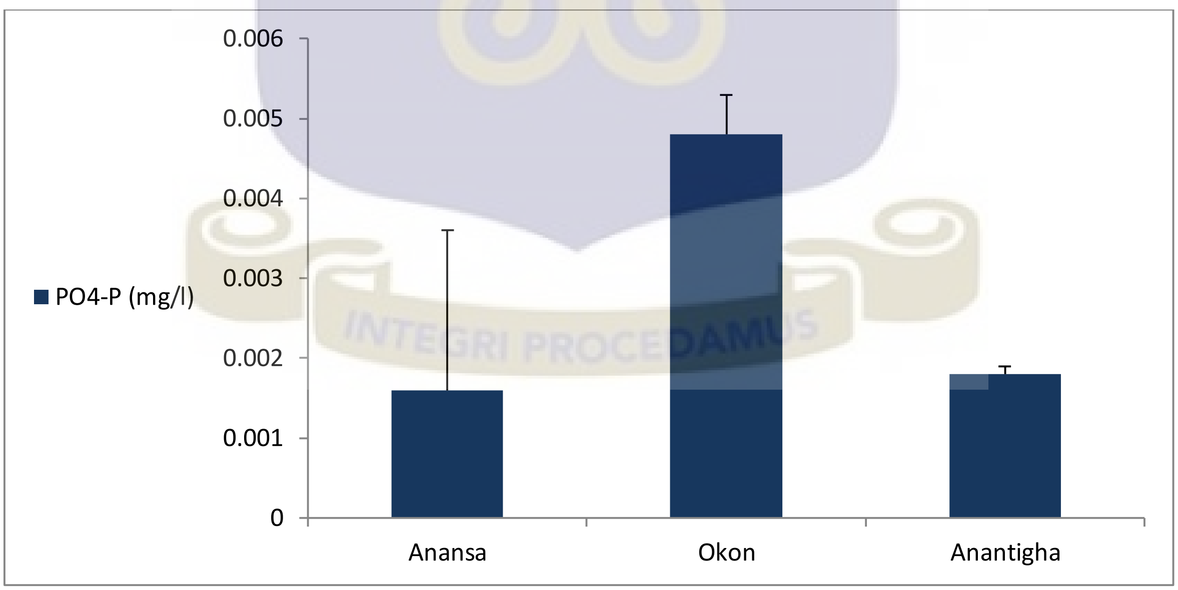

Figure 4.7: Mean Phosphate concentrations for the study locations.

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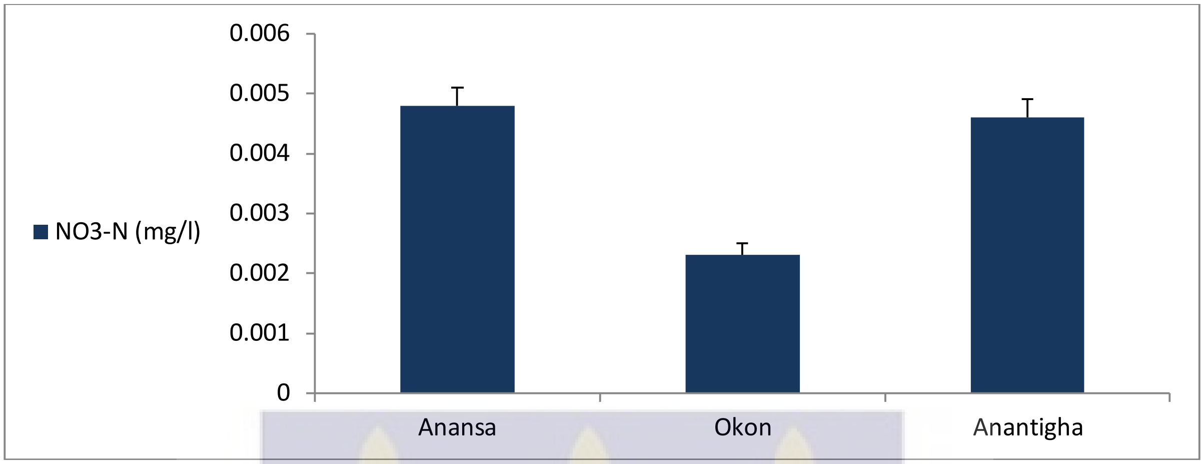

Figure 4.8: Mean Nitrate concentrations for the study locations.

4.1 Catch Assessment

Table 4.2: Monthly distribution of the CPUE (kg/canoe/trip) for the study locations

LOCATION	Dec.2014	Jan.2015	Feb.2015	Mar.2015	Apr.2015	May2015
Anansa	20.50	26.50	37.30	34.00	22.40	21.20
Okon	10.30	12.20	16.20	15.70	18.30	15.50
Anantigha	15.20	18.40	27.50	25.20	24.60	20.10
Mean	**15.33**	**19.03**	**27.00**	**24.97**	**21.77**	**18.93**

Table 4.2 represents the catch per effort of the multi-species gillnet fishery in the study locations. The total landings for each location sampled during the study period were 161.90 kg for Anansa, 88.20 kg for Okon, and 131.00 kg for Anantigha respectively, (range from 88.20kg to 161.90 kg).. The mean weight of monthly landings sampled (CPUE) was 21.20 kg/canoe/trip (range 15.33 kg to 27.00 kg). The mean CPUE for the study period for all the locations was 7.1 kg/canoe/trip. The highest mean CPUE (27.00 kg/canoe/trip) was recorded in February, 2015, while the lowest (15.33 kg/canoe/trip) occurred in December, 2014.

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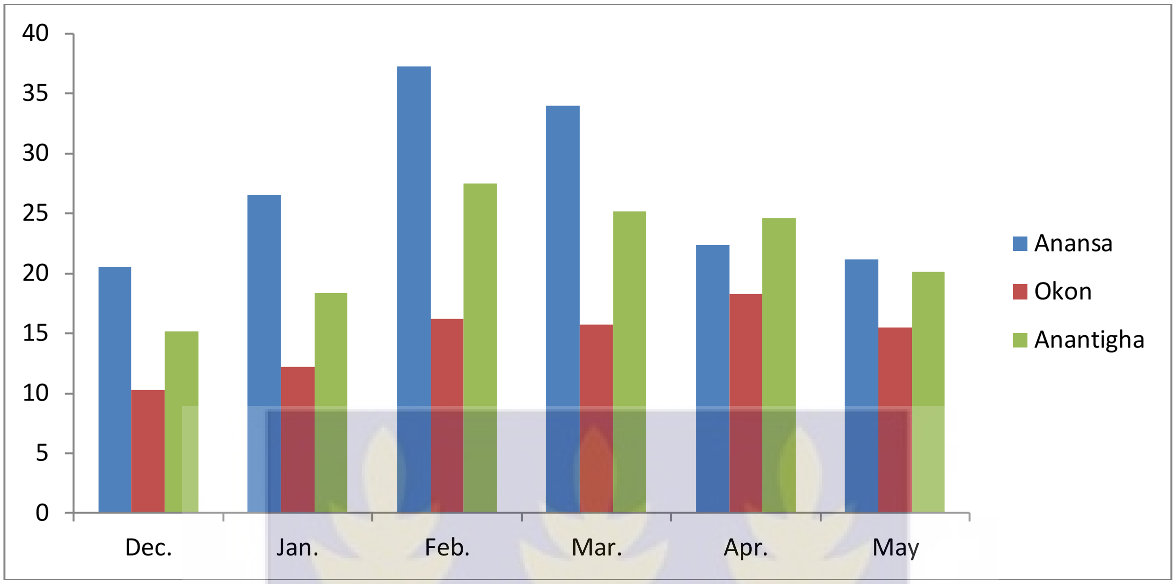

Figure 4.9: Monthly mean landings (kg) for the study locations (Dec. 2014 - May 2015)

The results of the assessment of the composition of catches in the study locations (Fig.4.10) revealed that the *Pseudotolithus elongatus* accounted for 56.69%, by weight, *Ethmalosa fimbriata* was 30.28% , *Chrysichthys nigrodigitatus* was 7.53% and other fishes made up 5.50% by weight of the total catch for the study period. Other fishes found included *Ilisha africana*, *Pseudotolithus typhus*, *Scomberomorus tritor*, *Liza falcipinnis*, *Caranx hippos*, *Polydactylus quadrifilis*, *Cynoglossus senegalensis*, *Arius parkii*, *Sphyraena sphyraena*, and *Schilbe mystus*. The bobo croaker (*P. elongatus*), bonga (*E. fimbriata*) and the estuarine catfish (*C. nigrodigitatus*) together accounted for 94.50% of the catch. It was observed *that Pseudotolithus elongatus* was present in the catch in all of the months, with its peak catches in January and April (82.29% and 85.34%). *Ethmalosa fimbriata* also occurred from December to May, but recorded higher levels of presence in the months of February and March (37.32% and 74.57%). *Chrysichthys nigrodigitatus* occurred throughout the study though in insignificant quantity, predominantly in the months of February and April (15.86% and 8.56%).

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Other species were also present throughout the study, with the most significant contribution in January and March. The lowest catch value was recorded in December, 2014. The highest catch value of 81.0 kg was recorded in February, 2015 and the total mean was 127.00 kg.

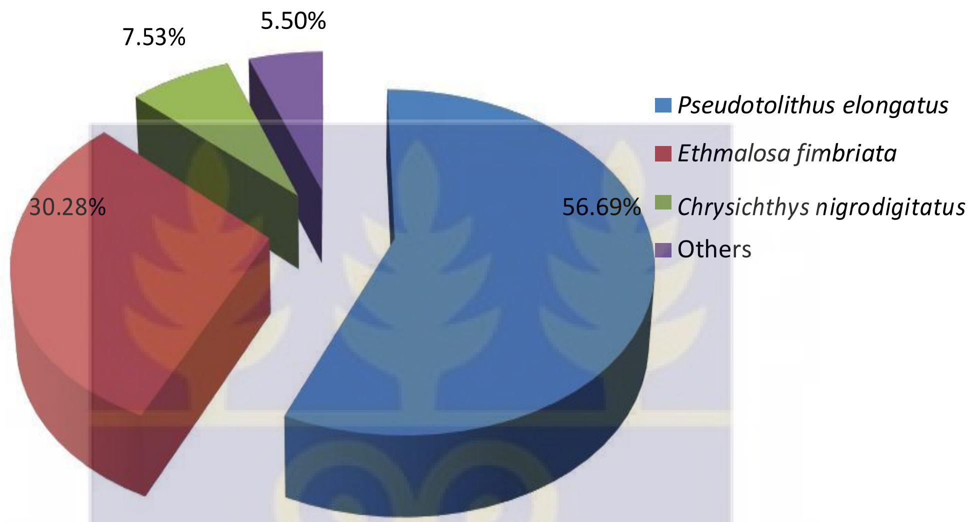

Figure 4.10: Catch composition (%) by weight of the gillnet fishery for the study period.

The fishing gears used in the study locations were near surface and near bottom gillnets of about 100 m in length and of stretched mesh size varying from 2.9 cm to 5.0 cm, for near-surface gillnets for bonga, and 4.0 cm to 6.6 cm for near-bottom drift nets for demersal fish. Others were hook and line, and traps of different types such as brush traps, basket pots, artificial shelters, basket traps, fish fences, and drums (Plate 2).

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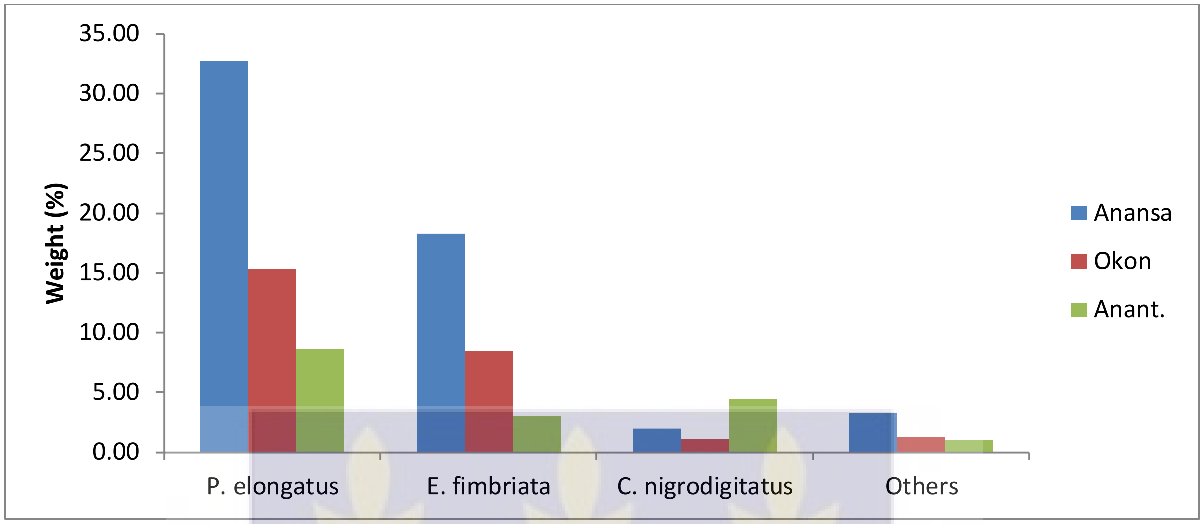

Figure 4.11: Catch composition (%) by weight for the study locations

Figure 4.11 shows the catch compositions of fish species in the three locations of study. The results showed that P. *elongatus* was 32.75% at Esuk Anansa, 15.32% at Esuk Okon and 8.62% for Esuk Anantigha, respectively. E. *fimbriata* was 18.60%, 8.50%, and 2.98%, while C. *nigrodigitatus* recorded 1.98%, 1.05% and 4.50% Esuk Anansa, Esuk Okon and Esuk Anantigha respectively. The miscellaneous species were 3.25%, 1.23%, and 1.02% at Esuk Anansa, Esuk Okon and Anantigha, respectively. *P. elongatus* constituted the highest (56.69%) catch composition in total, followed by E. *fimbriata* Esuk with 30.28% while C. *nigrodigitatus* had the least of 7.53%, with 2.03% at Anansa, 2.03% at Esuk Okon and 5.5% at Anantigha respectively. Most of the miscellaneous fishes occurred around Anansa and Okon area, scoring only 5.50% at all stations. The most productive location which had the highest percentage of landing 56.28% was Esuk Anansa, followed by Esuk Okon with 26.1% and the least was Esuk Anantigha with 17.12% of the total landing.

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4.2 Exploitation Rates and Sizes of Fish

During the study period, it was noted that over 80% of the fish caught were at their growing stages. Analysis of the mean length of the fishes showed that the mean length for *Pseudotolithus elongatus* was 14.30±2.45, *Ethmalosa fimbriata* was 10.47±1.58, while *Chrysichthys nigrodigitatus* was 17.7±3.23. The length distribution for the three most commonly caught fish species showed that the small fishes dominated the catches (Appendix V). Out of the 1814 sampled fishes, a total of 1,009 were between mid-length intervals of 10.5 cm to 19.5 cm. The dominant fish sizes were between 10 and 20 cm total length, and very few fishes ranged between 20 and 25 cm total length. However, a few relatively large adult fishes were caught, which were mostly mature females with eggs. The largest fish recorded in the landings was *Chrysichthys nigrodigitatus* with a total length of 53.2 cm. The simple ANOVA statistical test showed that difference in the monthly CPUE is not statistically significant while there is a significant difference in the CPUE across the sites (Appendix VII and VIII).

The results of the growth indices of the target species for this study were $L\infty$ = 26.78cm, K = 0.32yr^{-1}, M =1.80, Z = 2.72, F = 1.83, E = 0.67 for *P. elongatus*. $L\infty$ =17.33cm, K = 0.63yr^{-1}, M = 1.57, Z = 2.75, F = 1.18, E = 0.43 for *E. fimbriata* and $L\infty$ = 25.70cm, K = 0.46yr^{-1}, M = 1.15, Z = 3.78, F = 2.60, E = 0.69 for *C. nigrodigitatus*, at mean temperature 29.48ºC (Table 4.3).

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Table 4.3: Growth Parameters and exploitation rates of target species

Species	L∞ (cm)	K (yr^{-1})	Z	Z/K	M	F	E
P. elongatus	26.78	0.32	2.72	2.34	0.89	1.83	0.67
E. fimbriata	17.33	0.63	2.75	2.14	1.57	1.18	0.43
C. nigrodigitatus	25.70	0.46	3.78	1.35	1.15	2.60	0.69

4.3 Socioeconomic Information

To further understand the status of fisheries in the study area, one hundred and forty two copies of the questionnaire were distributed to fishermen, fish processors and mangrove fellers. The investigation revealed that most of the people were involved in fishing: 109 of the respondents were involved in fishing, representing 76.8% of the sample population, 9 of the respondents were fish processors, representing 6.3%, and 24 of the respondents were involved in mangrove felling, representing 16.9% of the sampled population. It was also found that 82% of the respondents engaged in subsistence farming and trading in addition to their main occupation.

One hundred and seven (107) constituting 75.35% were male and 35 (24.65%) were female. Those in the age brackets of between 31 and 35 years formed the bulk of the population with 44 respondents (31.0%), followed by the respondents whose ages were between 26 and 30, were 33 respondents (23.2%). The respondents that had their ages ranging between 36 and 40 years being 31 (21.8%), those between the ages of 41 to 45 years were 22 (15.5%).

Ten respondents had their age between 46 and 50 years (7.0%), while those with age ranging from 51 to 55 were only 2 (1.4%). Information on the marital status from the respondents revealed that the number of married respondents were 108 (76%), while 25 (17.6%) were

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single and 9 (6.3%) were divorced. The study of the location of the respondents fishing activities showed that 93 (68.4%) respondents were estuarine based, this was followed by their fresh water counterpart, which were 29 (21.3%), while the marine located were 8 (5.6%) and the lagoon based were 6 (4.4%). The fishing gears employed showed that most of the respondents used gillnet fishing. Seventy-nine; that is (55.2%) of the respondents were gillnet fishermen, 20 (14.0%) used hook-and-line, while 10 (7.0%) used fishing traps.

For the existence of catch and fishing trips records of respondents, 63 (44.4%) strongly disagreed, 48 (33.8%) disagreed, 24 (16.9%) agreed, while only 7 (4.9%) strongly agreed. The enforcement of rules and regulations in these areas showed that the town/village council dominated the outcome with 85 (59.9%) of the respondents, 54 (37.8%) for chiefs, while the chief fishermen were the least, 3 (2.1%). The frequency of the efficiency of the enforcement showed that 75 (52.8%) strongly disagreed that the enforcement was effective, 47 (33.1%) disagreed, while 15 (10.6%) and 5 (3.5%) agreed to the effectiveness of the rules and regulations in the area. The fisheries management structures were said to be Chief fishermen, traders associations, and town councils. Forty-six (43.0%) respondents strongly disagree that the fisheries management is effective, 44 (41.1%) disagreed, while 13 (12.1%) and 4 (3.7%) only agreed. Eighty-six (74.8%) of the respondents agreed that some fish species were lacking in their recent landings while, 29 (25.2%) were indifferent in their opinion. The main environmental problems of the study area showed that refuse disposal dominated the respondents' opinion with 33 (23.2%), followed by poor sanitation, which had 29 (20.4%), erosion was 21 (14.8%), deforestation 19 (13.4%), poor environmental management was 17 (12.0%), poor drainage 15 (10.6%), and only 8 (5.6%) for flood. Eighty-eight (62%) of the respondents had access to social infrastructure such as road, hotel, school, potable water,

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electricity and hospital while 54 (38.0%) had no access to such facilities. Fifty-nine (41.5%) of the respondents used the mangrove wood for cooking, 28 (19.7%) for palm oil production, 26 (18.3%) for bakery, 23 (16.1%) for building, and 9 (6.3%) for fish processing. Responses for ethnic structures showed that 85 (60.7%) were the Ibibios, 35 (25%) were the Efiks, while 20 (14.0%) were members of other ethnicity. One hundred and forty (i.e, 99.3%) respondents claimed that land ownership was communal, 89 (62.7%) were in support of the existence of conflicts in the area while 53 (37.3%) denied conflict existence.

All of the respondents claimed that the town council in collaboration with the local government council is responsible for the governance of the area. Most of the respondents supported the need to introduce a community-based coastal management strategy in the area in order to facilitate effective management of the fisheries and other coastal resources of the area. One hundred and eighteen respondents representing 83.1% supported CBCRM introduction, while 24 respondents representing 16.9% were indifferent.

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CHAPTER FIVE

DISCUSSION

5.0 Physicochemical Characteristics of the study area

The general results of the water quality analysis in the three locations of the study area indicated that apart from turbidity level, there was slight variation in other physicochemical characteristics of water in the study area. However, it was observed that the surface temperature of the water ranged from 28^0 C to 30^0 C with a mean of 29.48± 0.20. This is comparable to other African water bodies (Akpan, 1999). The slight difference in temperature may be due to the difference in the time of measurement as reported by Mustapha (2008). Statistical analysis showed that the P-value for the water quality between the study locations is less than 0.05 confidence limit meaning that the differences in recorded values are statistically significant (Appendix VI).

The pH range of 6.25 to 6.47 is within the tolerable limit for fish and shellfish survival in estuaries as reported by Boyd (1979) and Arrington *et al.* (1994). Akpan *et al*. (2002) reported that pH range of 5 to 6.75 is usual for unpolluted tropical rivers. The mildly acidic nature of the water during the study could be attributed to geological and biochemical factors (shales and sandstones), and humus materials from swamps and creeks within the river catchment as reported by Akpan *et al.* (1999). The pH was lower in the months of March and April. This may also be due to influx and exit of salt water in the estuary during wet season. A similar result was recorded by Karikari *et al*. (2006) in the Korle lagoon, Ghana. The result of the study by Michael (1992) about diurnal variation in pH for surface water was consistent with that of Akintola *et al*. (2011) in Badagry Creek, Nigeria, and that of the present study. The

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low pH of the study may also be attributed to low nutrient in the area as reported by Nyam (1998). Akpan (2004) attributed variation in pH to evapo-transpiration process and biological processes in the water.

The slight increase in temperature around April may be due to the effect of prevailing air masses (Akpan, 2004), owing to the approach of the rain. The results of the study showed that increase in temperature and rainfall resulted in a corresponding increase in pH. This corresponds with the report of the study by Adebisi (1991) at the upper Ogun River, Nigeria.

The mean dissolved oxygen recorded was 5.62±0.75 mg/L, with the range of 5.15 to 5.90mg/L. This can support the growth of fish in a reservoir, but may decrease growth rate according to Boyd (1979). Dissolved oxygen concentration (DO) decreases with increasing salinity. However, Michael (1992) stated that warm water species survive for long period of dissolved oxygen as low as 2 or 3 mg/L. DO was higher during the drier period of the study (December and January). This agrees with Akpan *et al*. (1989). The lowest concentrations of oxygen were recorded in March and April in all the stations (Ezenwa, 1981). The changes in oxygen concentration may be attributed to the dynamics of respiration and photosynthesis. The range of DO concentrations observed during the study is similar to those reported for the Cross River by Moses (1979). The slight difference in DO level at Esuk Okon may be attributed to current flow that enables the diffusion and mixing of atmospheric oxygen into the water. This is consistent with the report of Akpan (1993) for Qua Iboe River. The decomposition of organic load (leaf litter) increases oxygen depletion (King and Ekeh, 1990). However, Kendirim and Ejike (1992) had argued that dissolved oxygen concentration is higher in the drier periods due to high photosynthetic activities of phytoplankton. Turbidity variation was higher in the wetter months of March and April, with a range of 21.80 to 52.20

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NTU and a mean value of 34.78±21.87. This may be due to the increased amount of rainfall leading to erosional deposits from run-off.

The turbidity of the study area was highest at Esuk Anansa (52.20 NTU), while Esuk Anantigha recorded the lowest turbidity. This may be the result of the concentration of mangrove logging activities in the swamp resulting in the suspension of detritus and silt from mangrove exploitation, and the discharge of agricultural and human wastes at the location. Turbidity in the area may also be the result of evapo- crystallization from sea salt intrusion. Akpan (1991) reported same, though this contradicts the work on water bodies in Uyo by Akpan (2004) where he observed increase in turbidity with a corresponding increase in precipitation. Fatoki *et al.* (2001) noted an increase in turbidity in Umtata River (South Africa) which he attributed to contributions from runoff from settlements during the summer rains. Suspended solid particles rarely have direct impact on fish. However, they may adversely affect fish populations (Boyd, 1979). According to Kausch (1990) high turbidity is a characteristic of most estuaries with most having photic depths less than 1m.

The range of salinity observed was higher than salinity reported in the study by Moses, (1979), Lowenberg & Kunzel, (1992) and Akpan *et al.* (1999). This may be the result of the variation in the season of study and tidal situation. The salinity was higher during the drier months of December to February. High tide in the area is accompanied by high salinity due to incursion of sea water from the ocean. Akpan *et al.* (1999) attributed the generally lower levels of salinity in their study compared to reports from the Cross River to the restriction of sampling to only the low tide which excludes the influence of sea water intrusion. Salinity changes in estuaries are mainly controlled by fresh water discharge and precipitation (Cronin *et al.*, 1962). Esuk Okon with salinity range of 7.0 to 8.0 ppt. is characterized by strong salt

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and fresh water mixing, and may be classified as mid estuary according to Fairbridge (1980). Alkalinity level was almost homogenous throughout the study period in the three stations. The levels of phosphate were found to be lower than the range of 0.01 to 0.03 mg/L for phosphorous normally found in uncontaminated streams as defined by the United State Department of Agricultural Soil Conservation Service (USDASCS) (1975). Phosphate and Nitrate are important nutrients to plant blooms and the eutrophication of lakes and streams. Sources of phosphate to the estuary include industrial deposit, run-off from surface catchments, interaction between water and sediment from dead plant and animal remains at the bottom, and detergent which get accumulated in the river. The result of the present study revealed the study locations may likely be influenced by eutrophication, nutrient enrichment, productivity, decay and sedimentation as a result of deposition of nutrients by agricultural run-off in the area. George *et al*. (2012) recorded phosphate concentration in surface water of Tapi estuary, India as ranging from 0.001 mg/L to 0.822 mg/L from October to January. They noted that domestic as well as industrial effluents released from Surat city may be the major contributors to phosphate in the Tapi estuary. This corroborates the result of the present study in the Cross River estuary.

The range and mean of nitrate observed in the current study was below the 10 mg/L level, reported by Michael (1992), which he said that above the level, the nitrate is harmless but water may have toxic substances and pollution from industrial and agricultural sources. This may account for the higher concentrations of nitrate at Location1; Anansa (0.048 mg/L) and Location 3, Anantigha (0.046 mg/L) being urban settlements with associated local industrial and agricultural activities in these areas. Jaji *et al*. (2007) noted that unpolluted natural water usually contains only minute amount of nitrate.

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It therefore means that the water of the locations during the study period was unpolluted. Mustapha and Omotosho (2005) stated that Moro Lake has the highest concentration of nitrate (22.4 mg/L) in Nigeria, while Kolo (1996) reported 0.5 mg/ L in Shiroro Lake. The level of nitrate concentration in the present study was within the tolerance limit of the Federal Ministry of Environment and World Health Organization. The concentration of nitrate in these locations may be as a result of leaching and surface run-off of fertilizers from nearby farmlands. Nitrate is one of the most important indicators of pollution of water which represents the highest oxidized form of nitrogen. George *et al*. (2012) reported nitrogen range of 16 mg/L to 1.43 mg/L from June to December in Tapi estuary, India.

5.1 Catch Composition, Exploitation Rates and Sizes of Fish

The fish species found in the present study were similar to those of previous studies by Uwe (1988) and Holzlohner *et al*. (2007) in the Cross River estuary. The present investigation affirms the assertion by previous studies that *Pseudotolithus elongatus*, *Ethmalosa fimbriata* and *Chrysichthys nigrodigitatus* were the most important species in the catch as observed by Bassey (1988) and Holzlohner *et al*. (2007) and the importance of the marine nearshore area as a nursery location for a diverse assemblage of fishes (Nunoo, 2007). These species accounted for 80.1% of the catch by weight in the study by Bassey (1988), 92.1% in Holzlohner *et al*. (2007), and 94.5% in the present investigation. It was observed in the current study that *Pseudotolithus elongatus* was found in the catches throughout the study period December 2014 to May 2015. *Ethmalosa fimbriata* was present in the months of January to April with highest weight in March.

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The average weight of monthly catches per boat per trip of 21.2 kg and mean CPUE of 7.1 kg/boat/trip in the present study is not far from 36.2 kg and 6.2 kg/boat/trip, respectively as reported by Holzlohner *et al*. (2007). This shows that the fishery is in decline, though the previous study lasted for a whole year and sampled more locations than this study which sampled three locations only in six months. Bassey (1988) reported a mean CPUE of 4.9 kg/canoe/trip. A comprehensive study on the migration pattern and life cycle of *E. fimbriata* by Ama-Abasi *et al*. (2004) revealed that the adult stock inhabits the coastal waters all year round for feeding and spawning activities, hence their vulnerability to near shore purse seine fishery.

However, *P. elongatus* and *E. fimbriata* dominated the catches around the Anansa and Okon area that are closer to the marine water of the ocean, while *C. nigrodigitatus* dominated the freshwater area of Anantigha. Holzlohner *et al*. (2007) reported *P. elongatus* and *E. fimbriata* as marine species; while Moses (1979) asserted that *C. nigrodigitatus* inhabits brackishwater, small and large freshwater bodies of Africa. The highest catches were recorded at Esuk Anansa. This may be the result of the high turbidity owing to deposition of detritus from mangrove exploitation, and other nutrients from runoff of adjoining agricultural activities. *Chrysichthys nigrodigitatus* was found throughout the study period in small quantity. The lowest catch rates were recorded in December and April. The month of April marks the beginning of the wet season, when *P. elongatus* and *E. fimbriata*, and other marine species begin to migrate out of the estuary (Ama-Abasi *et al.*, 2004). It was generally observed during the present study that most of the fish caught were small, hence the need for sustainable fishing method such as the regulation of mesh sizes of fishing nets and the establishment of community-based coastal resource management system in the area. Similar reports had been observed in studies of gillnet fisheries by Holzlohner *et al*. (2007), Ama-Abasi*et al*. (2014) in

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the Cross River estuary and Ngodigha *et al.* (2015) at River Nun estuary, Bayelsa state, Niger Delta, Nigeria.

Nwosu *et al.* (2010) reported an exploitation ratio of *Pseudotolithus elongatus* in the Cross River estuary to be 0.79, indicating that the fishery is overexploited. The present study recorded exploitation rates of 0.67 and 0.69 for *P. elongatus* and *C. nigrodigitatus* and 0.43 for *E. fimbriata*. This may be as a result of the sampling period, sampling season and sampling locations. However, the study suggests management regulation, particularly seasonal closures coinciding with the period of peak spawning to be implemented in order to improve the fishery of the estuary. In addition, particular attention should be given to the management and conservation of the mangrove habitat that sustains the productivity of this system.

Ajang *et al*. (2011) gave the exploitation rate of the Cross River to be 0.81 per year, indicating that the fishery is under excessive fishing pressure from over exploitation. This calls for the need for the regulation of fishing effort (e.g. reduction of the number and type of gears), time of fishing, and mesh size regulation. However, it was also observed by this study that lack of comprehensive effort data is an obstacle to management of fisheries resources in the estuary as reported by Holzlohner *et al*. (2004). In addition, it is important to know how much fishing effort is used to catch a given quantity of fish. This enables an index of abundance to be calculated (Holden and Ritts, 1974). Continuous monitoring or at least periodic analysis of the catch structure of the fishery is necessary to track the biomass spectra of the fish populations. Any drastic changes in the structure, such as species disappearances or explosions resulting from fishing, habitat alteration, pollution load or even natural events, may be detected early and actions taken to conserve the fish stocks (Holzlohner *et al*., 2007).

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5.2 Socioeconomics

The result of the socioeconomic parameters indicated that most of the settlers of the study locations are engaged in fishing activities, followed by mangrove logging, subsistence farming and trading. The major concern of this study is focused on the need for introduction of a sustainable management strategy in order to improve fisheries productivity and restore nearshore fish-producing habitats with the participation of community organizations. The community organization must be guided by the need to promote technologies that could be implemented by fishers with minimum support services. These include the establishment of marine sanctuaries, sea ranching and aquaculture, and control of destructive fishing methods. The considerable amount of research information gathered by marine scientists and groups in the estuary tend to link directly to decreased levels of fishery production to unsustainable fishing activities and the destruction of coastal ecosystems, especially mangrove. Direct observations on upland deforestation and on the disappearance of mangrove forests further increased the general awareness of the critical service functions of this environment in maintaining fishery harvests.

Marine reserves which are areas of the marine environment protected from various forms of exploitation are a key element of present day CBCRM projects in the world according to Alcala, (1998). He further stated that virtually all CBCRM projects include a provision for the establishment of marine reserves as a strategy to allow recovery of the environment (e.g. mangroves, coral reefs) and the resource (e.g. fishery). The potential use of marine reserves in the management of coral fisheries, for example, includes the protection of a critical stock biomass to ensure recruitment supply via larval dispersal to areas that are fished and to

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maintain enhanced fish yields to areas adjacent to reserves through the movement of adult fish. The establishment of reserves as part of CBCRM in the study area would, therefore, appear attractive, even reasonable, to stakeholder communities. The fisheries of the study area could support the strides towards employment generation, poverty alleviation and supply of animal protein to the teeming Nigerian population, hence the need for its sustainable management. One of the major challenges to the establishment of CBCRM in the Cross River estuary is the widespread lack of community organization and capacity for carrying out basic management functions, such as those described by Pinkerton and Weinstein (1995).

5.3 Approaches for Community-Based Coastal Resource Management

The widespread lack of community organization and capacity for carrying out basic management functions in the study locations is the result of the weak management structure. Even in remote, rural villages isolated from the pressures and enticements of modern commercialism such as Esuk Okon and Ine Abasi, traditional community institutions are so weak as to be non-functional, which has made the villagers mostly fishermen not see the connection between declining fisheries and mangrove destruction, and have forgotten how to work together. There is need for the development of effective community organizations that can carry out major fisheries management tasks, among other functions in these communities.

Community-based coastal resource management generally has the following components in common: Social preparation and community organizing; Environmental education and capacity building; Resource management plans, including protective management; Support activities for livelihood and financial resources mobilization; Research and monitoring; and

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Networking activities. The effort and duration of time allocated to these activities by project implementers differ from project to project, but in general social preparation, community organizing and environmental education are given priority and much importance in the early stages of project implementation. This is so because it is through these activities that a community is given the opportunity to identify its own needs and the problems it must solve in order to improve the socioeconomic well-being of the people through cooperation of all its members.

A result of community organizing is the formation of viable people's organizations that would plan and implement identified development projects. Environmental education is also of utmost importance during the early stages of CBCRM. The community needs to be convinced of the need to protect and manage their own resources. In this connection, ecological relationships, e.g. roles of healthy environments in sustainable marine productivity, need to be demonstrated to the community. In addition, the economic values of tropical ecosystems, such as coral reefs and mangroves for coral reef fish production and for mangrove values should be made known to the stakeholders of the resource (Alcala, 1998).

The CBCRM approach requires at least one partner organization, which is usually an academic institution or an NGO. Partner organizations act as catalyst for development, providing initiative, direction, and technical advice and funding. During the period of partnership, they serve as co-managers of projects, but since the goal of CBCRM is to empower and enable the communities to protect and manage their own resources, partner agencies have to withdraw from project areas after a certain period of time. The time frame

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required to complete the various CBCRM activities is usually 2 to 3 years, but sometimes often extends to 4 or 5 years (Alcala, 1998). However, it is not unusual for partner organizations to maintain their links to organized communities long after their withdrawal.

During the past 20 years (1970s to 1990s), there have been about 20 fisheries or coastal resource-related programmes and projects that either incorporate various degrees of community participation or are fully community-based in character (Alcala, 1998). Some of these are small projects, limited to specific localities, while others are large, being regional or national in coverage.
Funding is provided by external agencies. Most of the small CBCRM projects have been initiated by either academic institutions or NGOs, but in all cases, have been conducted in cooperation or partnership with local government units. Only one project with a community component was directly under a town mayor of the Carbin Reef Marine Reserve in Sagay, Negros Occidental.

A highly successful community-based project may thus be characterized by the establishment of a viable organization or organizations in the community; a working marine reserve protected by the community; sources of livelihood based on coastal (fishery) resources; networking arrangements with government and international agencies, and NGOs; and a capacity-building programme. Although not all community-based projects have been successful, the most successful ones are community-based Alcala, (1998). There is always a certain probability of failure, as the CBCRM approach is dependent on a number of social factors that are difficult to control.

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Furthermore, there are a number of prerequisites to successful CBCRM, including the existence of a legislative framework and the acquisition of organizational and technical skills by communities. The critical role of community organizations and partner organizations in the management and protection of coastal ecosystems and fisheries has been widely recognized by governments and multilateral agencies. CBCRM has therefore become a popular strategy to address the issue of depletion of open-access resources, such as fisheries. These resources, unlike most land resources, are not covered by appropriate tenurial instruments as legal basis of ownership. Under the open-access situation, there are no property rights, only possession or actual use.

This has been blamed for the unrestricted exploitation of fisheries, resulting in resource depletion. What the CBCRM provides to resource users or stakeholders is the sense of being proprietors and claimants of a resource. In brief, if coastal communities are to be effective in coastal resource protection and management, they must be recognized and empowered as the day-to-day managers of coastal resources, such as coastal fisheries (Alcala, 1998).

5.4 Sustainability of CBCRM projects

Among several issues in CBCRM, that of sustainability stands out prominently. It is argued that local governments and local communities usually cannot adequately manage coastal ecosystems because of their limited area of jurisdiction, limited research capacity, budget constraints, and the dominance of parochial interests in local politics. The consequences of these limitations are that either management projects cannot take off at all or they cannot be

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sustained in the long term. It is confirmed that the parochial or even selfish interests on the part of local politicians have been one of the major reasons for failure of some projects (Alcala, 1998). The limitations in research capacity and in area jurisdiction though real are not insolvable. They have been overcome by training, capacity building, and networking with NGOs and academic institutions in a number of examples, resulting in relatively successful projects. What matters most is the budget limitation.

Generally, partner organizations that initiate CBCRM projects are prepared to support these projects financially for only 2 or 3 years, whereas 4 to 5 years are usually required for a community to establish viable organizations that are capable of formulating and implementing development plans. It also takes about the same duration of time to place communities on a solid footing in terms of provision of livelihood opportunities.

By coincidence, 4 years are needed for plankton-feeding fish (but 8 to 10 years for carnivores) to spill over from coral reef reserves to fishing areas, thereby increasing fish catches of fishermen. These time frames are important guides to partner organizations concerned in demonstrating the impact of protected areas on the fish food supply of communities. Newkirk and Rivera (1996) stated that "concrete gains in a project are the most effective mechanism to convince people about the relevance of community resource management".

It is important that before outside financial support to communities is terminated, all arrangements should be in place to ensure that people are engaged in livelihood activities on a sustainable basis. This is true of one of the most successful CBCRM projects in the Philippines, the Apo Island Marine Conservation Project in Central Visayas. The project

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began in 1981 and its marine reserve (10% of coral reef area) was established in 1982 and community organizing intensified in 1985 to 1986. The organized community of 500 people has successfully managed and protected the reserve with little help from the partner agency (Silliman University) for 9 years, since 1987. The fishermen now report that their fish catches from the non-reserve have substantially increased, and they attribute this increase to the establishment of the reserve. They are happy because the reserve now brings more income to them through increased fish yield and tourism.

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CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

The study concentrated on the multispecies gillnet fishery of the estuary, and the most dominant catch composition in the area included *Pseudotolithus elongatus*, *Ethmalosa fimbriata*, and *Chrysichthys nigrodigitatus*. The data obtained revealed that there was significant difference in the water quality parameters. However, the water quality was within the tolerable limit of fishes. Gill net constituted about 70% of the total gear used in the study area and which also determined the size of fish harvested. Generally, it was observed during the study that most of the fish caught were small in size and the fisheries were being threatened in terms of rate of exploitation. The mangroves of the area were indiscriminately harvested for fuel wood in oil palm processing and fish processing, cooking and baking, also for agriculture and building with consequent habitat destruction. The fishery of the area could support the strides towards employment generation, poverty alleviation and supply of animal protein to the population, hence the need for its sustainable management. The study recommends the following for the management of fisheries of the area.

6.1 Recommendations

•Adoption of Community-Based Coastal Resource Management

Conventional coastal management systems have contributed to the failure of the overall health of the marine ecosystems; they are not designed to address issues on a local scale. There is need to consider the integration of local ecosystem dynamics with community needs. The weak and ineffective management structure in the study area calls for the need of the establishment of an organized, proactive, and effective management system for the fisheries

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and coastal resources of the area. To ensure the enduring character of community, ecological, and economic vitality, community-based management in the estuary must include modification of existing management approaches including direct allocations to communities. Successful coastal resources management depends on an inclusive process that starts at the community level, integrates science, government, local and traditional knowledge and stakeholders, and addresses the appropriate scale of the management issues. Community-based management will promote diverse, selective fisheries; it will maintain habitat integrity through the use of low-impact gear and practices. At the community level, stakeholders are held responsible for stewardship and all users are responsible for fully accounting and monitoring of catch and landings information. Communities are the most appropriate entities to promote the restoration of impaired fisheries resources and habitats on an appropriate local scale.

•Regular assessment and monitoring of the fisheries and ecosystem

Continuous monitoring or at least periodic analysis of the catch structure of the fishery is necessary to track the biomass spectra of the fish populations. By this measure any drastic changes in the structure, such as species disappearances or explosions resulting from fishing, habitat alteration, pollution load or even natural events, may be detected early and actions taken to conserve the fish stocks.

•Gender, fisheries and development

Although Cross River estuary fisheries have been the subject of considerable study, little attention has been paid to the role of gender in the development process and, more specifically, the work done by women in the overall management of fisheries. Lack of attention to the gender dimension of fisheries management in the area can result in policy

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interventions missing their target of creating sustainable livelihoods at the community level. There is little doubt that fishing-dependent communities have a vital role to play in the overall development process of many coastal West African States, but without a complete understanding of the complexity of gender roles, the goal of sustainable livelihoods is unlikely to be achieved. A move toward collecting gender and fisheries disaggregated data in the estuary would also help expand existing knowledge about what are often marginal and isolated economic sectors. CBCRM is a vital tool for the mobilization of women for sustainable fisheries.

•Development and Fisheries Management

The development of fisheries and fisheries management is essential in the Cross River Estuary. The problems and constraints faced when attempting to manage a fishery resource must be identified and addressed. The particular fishery management problems faced by developing nations in general and with reference to countries in West Africa should be addressed such as the inability, political constraints, to avoid short term solutions which then place the resource-base at risk. Ironically, the relative effectiveness of other countries' management plans may place the resources of these less-developed countries at greater risk as fishermen weigh the costs of entering various fisheries and choose those with ineffective management.

•Intensification of Research in the Estuary

In a broad sense, strategies addressing the need to increase our overall knowledge about biodiversity and how to manage it include identifying key areas where information is lacking, promoting research opportunities and seeking new sources of funding. It is important that management practices are based on current information. Continuing applied research efforts

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and inventories that update knowledge of the occurrence of species and habitats will provide an objective basis for biodiversity management of the Cross River estuary.

•Education

Education strategies to address a variety of threats to biodiversity and can be implemented at a variety of levels. Many education strategies address the desire to raise public awareness and understanding about biodiversity issues and the need for conservation. Education of the fishermen in the Cross River estuary will increase their understanding of biodiversity conservation and promote the utilization of conservation tools in the management of fisheries and mangroves in the estuary. Partnership with other organizations to develop several tools for sustainable management can be useful to local fishermen in the estuary. Education of the inhabitants of the estuary on proper practices and the establishment of an effective waste management system in the estuary will be worthwhile.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE

"This questionnaire for the project titled "Community-Based Coastal Resource Management Approach to Fisheries and Mangroves for sustainability in the Cross River estuary" is to examine the Coastal and fisheries issues in the Cross River Estuary. All information supplied will be treated confidentially and will be strictly used for the purpose for which this study is intended. Please tick the box against the option that best answers the questions, and also make comments where necessary.

A. SOCIO –DEMOGRAPHIC BACKGROUND OF RESPONDENTS

1. What is your occupation?

Fishing ☐ Farming ☐ Processing/Trading ☐ Mangrove Logging ☐

2. What is your Gender? Male ☐ Female ☐

3. What is your fishing location

Freshwater ☐ Marine ☐ Lagoon ☐ Estuary ☐

4. How many years have you been fishing/farming

0-5yrs ☐ 6-10yrs ☐ 11-15yrs ☐ 16-20yrs ☐

5. What kind of fishing/farming

Full time ☐ Part time ☐ Seasonal ☐

6. What is your Age?

21-25yrs ☐ 26-30yrs ☐ 31-35yrs ☐ 36-40yrs ☐

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41 – 45yrs ☐ 46 – 50yrs ☐ 50 and above ☐

B. TRADITIONAL FISHERIES MANAGEMENT

7. What is the fishing method used?

i. Gillnet ☐

ii. Hook and line ☐

iii. Traps ☐

iv. Explosives ☐

8. Do you keep records of your catch? Yes ☐ No ☐

9. Do you keep records of fishing trips in this area? Yes ☐ No ☐

10. What are the main problems related to fishing in this area?

……………………………………………………………………………………………

11. What are the traditional practices performed to prevent overfishing?

……………………………………………………………………………………………

……………………………………………………………………………………………

12. Do you have no fishing days in this area Yes ☐ No ☐

13. Do you have closed areas on your fishing location that you govern yourselves?

Yes ☐ No ☐

14. Do you know of any taboos or cultural practices that aid in the conservation of fishery resources in this area? Yes ☐ No ☐

b. If Yes, give some examples please

……………………………………………………………………………………………

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15. What currents rules and regulations have you created in the community to govern your fishing activities? Please list.

…………………………………………………………………………………………

…………………………………………………………………………………………

16. Who enforces these rules and regulations? Chief ☐ Chief Fishermen ☐

Town Council ☐ Chief Priest ☐ District Assembly ☐ CBFMC ☐

17. Do people easily obey them?

Never ☐ Sometimes ☐ Always ☐

18. What structures exist in the community with the objectives to contribute to management of resources? CBFMC ☐ Chief fishermen ☐

Women organization ☐ Trade Association ☐

19. Is this structure efficient in its responsibility? Yes ☐ No ☐

20. Do you co-operate with fishers from other communities to manage the fishery resources.

Yes ☐ No ☐

C. OTHER ESTUARINE RESOURCES MANAGEMENT

21. How are the mangroves managed? ……………………………………………

22. How do you ensure good water quality? ………………………………..

……………………………………………………………………………...

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23. What are the main environmental problems of the area? Sewage disposal ☐

Poor sanitation ☐ Poor management ☐ Poor drainage ☐ Refuse disposal ☐

Deforestation ☐ Erosion ☐

D. **SOCIO-ETHNIC INFORMATION**

24. What are the major Socio ethnic structures in the area? …………………………

……………………………………………………………………………………………

25. What is the system of land ownership and allocation? ……………………………..

……………………………………………………………………………………………

26. What is the population of the area? ……………………………………………………

……………………………………………………………………………………………

E. SOCIO-ECONOMIC INFORMATION

27. What is the main occupation of the people in the area?

Fishing ☐ Farming ☐ Logging ☐ Processing ☐ Trading ☐

28. What are types of infrastructure found in the area?

……………………………………………………………………………………………

29. Is there any industry, airport, seaport, hotel? Yes ☐ No ☐

30. If Yes, which of the above? …………………………………………………

31. Are there any existing conflicts in the use of coastal resources? Yes ☐ No ☐

32. Are there any potential conflicts? Yes ☐ No ☐

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F. GOVERNANCE IN THE AREA

33. How is the area governed? …………………………………………………………

34. What is the governing structure? ………………………………………………

THANK YOU

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Appendix Ii

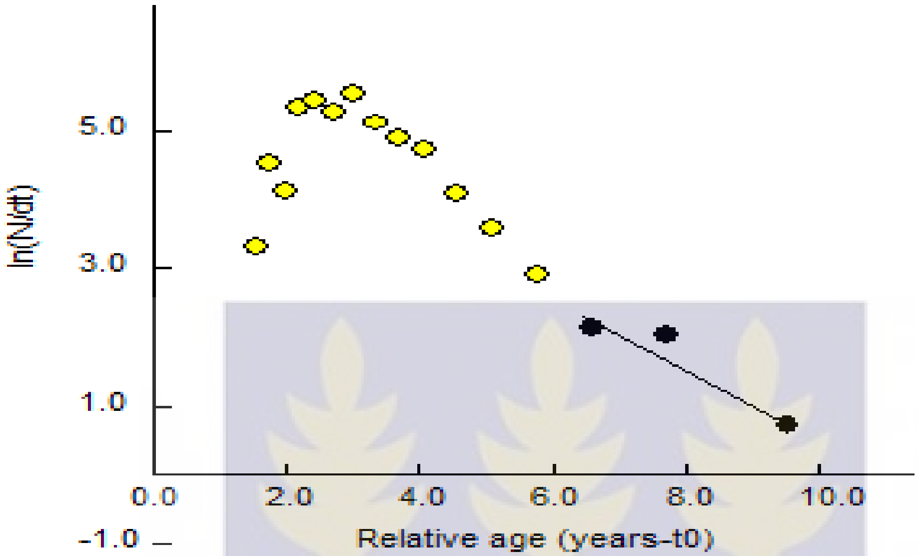

Figure 4.12 Length-converted catch curve of *P. elongatus*

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Appendix Iii

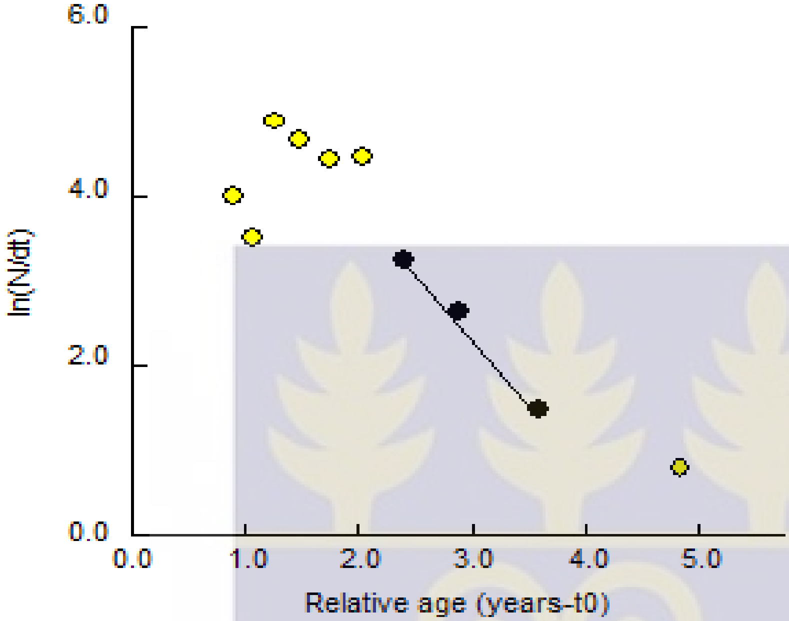

Figure 4.13 Length-converted catch curve for *E. fimbriata*

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Appendix Iv

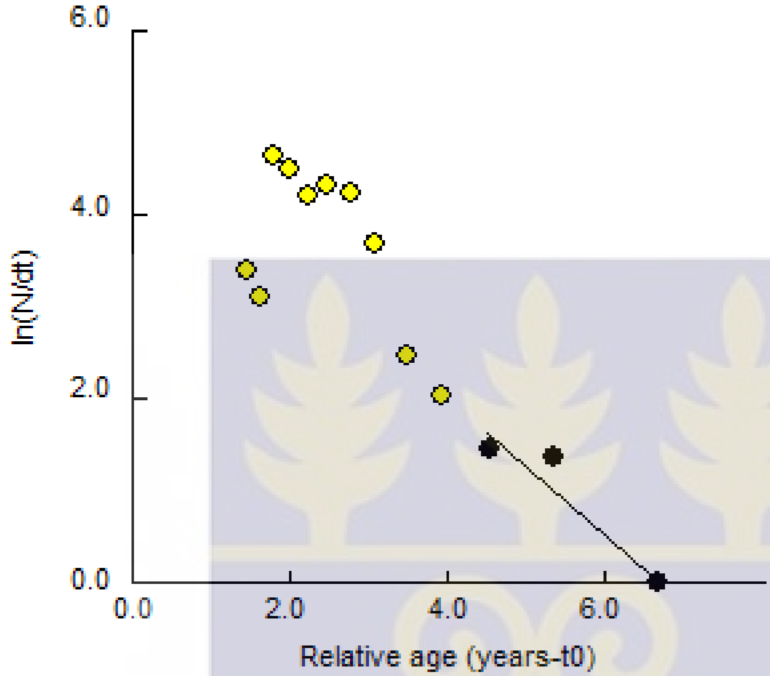

Figure 4.14 Length-converted catch curve for *C. nigrodigitatus*

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Appendix V

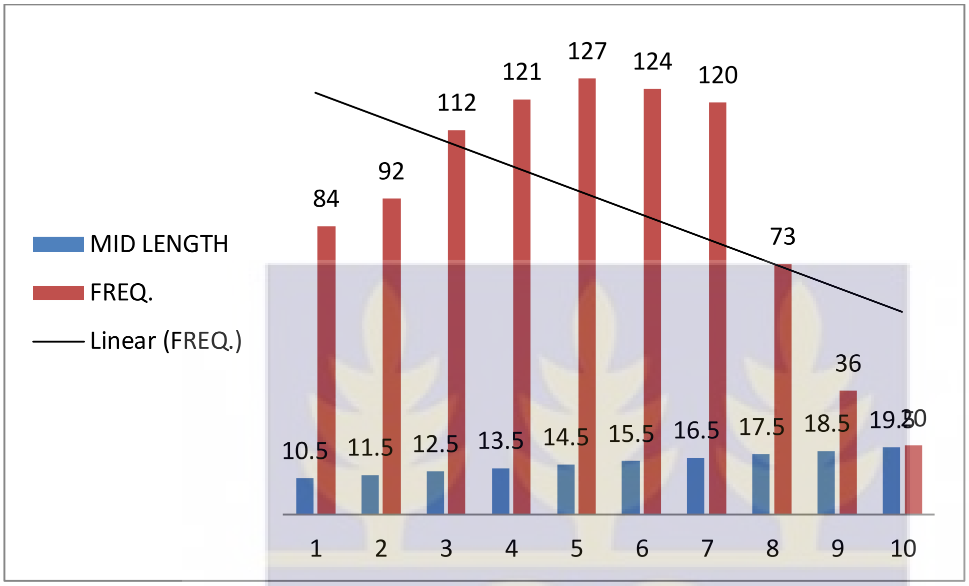

Fig. 4.15 Length distribution of the fishes in the study locations

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Appendix Vi

ANOVA: Single Factor

Water Quality for the locations of study

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Temp.	3	88.45	29.48333	0.050833
pH	3	18.99	6.33	0.0148
DO	3	16.85	5.616667	0.165833
Turbidity	3	104.33	34.77667	245.8696
Salinity	3	28.48	9.493333	2.594633
Alkalinity	3	113.75	37.91667	16.14583
PO4-P	3	0.0082	0.002733	3.21E-06
NO3-N	3	0.0117	0.0039	1.93E-06

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5303.269	7	757.6098	22.88492	3.33E-07	2.657197
Within Groups	529.6831	16	33.1052			
Total	5832.952	23				

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Appendix Vii

ANOVA: Single Factor

CPUE for the study period (Dec. 2014- May 2015).

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dec.	3	46	15.33333	26.02333
Jan.	3	57.1	19.03333	51.42333
Feb.	3	81	27	111.49
Mar.	3	74.9	24.96667	83.76333
Apr.	3	65.3	21.76667	10.22333
May	3	56.8	18.93333	9.143333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	277.1828	5	55.43656	1.138847	0.392144	3.105875
Within Groups	584.1333	12	48.67778			
Total	861.3161	17				

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Appendix Viii

ANOVA: Single Factor

CPUE for the study locations

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Anansa	6	161.9	26.98333	50.47767
Okon	6	88.2	14.7	8.492
Anantigha	6	131	21.83333	21.97867

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	456.5744	2	228.2872	8.460479	0.003468	3.68232
Within Groups	404.7417	15	26.98278			
Total	861.3161	17				

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Appendix Ix

Table 5.0 Occupation of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fishing	109	76.2	76.8	76.8
	processing	9	6.3	6.3	83.1
	Felling	24	16.8	16.9	100.0
	Total	142	99.3	100.0	
Missing	System	1	.7		
Total		143	100.0		

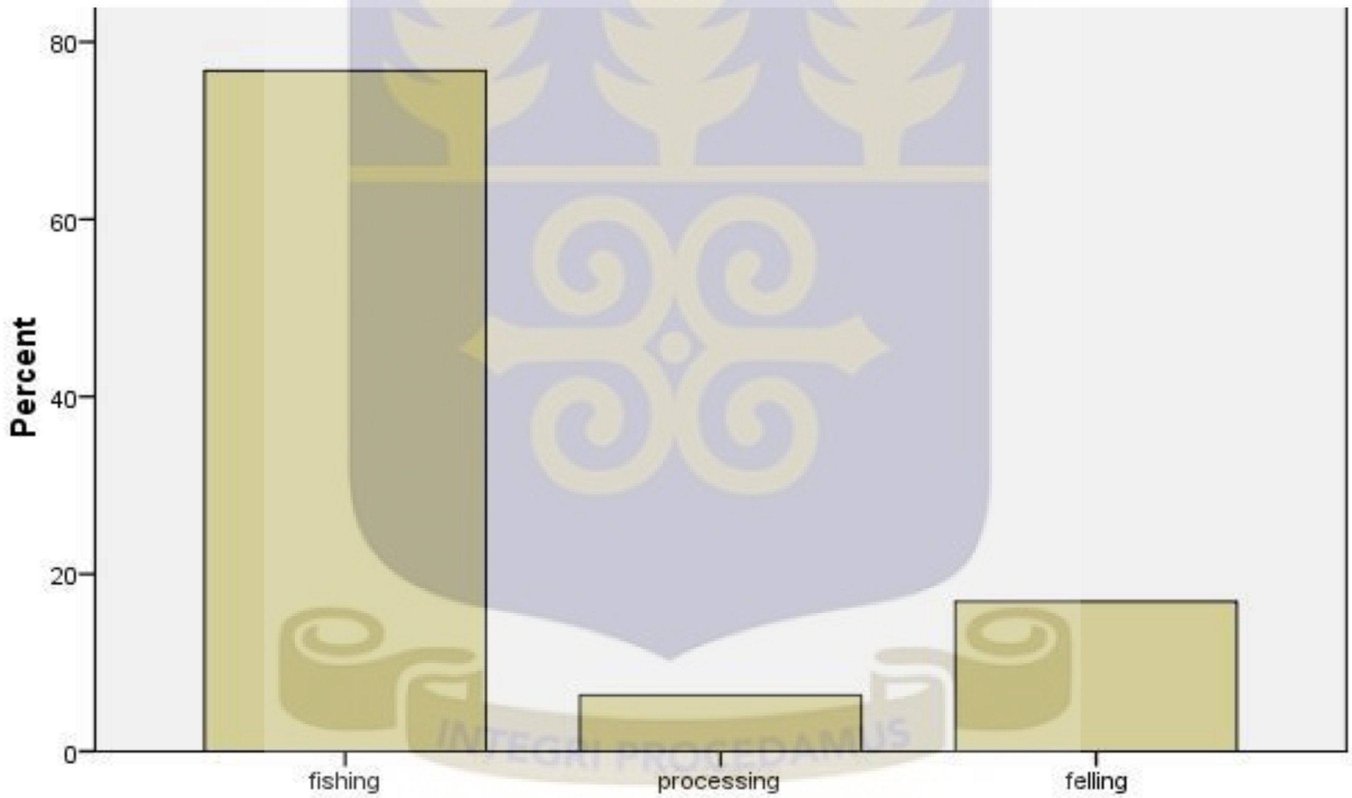

Figure 5.0 Occupation of respondents

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Appendix X

Table 5.1 Age distribution of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21-25yrs	2	1.4	1.4	1.4
	26-30yrs	33	23.1	23.2	24.6
	31-35yrs	44	30.8	31.0	55.6
	36-40yrs	31	21.7	21.8	77.5
	41-45yrs	22	15.4	15.5	93.0
	46-50yrs	10	7.0	7.0	100.0
	Total	142	99.3	100.0	
Missing	System	1	.7		
Total		143	100.0		

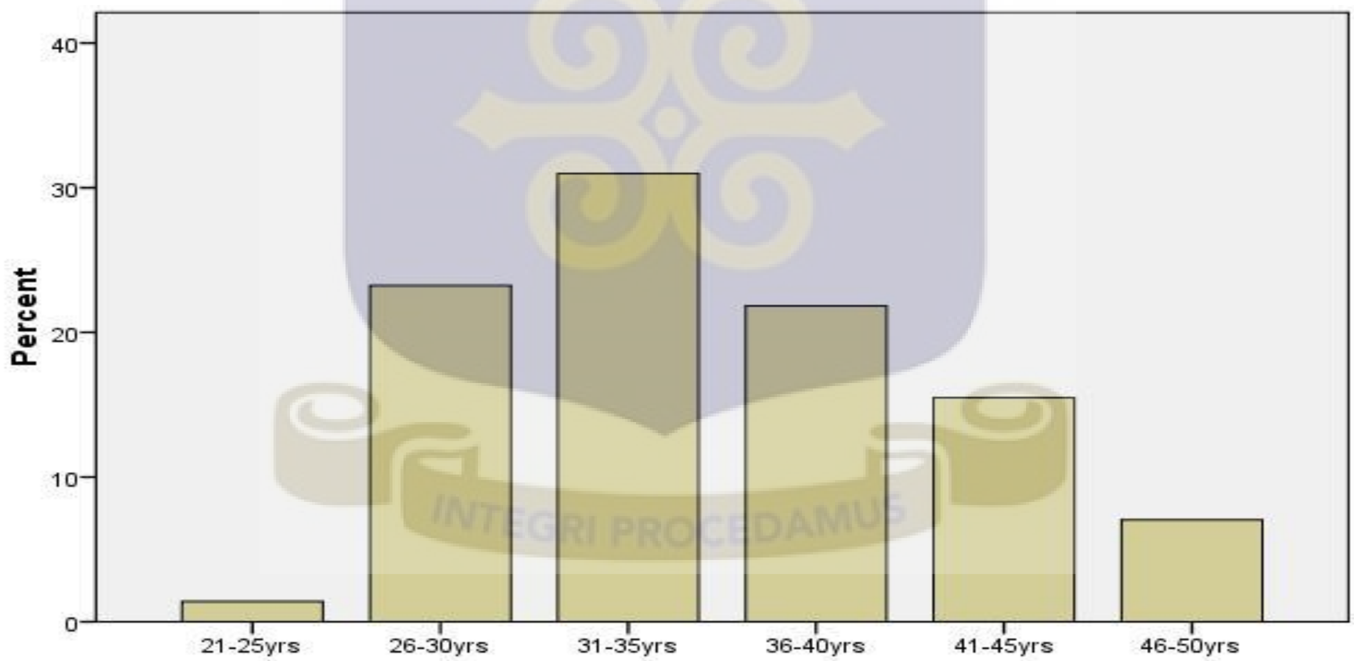

Figure 5.1 Age distribution of respondents

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Appendix Xi

Table 5.2 Experience of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-5yrs	11	7.7	7.7	7.7
	6-10yrs	65	45.5	45.8	53.5
	11-15yrs	44	30.8	31.0	84.5
	16-20yrs	21	14.7	14.8	99.3
	6	1	.7	.7	100.0
	Total	142	99.3	100.0	
Missing	System	1	.7		
Total		143	100.0		

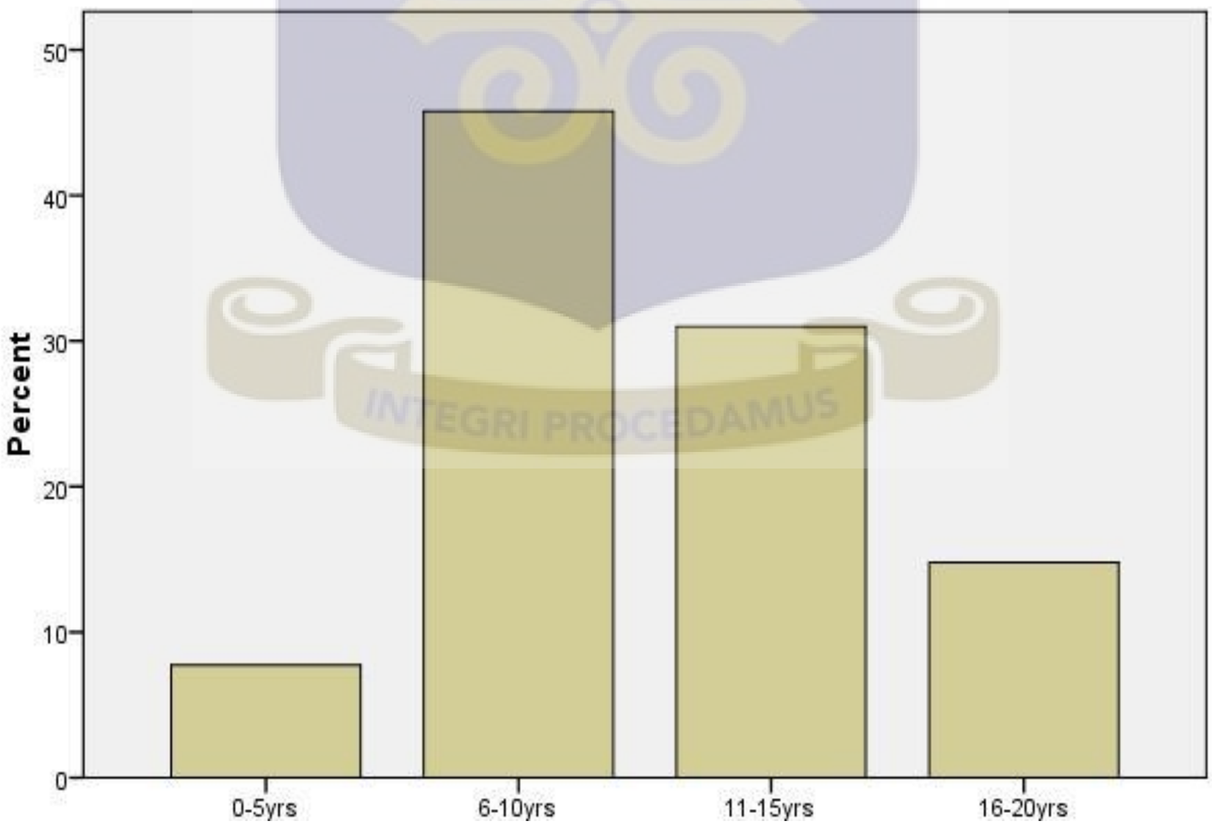

Figure 5.2 Experience of the respondents

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Appendix Xii

Table 5.3 Respondents fishing methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Gillnet	79	55.2	72.5	72.5
	Hook and line	20	14.0	18.3	90.8
	fishing traps	10	7.0	9.2	100.0
	Total	109	76.2	100.0	
Missing	System	34	23.8		
Total		143	100.0		

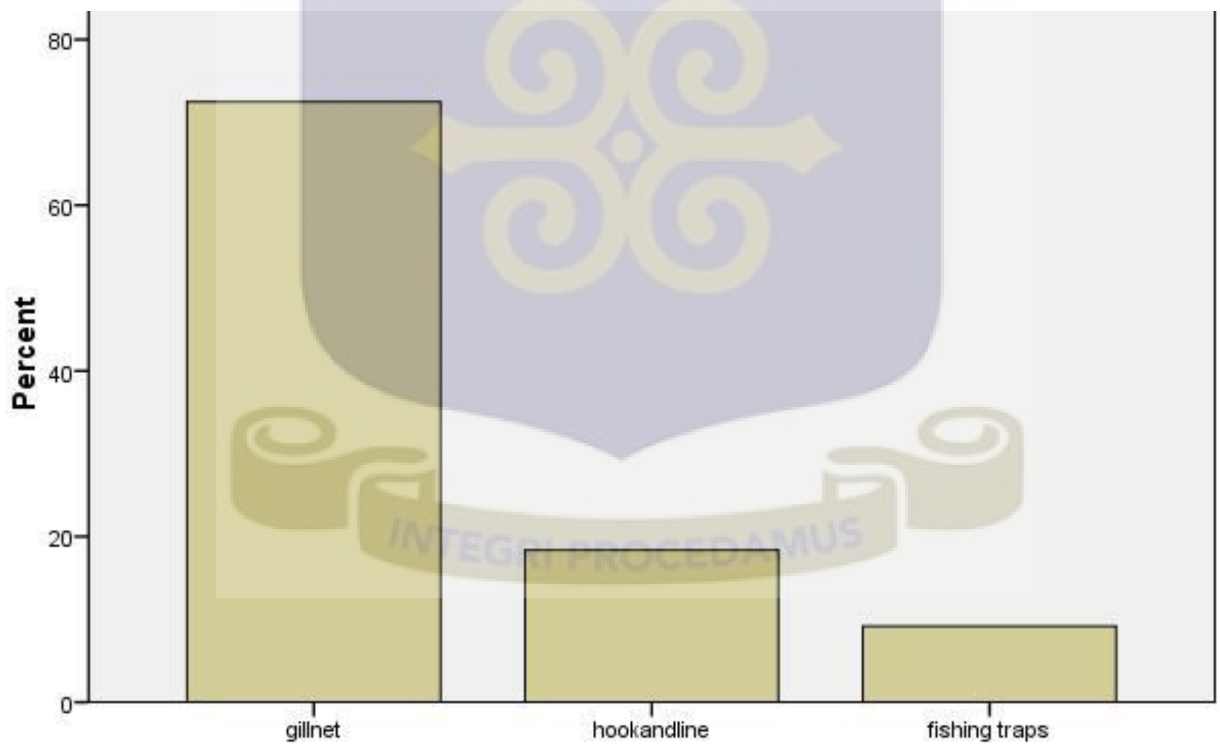

Figure 5.3 Respondents fishing methods

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Appendix Xiii

Table 5.4 Main environmental problems of the study area

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sewage Disposal	8	5.6	5.6	5.6
	Poor Sanitation	29	20.3	20.4	26.1
	Poor management	17	11.9	12.0	38.0
	Poor Drainage	15	10.5	10.6	48.6
	Refuse Disposal	33	23.1	23.2	71.8
	Deforestation	19	13.3	13.4	85.2
	Erosion	21	14.7	14.8	100.0
	Total	142	99.3	100.0	
Missing	System	1	.7		
Total		143	100.0		

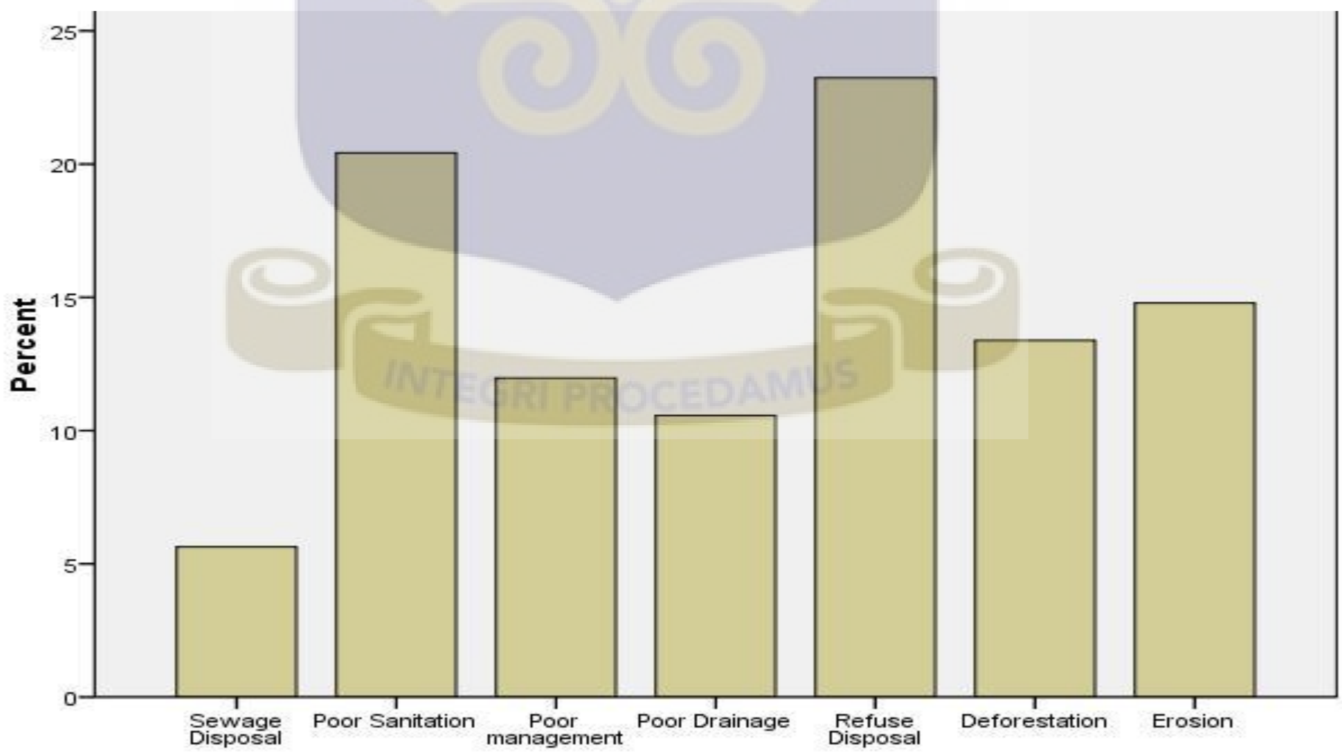

Figure 5.4 Main environmental problems of the study area

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Appendix Xiv

Table 5.5 Monthly distribution of rainfall for the study period

MONTH	RAINFALL(mm)	No. OF DAYS
December	Non trace	None
January	No trace	None
February	96.0	9
March	148.1	10
April	100.2	11
May	88.4	8

Source: Meteorological Department, Nigerian Airport Authority, Calabar. CRS.

INTEGRI PROCEDAMUS

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Plate 1: Catch composition of gillnet fishery for the study area.

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Plate 2: **Gear composition of the artisanal fishery for the study area**

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Plate 3: **Landing sites for mangroves and shellfish**

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Plate 4: **Focus group discussions and sampling**