THE BIOLOGY OF THE SOMPAT GRUNT, *POMADASYS JUBELINI* (CUVIER, 1830) IN THE NEW CALABAR-BONNY RIVER, RIVERS STATE, NIGERIA

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN FISHERIES

DEPARTMENT OF BIOLOGICAL SCIENCES, FACULTY OF SCIENCE,
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JULY, 2014

DECLARATION

I declare that this work in the dissertation entitled 'The biology of the Sompat grunt *Pomadasys jubelini* in the New Calabar-Bonny River, Port-Harcourt, Rivers State" has been performed by me in the Department of Biological Sciences. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This dissertation entitled "THE BIOLOGY OF THE SOMPAT GRUNT, *POMADASYS JUBELINI* (CUVIER, 1830) IN THE NEW CALABAR-BONNY RIVER, RIVERS STATE, NIGERIA" by Marian Onwude AGBUGUI meets the regulation governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation

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ABSTRACT

The biology of the Sompat grunt *Pomadasys jubelini* (Cuvier, 1830) from New Calabar-Bonny River was studied from June 2011 to May 2013. *Pomadasys jubelini* belongs to the family Haemulidae, genus *Pomadasys*. This species is common in costal and brackish waters of Nigeria. It is affordable, tasty with high economic and nutritional value. Specimens caught using gill nets, hook and line and traps were used to study the biometrics, growth, fecundity and stomach contents using standard procedures. Physico-chemical parameters of water from the River were determined by using a Multi-*insitu*meter at the three stations and results obtained were temperature 28.62±0.62°C, 28.37±0.7°C and 28.41±0.57°C; pH 6.36±0.34, 6.19±38 and 6.27±0.74; salinity 11.50±7.71ppt, 12.15±5.24ppt and 0.58±0.94ppt; and dissolved oxygen 6.88±0.51mg/l, 6.92±0.58mg/l and 6.88±0.63mg/l for Stations 1, 2 and 3 respectively. There were significant differences ($P \leq 0.05$) in salinity among the three Stations, Station 1 was salt water, Station 2 brackish/tidal and Station 3 predominantly freshwater. The standard length of *P. jubelini* ranged from 8.50cm to 47.60cm and the weight from 17.00g to 2320g. There was a high positive relationship ($r = 0.91$) between fish length and weight in males and females ($r = 0.99$). The b-value ($b<3$) indicated a negative allometric growth. The monthly condition factor (K) ranged from 0.00–2.15 in both males and females. The male to female ratio of *Pomadasys jubelini* was 1:2.1. The age range was 0+ to 4+ and the immature fish were found in the 5.0cm-15.00cm length class. Sub-adults occurred in the 15.10cm-30.00cm length class while the adults were between 30.10cm-55.00cm. More of class length 20.10cm-50.00cm (40%) were obtained from Station 2 and most from Station 3 (60%), an indication that juveniles inhabit brackish water and the adults salt water. Ageing structures such as

otoliths, scales and transverse section of spines did not show definite patterns of annuli formation. The occurrence of gravid females in September and October indicates that spawning coincided with the end of the rainy season. The minimum and maximum fecundity were 9,085 and 37,926 eggs respectively; there was a significant correlation (r=0.94) between fish weight and fecundity. The mean gonado-somatic index (2.89%) revealed that this species uses up to 2.89% of its total body weight for egg production. The terminal mouth in *P. jubelini* with a gape of up to 10% of its total body length, allows the fish to seize its prey easily. The setiform teeth in multiserial bands enable the fish to grip its prey firmly in the mouth before swallowing, and the pharyngeal teeth on the roof and floor of the mouth are smooth and pebble-like and adapted for crushing prey before swallowing. The long and hard gill rakersconfirm that *P. jubelini* is a carnivore. Stomach content analysis showed that *Callinectesamnicola*(crabs) 73.1%, *Sardinellamaderensis* (0.69%), *Scomberomorustritor* (1.51%), *Ethmalosafimbriata*(0.56%), *Macrobrachiummacrobrachion*(24.08%), and *Littorinaanguilifera*(0.02%) were the main food items consumed by *P. jubelini*;most of the food items were found intact, indicating that preys are swallowed whole. In conclusion, there are variations in the physico-chemical parameters of water of the New Calabar-Bonny River; *P. jubelini* shows a negative allometric growth pattern and its attainable age is 0+ to 4+. *Pomadasys jubelini* is a total spawner, and a carnivorous fish species that shows transition from consumption of invertebrates at the immature and sub-adult stages to piscivorous diets at adult stage. It is recommended that relevant/appropriate government agencies monitor and control activities that may pollute the New Calabar-Bonny River. The breeding grounds of *P. jubelini*,which is most likely at the freshwater zone, will thus be protected. The juveniles of *P. jubelini* are

recommended for cage culture in the marine environment, and its feed should comprise invertebrates and smaller fish species.

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Abbreviations, Definitions and Symbols

Abbreviations:

E.E.A – Essential Amino Acids

GIT – Gastro-Intestinal Tract

K – Condition factor

LGR– Length-Girth relationship

LWR– Length-Weight relationship

ppm. -. parts per million

ppt. – parts per thousand

D.P.X. – Distrene, Plasticer and Xylene

Definitions

Amphidromous – animal migration in both directions, from sea to freshwater and vice versa.

Anal fin - the median, unpaired fin located on the ventral surface in front of the caudal fin.

Anandromous – applied to fishes which migrate from salt water to fresh water annually.

Atresia – absence of a normal opening or failure of a structure to be tubular.

Carnivorous - feeding on animal material; flesh-eating.

Cartilage - skeletal tissue, usually soft and flexible, and in bony fishes it is mostly replaced by bone during the early growth stages.

Catadromous– applied to fishes which migrate from fresh to salt water to spawn.

Caudal fin - the fin at the rear of the tail.

Caudal peduncle - the part of the body from the rear end of the anal fin base to the base of the caudal fin.

Cloaca - the chamber that contains the anus and urogenital openings.

Compressed - flattened from side to side.

Ctenoid – comb shaped; with comb-like margin.

Emerginate - with a slightly concave margin.

Gill-rakers - bony, finger-like projections along the anterior edge of the gill arche.

Goblet cells – a goblet shaped cell, found in the epithelium of the intestine of fish that secretes mucus. Goblet cells have a wide top and constricted base.

Gonad - the reproductive organ: ovary or testis.

Inter-orbital - the area between the eyes, on top of the head.

Lateral line - a system of tubes or canals containing sensory cells (receptors) sensitive to low-frequency sounds and vibrations produced by the movements of other animals in the vicinity.

Mandible - the lower jaw.

Maxilla (plural maxillae) - one of the two bones that comprise each half of the upper jaw.

Meristematic – segmented into parts, changes in number of parts or segments and in the geometrical relation of parts.

Mucus - a slimy substance.

Multiserial - arranged in several rows or series.

Pharyngeal teeth - teeth located on the pharyngeal bones (modified fifth gill arches) in the throat behind the gills.

Predator - an animal that captures and eats other animals.

Prey - animals that are the food of predators.

Setiform - bristle-like.

Spawning - The deposition and collection of eggs.

Spine - a sharp projecting point; a fin ray that is unpaired, un-branched, lacks segmentation and is usually stiff and sharp pointed.

Terminal- pertaining to a mouth at the most anteriorpart of the head.

The lateral-line system on the head divides into a network of branching canals, but on the body it is usually a single perforated tube extending from the head to the base of the caudal fin.

Symbols

°C – Degree Centigrade/Celsius

mg/l – milligram per liter

mμ/cm - microsiemens per centimeter

CHAPTER ONE

1.0 INTRODUCTION

Nigeria is blessed with over 14 million hectares of water bodies. These water bodies, which consist of rivers, lakes and streams, support over 270 species of fish. In addition to inland water bodies there are estuaries, lagoons and over 90 million hectares of marine environment in the Atlantic Ocean, that all support artisanal, small scale, industrial fishing and aquaculture in Nigeria (Kelvin and Peter, 2000).

Fishery products constitute some of the cheapest and easily accessible and affordable sources of good quality animal protein. They are rich in most of all the Essential Amino Acids (EAA), lysine, leucine, arginine, methionine, valine, histidine, tryptophan, isoleucine, phenylalanine and threonine required for healthy human growth. Fish is an excellent source of protein in the diet of many, both in rural and urban settings and plays a significant role in food security and nutritional status of the populace. In addition, fish and fishery products are important sources of vitamins especially vitamin A, D and minerals such as calcium, phosphorus, iron and iodine (FRDC, 2001).

The demand for animal protein particularly fish is on the increase, because of its palatability, affordability and quality. (Anko and Eyo, 2001). The present global production of 90 million tonnes of fish is said not to meet the high demand of the ever geometrically growing population of humans; it would therefore be necessary to increase production to over 125 million tonnes (Anko and Eyo, 2001).

The bulk of fish production in Nigeria comes from the artisanal sector, which is inadequate to meet the demand of the population. This increases the pressure on the

already depleting wild stock (Peter, 2003). Ndok (1982) reported that Nigeria produces one-third of its fish requirement with the balance coming from imported frozen fish, canned fish and stock fish. With the aforementioned it is observed that the nation's fish stock is declining and the sizes of fish in the markets are smaller as a result of overfishing, which is often aggravated by large fishing trawlers licensed to fish in our coastal waters (Eyo, 2001). The "unfriendly" fishing methods of our local fishermen also affect the catch of fish. There is also the severe competition among fisher folk to exploit the fish stock available in the different water bodies including the rivers, streams lakes and estuaries. In the creeks of the Niger Delta, there is the problem of pollution which affects the production of aquatic resources (Sikoki and Francis, 2007). This calls for an increase in domestic fish production through proper management of the nation's fisheries resources. There are already advocacies in this direction in the areas of monitoring the nation's aquatic ecosystems, accumulation of knowledge of the biology of the fish species and statistics (Bonga Supplement, 1996).

Fishes depend on many conditions in their environment, including food for their survival. Feeding is a daily, frequent and voluntary action carried out by fishes. The food and the feeding behavior vary characteristically between species. The amount of food ingested per day and the times of day that feeding is carried out depends on many factors such as active predation, daily and seasonal changes, temperature fluctuations and environmental conditions (Ugwumba and Ugwumba, 2007).

The major objective of fisheries management is the attainment of sustainable yield for all stocks. The management of fishery resources involves controlling the methods and rate of exploitation so that yields can be optimal (Deekae, 2009). Several fish stocks are of

commercial importance in the artisanal fisheries in Nigeria yet basic information about them is lacking.

1.1 Research Problems

Several water bodies exist in Nigeria, but all have not been properly analysed to determine their suitability for fish production. In addition, various forms of aquatic pollution are threatening these water bodies particularly oil pollution in the South–South region. Studies have been conducted on the biology, nutrition, growth and management of several fish families including Mormyridae, Bagridae, Schilbeidae Cichlidae, Citharinidae and Clariidae (Olatunde, 1979; Arawomo, 1982; Eyo and Mgbenka, 1992; Ikomi, 1996; Eyo and Olatunde, 2001, Allison, 2006; Onimisi *et al*., 2009; Oniye and Onimisi, 2010). These studies form the basis for developing strategies and formulating policies for effective management of the fish families.

Three species of *Pomadasys jubelini* are known in Nigerian waters (*Pomadasys jubelini, Pomadasys rogerri* and *Pomadasys perotiti*); the most common of the three is *P. jubelini.* This species is of high economic and nutritive value and in high demand in the coastal cities of Nigeria (Sikoki and Francis, 2007). However, *Pomadasys jubelini* with promising aqua-cultural potential has not been cultured and domesticated because of the improper understanding of its biology. The dearth of information on the biology and ecology of *P. jubelini* in Nigeria has made the management and maximum utilization of this economically important fish species a difficult task.

1.2 Justification

The study of the biology of fish gives information on the growth rate, food and feeding habits, sex ratio, fecundity, mortality, and ecology of the fish thereby providing better and detailed information about the particular fish. *Pomadasys jubelini* is important in the riparian community of the Niger delta area of Nigeria because it is in high demand due to its palatable flesh, economic and nutritional value (Idodo-Umeh, 2003).

Apart from the summary by Viveen *et al*. (1977) and Idodo-Umeh (2003), no extensive and comprehensive work has been carried out on its food and feeding habit, growth, fecundity, and ecology in the Niger Delta area of Nigeria.

Unfortunately, estuaries, streams and rivers in the Niger Delta region of Nigeria have been exposed to anthropogenic activities particularly oil pollution which threatens the survival of various aquatic organisms, particularly fishes, and the source of livelihood of several fish folk. In order to salvage some of the fish species of this region, *P. jubelini* was chosen as a key fish species for study.

If thoroughly studied, *Pomadasys jubelini* could be add to the existing culturable species in Nigeria and propagated nationally. This study could also form a basis for recommending the species for its artificial breeding and strategic management and development.

The New Calabar-Bonny River is an important river in Rivers State and one of the most important in the Niger Delta region. It provides nursery and breeding grounds for a large variety of fish species (Abowei and Hart, 2009). Fishing is one of the dominant activities in the river thus fish are abundant and available all year round, but the physicochemical parameters of this river with respect to fish production and its sustainability for the production of *P. jubelini* is yet to be properly understood.

This study was undertaken to provide information on some aspects of the morphometry growth, length-weight relationship, food and feeding habits and fecundity of *Pomadasys jubelini*. The determination of fecundity, growth and fish age is very essential in sustainable management.

1.3 Aim and Objectives

The aim of the study is to investigate the biology of the fish *Pomadasys jubelini* in the New Calabar-Bonny River with respect to fish production and aquaculture purposes.

The specific objectives are to determine

- the physico-chemical parameters of the New Calabar-Bonny River
- the length–weight relationship of *Pomadasys jubelini*
- the age and growth rate of *Pomadasys jubelini*
- the food and feeding habit of *Pomadasys jubelini*
- the sex ratio, fecundity and gonadosomatic index of *Pomadasys jubelini*

1.4 HYPOTHESES

- There is no seasonal variation in the physico-chemical parameters of the New Calabar-Bonny River
- The length-weight relationship of *Pomadasys jubelini* exhibits isometric growth

- The age and growth pattern of *Pomadasys jubelini* do not differ between sexes
- *Pomadasys jubelini* does not consume a variety of food items
- There are no variations in sex ratio, fecundity and gonadosomatic index of *Pomadasys jubelini*

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Water Quality

Water quality is determined by the physical and chemical state of the water body. This includes all the physical, chemical and biological factors that influence the beneficial use of the water. Water quality is important in drinking water supply, irrigation, fish production, recreation and other purpose for which the water was created (Moshood, 2008). Water quality deterioration in natural rivers usually comes from excessive nutrient input, eutrophication, acidification, heavy metal contamination, organic pollution and obnoxious fishing practices (Moshood, 2008). The effects of these ``inputs" in the water body do not only affect the socio-economic functions of the water negatively, but also bring loss of structural biodiversity (EPA, 2003). According to Ademoroti (1996), water from market stalls, slaughter houses, street washing and flushing sewage, which flow through drains into rivers cause pollution. Other sources include industrial activities (oil spillage, loading and washing of oil tanks) and frequent discharges of agricultural wastes. These pollutants in the water body greatly affect its quality.

The productivity of a given body of water is determined by its physical, chemical and biological properties. The environmental properties of water need to be conducive for fish to grow well. Ideal water conditions are necessary for the survival of fish since its entire life processes are wholly dependent on the quality of its environment (water quality) (EPA, 2003).

The changes in the characteristics like temperature, transparency and chemical elements of water such as dissolved oxygen (DO), hydrogen ion concentration (pH) and electrical conductivity provide valuable information on the quality of water and their impacts on the functions and biodiversity of the water body (Lind, 1979; Powell *et al*., 1985).

2.2 Physico–chemical Parameters of Water

2.2.1 Temperature

Temperature is defined as the degree of hotness or coldness of a body (Lucinda and Martin, 1999). Temperature is an important factor in the welfare of fish. Fish are poikilothermic and water temperature plays a tremendous role in their feeding. This parameter affects their metabolic activities (feeding, growth potential, survival, reproduction and efficiency of food conversion). It has been reported that a $5^{o}C$ change in temperature will stress or even kill fish and this formed the basis of the acclimatization of fish (Adeniji and Ovie, 1990). Temperature has a profound effect on the rate of chemical and biological processes in water. For instance, fish require twice as much oxygen at $30^{o}C$ than at $20^{o}C$ (Adeniji and Ovie, 1990). Increase in water level may therefore be necessary at higher temperatures.

Temperature at the surface of a flood plain may be up to 40°C and may affect the dominance and distribution of aquatic organisms. Basically, fish and shell fish move away from excessive heat to more conducive parts of their system. Extreme or sudden changes in temperature are often lethal and most often at times influence the movements and

migration of fishes (Ademoroti, 1996). In the tropics, fish grow best at temperatures of between 25 and 32°C (Sikoki and Veen, 2004).

2.2.2 Hydrogen Ion Concentration (pH)

The pH of water is a measure of the degree of its acidity or alkaline concentration. It is also defined as the hydroxyl ions concentration in a liquid; it is expressed on a scale of 0-14 with 7 being regarded as neutral. In fish ponds, the time of the day that a sample is taken often affects the pH because of variations in carbon IV oxide concentration. As plants in water remove carbon IV oxide for photosynthesis during the day, the pH increases, whereas at night, the pH decrease as carbon IV oxide accumulates. Increasing the total alkalinity concentration in water helps buffer against pH changes. Chronic pH levels (>11 to 14) may reduce fish reproduction and are associated with fish die offs (Stone and Thomforde, 2006), also, the acid and alkaline death points are approximately at pH of 4 and 11 respectively. Waters with pH values ranging from 6.5 to 9 are said to be the most suitable for fish production (Viveen *et al.,* 1977).

2.2.3 Dissolved Oxygen (DO)

Dissolved oxygen is the most important and critical water quality parameter for aquatic organisms including fish, in pond culture systems (Boyd and Lichtopher, 1979; EPA, 2003). Nearly all aquatic organisms, except some bacteria must have oxygen to survive. Most of these organisms must extract their oxygen from water. Thus, the extraction of oxygen from water and its addition to water are operations of importance to fish. Oxygen is often a limiting factor in aquatic systems. Primary production sources (photosynthetic

plants) produce oxygen in the presence of light but will require it when it is dark. Oxygen can then be said to limit both primary and secondary production. Two main sources of oxygen for water are plants (in which photosynthesis occurs), and the atmosphere. The amount of oxygen in water is increased by primary productivity which takes place in outdoor tanks and by wind action which aerates the water surface (Wheaton, 1977; www.epa.org).

Photosynthesis stops at night, but plants and animals respire continuously, consuming oxygen, resulting in the drastic reduction dissolved oxygen just before dawn. Photosynthetic oxygen production slightly lags behind the daily radiant energy cycle. In natural and pond waters the oxygen content reaches its daily minimum just at or slightly after daybreak. From then on the dissolved oxygen levels rise from morning through the afternoon as a result of photosynthesis, reaching a peak in late afternoon. Maximum oxygen concentrations are observed in the mid to late afternoon (Kutty, 1981).

The solubility of oxygen in water is controlled by major factors such as temperature, salinity, pressure and turbulence in the water caused by wind currents and waves. Surface agitation of water helps to increase the solubility of dissolved oxygen (Boyd, 1979). In rivers and streams turbulence ensures that oxygen is uniformly distributed across the water and in very shallow streams the water may become supersaturated (Willoughby, 1992).

Inadequate dissolved oxygen has many effects on fish for example, fish stops feeding, growth is impaired and fish becomes stressed thereby becoming more susceptible to diseases. Cold water fishes require large amounts of dissolved oxygen in water. This is only physically possible in water at 5-15°C whereas, warm water fishes are able to survive

in water with low dissolved oxygen content (20-40^{o}C) where the fish are reared (Wheaton, 1977).

2.2.4 Salinity

Salinity, which is usually expressed as ppm or ‰ is the total concentration of electrically charged ions in water or the total amount of salts dissolved in water. These ions are the four major cations i.e calcium, magnesium, potassium and sodium, and the four major anions namely, carbonates (CO^{-}_{3}), sulphates ($SO^{-}_{4)}$, chloride (Cl^{-}), and bicarbonates (HCO^{-}_{3}). Other components of salinity are charged nitrogenous compounds such as nitrates (NO^{-}_{3}), ammonium ions (NH_4^{+}) and phosphates (PO_4^{-}). It is expressed in terms of weight of salts per volume of water or as milli-equivalent of the ions per volume of water (WHO, 1963). Salinity is an important property of industrial and natural waters, which was conceived as a measure of the mass of dissolved salts in a given mass of solution. It varies during the year; it is higher during the dry season when sea water penetrates far up the rivers than in the wet season, when rain and flood water from inland rivers drive the salt water back towards the sea (Scott, 1996). The salinity value in sea water during the dry season is about 26ppt, while in the rainy season it drops to about 2ppt. Generally, the salinity of brackish water is about 5ppt to 30ppt (Deekae and Henrion, 1993). Unfavourable saline conditions of above 30ppt affect the survival, growth and reproduction of fish (EPA, 2003).

2.2.5 Alkalinity

The alkalinity of a water body refers to the kind and quantity of dissolved ions which collectively shift the pH to the alkaline side of the scale. It is an indirect measure of the concentration of anions in water. It is caused by the presence of bicarbonates, hydroxides and less frequently, borates, silicates and phosphates (McNeely *et al*., 1979). These ions are derived from dissolved rock, salts, soils, industrial waste-water discharges and plant activities (EPA, 2003; Ogbeigbu and Victor, 1995). The total alkalinity of water is expressed as milligram per litre (mg/l) equivalent of calcium trioxo-carbonate vi (CaCO3). The availability of carbon (IV) oxide for plankton growth is related to alkalinity.

Waters with total alkalinity of between 20mg/l and 50mg/l permit plankton production for fish culture (Boyd, 1979). Alkalinity within the range of 30mg/l to 500mg/l is generally acceptable to fish. Above the aforementioned range becomes undesirable because of excessive hardness and high concentration of sodium salts. Alkalinity in natural waters rarely exceeds 500mg/l (www.epa.org). In the Niger Delta area, the total alkalinity as reported by Adeniyi (1986) for the fresh water section of the Bonny estuary was between 2mg/l and 44mg/l. Erondu and Chindah (1991) reported a range of 3mg/l–15mg/l for the New Calabar River. Dibia (2007) reported an alkalinity level of 2mg/l–4mg/l for Mini Chindah stream, Port-Harcourt while Davies *et al*. (2008) reported alkalinity of 46.85mg/l to 59.71mg/l for mini Chindah stream, Port-Harcourt. Kosa (2007) reported the total alkalinity of Luubara creek was between 7.33mg/l–110mg/l whereas Deekae (2009) reported an alkalinity range of 5mg/l–15mg/l for Luubara creek. Excess of alkalinity (>500mg/l) in water can cause stress, poor growth and finally death to fish.

2.2.6 Total Dissolved Solids

Total dissolved solids are the amounts of mobile charged ions, minerals, salts, metals in a given volume of water. It is expressed in units of milligrams per unit volume of water (mg/l) and also referred to as parts per million (ppm). Total dissolved solid is directly related to the purity of water and the quality of water purification systems. It affects everything that consumes, lives in or use the water; whether organic or inorganic (www.hcsc.ge.ca). The presence of such solutes alters the physical and chemical properties of water (McNeely *et al*., 1979). High concentration of TDS limits the suitability of water as a good breeding ground for fish. These dissolved solids often come from organic sources such as leaves, silt, plankton, industrial waste and sewage; others are runoff from urban areas, roads used on street during the winter, fertilizers and pesticides used on farms and lawns (www.tdsmeter.com). Dissolved solids from inorganic materials are rocks and air that contain calcium bicarbonate, nitrogen iron, phosphorus and sulfur. Many of these materials from salts; these salts are compounds that contain both metal and nonmetals which when dissolved in water form ions. Ions are particles that give a positive or negative charge (www.koianswer.com).

The recommended level for TDS in fish production is 0 -100 ppm (www.tdsmeter.com). 200–300 ppp is regarded as average, while 400ppm and above is regarded as high TDS in water. This high TDS leads to an undesirable taste as water tends to be salty, bitter and metallic, which is not suitable for fish production. Excess of TDS can be toxic to fish and fish eggs.

2.2.7 Conductivity

Conductivity is the measure of the ability of water to pass an electric current. It is affected by the presence of inorganic dissolved solids such a chloride, nitrate, sulphate and phosphate anions, sodium, magnesium calcium, iron and aluminum cations (APHA, 2010). Conductivity is affected by temperature, the warmer the water the higher the conductivity which has an absolute relationship with total dissolved solids. As more dissolved solids are added in water conductivity increases (McNeely e*t al*., 1979). The conductivity of salt water is usually higher than fresh water because the former contains more electrically charged ions than the latter. Conductivity is measured with a probe and a meter and its basic unit of measurement is the Siemens, it is measured in microsiemens per centimeter (mμ/cm) (www.water-research.net). Various conductivity values have been reported, Kosa (2007) recorded a range of 30–70 mμ/cm in the fresh water reaches of the Lower Nun River. Deekae, (2009) observed a range of 8 mμ/cm–24.50 mμ/cm in Luubara creek of the Niger Delta, while Amakiri (2011) obtained a range between 13 mμ/cm–45 mμ/cm in the Upper Sombreiro River. For maximum growth of fish to be obtained, conductivity of a water body has to be between 0-500 mμ/cm, below or above this range will lead to sudden death of fish (Egborge, 1994). A sudden increase or decrease in conduntivity can indicate pollution. Agricultural runoff or oil spill can increase conductivity due to the addition of chloride, phosphate and nitrate ions. An oil spill or addition of other inorganic compounds would decrease conductivity as these elements do not breakdown into ions. In both cases the addition of inorganic dissolved solid would have a negative impact on water which invariable affects the living state of fish species.

2.2.8 Turbidity

Turbidity refers to the clarity of water and may be caused by wind, currents and erosion that sweep sediments from land to the continental shelf or any part of the water (Lucinda and Martin, 1999). Turbid materials clog the eyes and gills of fish leading to reduced feeding and exchange of gases (Bond, 1978; www.epa.org). In some rivers and flood plains, turbidity can be so high as to hinder light penetration thereby reducing photosynthetic activities. In shallow turbid waters, certain catfishes are adapted to breathing atmospheric oxygen with accessory breathing organs to counter suffocation as suspended materials may clog their gills (Bond, 1978). Turbidity from persistent clay collision which restricts light penetration to 30cm or less would adversely decrease phytoplankton blooms and consequently fish production (Sikoki and Veen, 2004).

2.3 Distribution, Abundance and Habitat of *P. jubelini*

Pomadasys jubelini is a bottom feeder inhabiting most estuaries, coastal and brackish waters of Nigeria and other West African Rivers (Viveen *et al*., 1977; Idodo-Umeh, 2003). The fish is found in the Atlantic, Indian and Pacific Oceanic regions of the world and are distributed widely from the coastline to about 200m depth in the marine environment (Sikoki and Francis, 2007). Large catches are made throughout the year. Specimens weighing 32.4g–600g and length of 32.10cm–50.00 cm have been recorded in River Ase, River Andoni in the south south region and Kaiji Lake-in northern Nigeria (Reed *et al*., 1967; Idodo-Umeh, 1967; FAO 1981a; Sikoki and Francis, 2007).

All the species recorded in the East Central Fishing Area of Africa (FAO, 1981b) are regularly exploited by local artisanal fishers or taken as by-catch from inshore trawling operations.

2.4 Fish Growth

2.4.1 General aspects of fish growth

Growth is an increase in size (or cell number) over time, accompanied by a positive energy balance. Indeterminate growth is observed in fishes where growth continues after maturation, throughout life. Fish growth is often periodic as a result of seasonal variation in temperature, food availability and spawning activity, which can cause seasonal growth cessation. If periods are regular, a growth record is formed in hard structures such as scales, fin spines or rays, vertebral centra, opercula, ear bones (otoliths). Periodic growth marks allow estimation of growth rates by counting and measuring distances between growth ridges (circuli) (Bond, 1978).

2.4.2 Age and growth

The age of fish and the ability to determine its age is an important tool in fisheries biology. Age data, in conjunction with weight and length measurements can provide information on stock composition, age at maturity, life span, mortality, growth and production. Age and growth data give the general background information needed for management decisions and facilitate the diagnosis of management needs such as the recognition of overcrowding, stunting and abundance (Tesch, 1968). The most popular method for age determination for most temperate species is the direct method which is based on the counting and

interpretation of growth zones or growth checks (annuli) which appear in the hard parts (scales, bones, otoliths, opercula) of fishes. These are formed once a year and are called year marks, annuli marks, annuli rings or annuli. They are formed during alternate periods of slow and fast growth particularly in the temperate regions. In parts of the world where temperature is throughout the year (as in the tropics) annuli are either haphazardly formed or absent. This is because rain falls all year round making food abundant throughout the year so that there are no well-defined periods of slow and fast growth. When annuli are properly formed, they allow direct methods of determining age with high precision (Espino-Barr *et al*., 2006). In tropical species, the preferred method of assessing growth is the computer-based length frequency distribution analysis. This method eliminates most of the biases produced by small samples taken with low periodicity, poor formation of annuli and allow for the identification of the first age groups (Francis *et al*., 2005).

Individuals of a given fish species have a genetic potential for reaching a characteristic maximum size under the most favourable circumstances. Maximum size is reached in a relatively short time in short-lived species, but may be attained only after decades in long lived species. Unless in less favourable environmental conditions, fishes should attain the maximum size physiologically attainable for the species (Bond, 1978).

The growth rate of a fish may be assessed by measuring its size at various ages. Fish size may be measured by weight or by length, but the latter is usually preferable, because it correlates well with the size of hard structures, but weight can vary at different times (Pandey and Shukla, 2005).

Growth of fish decreases with age and with increased allocation to reproduction and maintenance. Growth curves often differ between males and females, different age of

maturity, allocation to reproduction, and other intrinsic differences. Growth will increase with food intake and food availability but when ration is maintained, no positive growth can be obtained. An optimum ration will result in best conversion above this growth efficiency declines (Pandey and Shukla, 2005).

Temperature influences a number of processes affecting growth. The growth rate of fish is intimately linked to its metabolic rate and increases with increasing temperature up to the so-called optimum growth temperature. The optimum temperature is the temperature needed to achieve a maximum growth rate. Generally, granting the fulfillment of other needs, such as food and oxygen requirement, best fish growth is often obtained during warmer periods/ seasons of the year (Pandey and Shukla, 2005).

2.4.3 Length–weight relationship and condition factor

According to Frosta *et al*. (2004), the exponent "b" indicates the rate of weight gain relative to increase in length and varies among different populations of the same species or within species. Isometric value of b = 3 for an ideal fish that maintains a three dimensional equality (Thomas *et al*., 2003). When b value is < 3, a fish has negative allometric growth, and when b > 3 it has a positive allometric growth (Khaironizam and Norma-Rashid, 2002). *Pomadasys jubelini,* as reported in Sierra Leone had a "b'' value of 2.966, indicating a negative allometric growth pattern (Annon, 2011).

The condition factor is an estimation of the general well-being of fish. It is based on the hypothesis that heavier fish of a given length are in better condition than those that weigh less (Bagenal and Tesch, 1978; Jones *et al*., 1999).

The condition factor (K = 0.45) of *P. pellucida* of the lower Nun River in Port-Harcourt revealed that the fish does not grow fast and approaches its maximum length at a relatively slow rate and that the growth potential of a fish may be determined by genetic make up, fishing regime and diet type (Allison, 2006).

The condition factor of *Chrysichthys auratus* was found to be higher in the rainy season than in the dry season; this seemed to be influenced by rainfall regime leading to effective utilization of the rich resources of the rainy season. The increase in the K value of both male and female fish was attributed to conversion of stored energy, increasing size and weight of maturing gonads (Ikomi and Odum, 1998). Ogbe *et al*. (2006) reported a condition factor of 1.51 for *Bagrus bayad*, indicating that the fish were in good condition throughout the experimental period which was likely attributed to favourable environmental conditions and especially, availability of food. Other studies of condition factor carried out on the Giraffe catfish, *Auchenoglanis occidentalis* and *Clarias gariepinus* showed "b" values greater than 3, indicating allometric growth (Oniye *et al*., 2006; Yem *et al*., 2007; Onimisi *et al*., 2009).

2.4.4 Length-girth relationship (LGR)

The length-girth relationship is used in assessing the relative well-being of a fish population (Bolger and Connolly 1989), in estimating the average weight of fish at a given length and girth (Beryer, 1987) and in the design of fishing gear (Abowei, 2000). It is also used to evaluate the changes in morphometric parameters relative to length. If the growth exponent J = 1, then growth rate is constant and equal to the initial growth rate (isometric

growth) otherwise there is a negative (J<1.0) or positive (J>1.0) allometric growth (King 1991), thus the LGR is an important tool in fishery management.

2.5 Food and Feeding Habit

Food is the major source of energy for reproduction, species perpetuation, growth for elaboration of all organelles, respiration for production of energy and excretion for removal of wastes; it is thus simply referred to as any ingested material for energy production (Ugwumba and Ugwumba, 2007). Food should provide the adequate nutrition required by fish in order to survive in its environment (Gerking, 1994).

The type of food consumed depends on the availability of food item in the environment (Lagler *et al.*, 1977). It also depends on the physical adaptation of the fish in terms of shape of the mouth, arrangement and type of teeth, pharyngeal bone, gut length, nature and composition of digestive physiology, body shape and behavior (Welcome, 2001) The size of fish, season, sex, temperature, habitat/locality, competition, preference/selectivity and time of day are also important factors in determining the type of food consumed (Ugwumba and Ugwumba, 2007).

Ikomi and Odum (1998) reported that the food habit of *Chrysichthys auratus*, was reflected in the high percentage (>75%) of food items identified, which were mainly of animal origin which was dominated by fish species.

The diets of *Protopterus annectens* consisted of small animals such as fishes, mollusc and seeds of plants. It was also observed that food items were identified in both sexes which

suggested an absence of sex-related preference for food (Reed *et al*., 1967; Oniye *et al*., 2006).

Onimisi *et al*. (2006) reported that *Auchenoglanis occidentalis* is a versatile food consumer with a high proportion of stomach (>75%) containing food. Food items were of plant and animal origin, though dominated by bottom dwelling immature dipterans, insects and fishes; concluded that *A. occidentalis* is an omnivore feeding at the water surface and bottom substratum. *Distichodus* spp. is principally a herbivore feeding on plant materials and the young specimens of less than 12 cm feed predominantly on algae (Arawomo, 1982), more so *Brienomyrus longianalis* of length less than 7.4 cm fed more on lithographic food items of plant origin while fish greater than 7.4 cm fed more on insects (Ikomi, 1996). This is an indication that food preference in most fishes changes with age (Bond, 1978; Welcomme, 2001; Pandey and Shukla, 2005).

In *Protopterus annectens*, the food items in the stomach of 412 specimens were principally plant remains and seeds (86.81%), other items of secondary importance included insects (7.42%), molluscs (4.97%), fish (0.97%), leeches (0.10%), and simuliid larvae were also identified as the most important insect food materials consumed by this fish which was classified as omnivorous, but with a high tendency towards being herbivorous in Jachi Dam, Katsina State, Nigeria (Oniye *et al*., 2006).

Variation in food items with age and size in *Schilbe mystus* showed that in the first year of life (0+) the fish fed on a wide range of food items with insects predominating, while older fish (+1) and (2+) fed mainly on fish and larger insects like grasshoppers (Olatunde, 1979).

Eutropius niloticus fed more on insects than other food items and the gut contained 64.5% of adult and immature insects, 2.9% fish and the remaining items were crustaceans, bottom deposits and plant remains, and that high feeding intensity was observed throughout the year with the highest intensity in November and December and the lowest in October (Olatunde, 1978a). High feeding intensity of *E. niloticus* was attributed to the ``black flood" in which there was improved accumulation of food but low feeding due to the white flood regime when the lake Kainji was turbid and had poor visibility, thus reducing the chances of fish locating food (Olatunde, 1978a).

Malami *et al*. (2007) reported that the frequency occurrence of stomachs with food in *Hyperopisus bebe* was higher in early dry and rainy seasons which were attributed to food abundance. The frequency of food items in the juveniles and adults differed with size class, seasons and water bodies.

Allison (2006) reported that the diet of *Parailia pellucida* in the Lower Nun River of the Niger Delta consisted of cladocerans, copepods, insects, rotifers, ostracods, fish and algae; there was no qualitative seasonal variation in the food items but quantitative variation existed. Peak consumption of cladocerans was in January, copepods in February, insects in September, rotifers in October and March, while algae was in April with higher abundance in the dry season than the wet season. Fish did not show preference for any food items with fish size, but did with sex and season (Allison, 2006).

According to Balogun (2000), the food items found in the stomachs of different sizes of *Lates niloticus* in Lake Kainji, included fish remains, whole fishes, prawns, insect larvae, plant materials and pebbles. The dominant prey fish were tilapias, clupeids, *Labeo spp.,*

Chrysichthys spp., *Alestes* spp. and *Synodontis* spp. in descending order of frequency of occurrence. Clupeids and *Alestes* spp. appeared to be the prey fishes for the juvenile and adult *Lates* (10 to 139cm Standard length), tilapias and *Chrysichthys* spp. were found mainly in the stomachs of larger fish 40 to 139cm (S.L) whereas *Labeo* and *Synodontis* species were recorded in the stomachs of larger fish (>60cm S.L). Furthermore, Lipton (2003), observed that small size prey fishes such as *Physalia* and *Barilius* were dominant food items of *L. niloticus* (20 to 40 cm (S.L.)), while the smaller sizes (<20cm S.L.) fed more on prawns and insect larvae, an indication that *Lates* changed in its food habit with age. In Senegal, zoo-benthos, shrimps, prawns, crabs, bivalves, gastropods, annelids and bonny fishes have been found in the diets of both the juveniles and adults of *Pomadasys jubelini* (Froese and Pauly, 2013).

2.6 Fecundity

Fecundity is the total number of ripe eggs prior to spawning in the female fish (Bagenal and Tesch, 1978; Bond, 1978; Pandey and Shukla, 2005). Reproductive strategies depend on the abiotic environment, food availability, pressure of predators and the habitat of parental fish (Wootton, 1990). The size of eggs, condition factor and fecundity varies with individual fish species and their location. For instance, *Chrysichthys nigrodigitatus* produced larger eggs and had higher fecundity in River Warri than those from other locations (Ezenwa *et al*., 1987). Larger eggs enhance fry and larval viability which is used to determine the best brood stock of species, particularly in hypophysation technique and other hatching manipulations (Bond, 1978).

Ekanem (2000) described Relative Fecundity as the number of eggs per unit length (cm) or the number of eggs per unit weight (g) of fish. Species of fish with the same length were observed to have variation in egg size and the relationship between fish length and egg size was linear (Ekanem, 2000; Abayomi and Arawomo, 2001). King (1997) studied weight–fecundity relationships of some Nigerian fish population and reported that as body weight of fish increased, the number of ripe eggs produced also increased, and suggested that this was linked to the continuous growth of fish after fecundity had stabilized.

Fagade (1979) and Ikomi and Odum (1998) carried out studies on *Tilapia guineensis* and *Chrysichthys auratus* respectively, it was observed that there was a significant correlation ($r=0.873$; $P\leq0.05$) between weight and fecundity; which suggests that as weight of fish increased fecundity is also increasing. Similar observations were also made for the fecundity of *Hyperopisus bebe* (Oniye and Onimisi, 2010), where an insignificant correlation ($r=0.497$, $P>0.05$) between the standard length and fecundity of the fish was observed, indicating that increase in length does not necessarily commensurate with increase in fecundity. Allison (2006), reported also that absolute fecundity and relative fecundity (in cm) increased with increasing fish length with a mean of 966 ± 51.50 eggs cm^{-1} for *Parailia pellucida* . The fecundity estimate of *Chrysichthys auratus* varied with size of fish with the average number of eggs in ripe ovary ranging from 260 to 620 in fish 10.20cm-14.00cm long. Furthermore, the observed male: female ratio of 1:0.98 was not significantly different from the expected ratio of 1:1. While in *Protopterus annectens* a male to female ratio of 1:1.09 was observed (Oniye *et al.,* 2006).

2.7 Gonado-Somatic Index (GSI)

This is the measure of weight of the gonad relative to total or somatic weight (King, 1997). Total spawners produce a large number of small eggs, which are deposited over a short period of time while multiple spawners produce fewer and larger eggs and with a longer breeding period which may last throughout the year, and only a proportion of the eggs ripen in the gonad at one spawning (Lowe-McConnell, 1987); total spawners are said to have a higher GSI than multiple spawners (Wootton, 1990). According to Allison (2006), the GSI of *Parailia pellucida* show monthly variation with oocyte diameter, which increased with fish size, and that gonad weight was the best predictor of fecundity amongst all fecundity related parameters of length, weight, and condition factor.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study area is located at the upper limit of the New Calabar-Bonny River near Port-Harcourt metropolis, Rivers State, Nigeria, between latitude 4°36′ and 4°55′N and longitude 6°45′ and 7°72′ E. Three stations were selected along the river for the purpose of this study based on the salinity of the river as reported by Nedeco (1961) and Deekae (1993). The stations are located at Choba, Iwofe and Abonema wharf (Figure 3.1). The Choba section of the River is most fresh water, the fresh water flows in to it from streams and rivers during certain periods of the year. The Iwofe section is brackish and Abonema wharf is an inter-tidal zone which contains predominantly ocean water (mostly salt water). Rainfall is heavy in May-October and reduces the salinity of the rivers (Nedeco 1961).

Fish species found in the river include the Mullets *Mugil cephalus*, silver catfish *Chrysichthys nigrodigitatus*, sardines *Sardinella maderensis*, *Synodontis* spp., the red snapper *Lutjanus agennes*, the barracuda *Sphyraena afra*, *Tilapia* spp., the sword fish, the giraffe catfish *Auchenoglanis bebe* and *Pomadasys jubelini,* which is a highly commercial fish in the area (Idodo Umeh, 2003). There are also various shrimps, crabs, and oysters (Deekae, 2009).

The *Raphia* spp. (Raffia palm), *Pandans condelabrm, Rhizophera racemosa, Raspalm vaginatm* and *Lagnoularia racemosa* are found along the river bed. These plants grow in the high and mid inter-tidal zones whereas the low inter-tidal zone is usually bare and may comprise sand, mud, peat or clay deposits (Deekae, 2009).

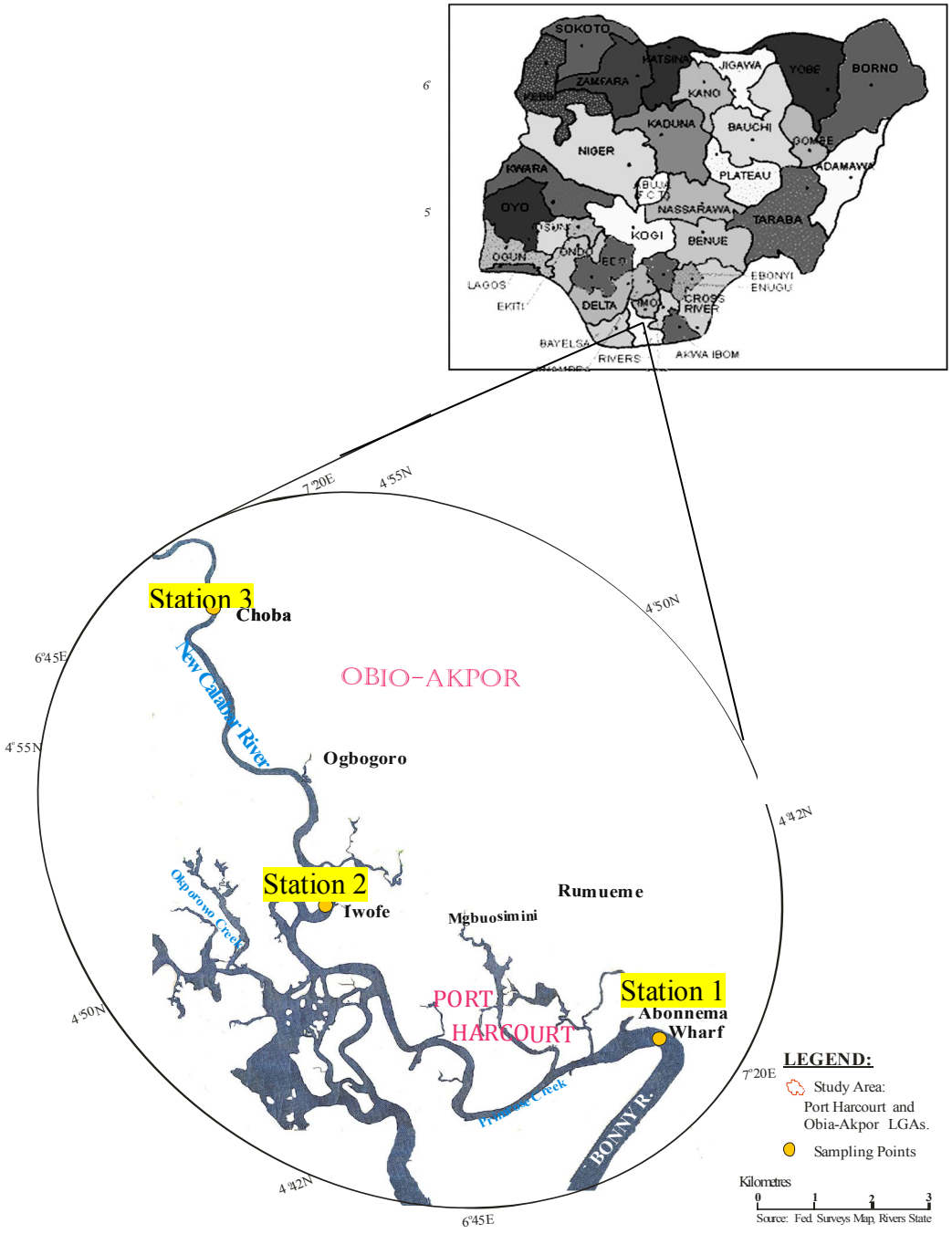


Figure 3.1: Map of Nigeria Showing Rivers State and Study area

There various companies carrying out different activities along the river side these include Shell BP (pipe sites), Indomie noodles, Wilbros and Eagle cement.

3.2 Collection and Sampling of Fish

Fish were purchased from catch landings of pre-arranged fishermen using gill nets, hooks and traps.

Fish samples were collected from the three stations monthly for twenty-four (24) months, from June 2011 to May 2013. The fish were transported in an insulated box containing ice chips, to the Fisheries Laboratory, Department of Fisheries and Aquatic Environment, Rivers State University of Science and Technology, Port-Harcourt.

Fish were identified using text and keys by Reed *et al*. (1967); FAO (1981); Idodo-Umeh (2003); Sikoki and Francis (2007); and Froese and Pauly (2013).

3.3 Identification of *Pomadasys jubelini*

Pomadasys species belong to the Order Perciformes, family Haemulidae. *Pomadasys jubelini* is commonly called the Sompat grunt. The "Kalabari' and "Ikwere' people of Rivers State call it "Ewele", "Bile" or "Kangi".

Pomadasys jubelini were identified by its oblong compressed body with large ctenoid scales, which are rough to feel and denticulate. The head is slightly convex and covered by scales, except the snout and chin region. It has a small terminal mouth with thick protactile lips. The preopercule is moderately serrated.

Fin rays, scales, and gill rakers were counted and the nature of the teeth was noted. Measurements of the different body parts were carried out. The dorsal fin has 11 to 14 strong spines (first dorsal spine being the shortest and the third the longest) and 9 to 11 soft rays. The pelvic fin has one spine and 5 soft rays. The anal fin has 3 strong spines and 6–13 soft rays with the second spine being extremely long and stout.

The caudal fin is lunate/emerginate and the lateral line follows the same course as the dorsal profile. There are five rows of scales above the lateral line. In the fresh condition, the colour of the body is silvery grey with dark brown dots forming four interrupted transverse bands which are darker in upper side and lighter in the middle. There is a small black spot at the posterior edge of the operculum (Plate I).

3.4 Collection of Water Samples

Bottles with the capacity of one hundred and fifty milliliters each were used to collect water samples. Each bottle was immersed to about 6cm below the water surface and filled to capacity. The bottle was then brought out, properly capped and wrapped completely with a black polythene bag to prevent light penetration.

3.4.1 Physico-chemical parameters of water

The physico-chemical parameters of water from the New Calabar-Bonny River such as temperature (T°), hydrogen ion concentration (pH), Dissolved oxygen (DO) and Total dissolved solids (TDS), salinity, alkalinity, turbidity and conductivity were determined by using a Multi–parameter, *in-situ* water meter (Horiba U- 2, Japan).



Plate I: ***Pomadasys jubelini*** (note the black spot (arrowed) at the posterior edge of the operculum)

The values of the water parameters were determined by inserting the electrode of an *in-situ* water meter into a beaker containing the water sample and the readings taken. An average value of three readings was taken and recorded.

3.5 Laboratory Procedures

3.5.1 Morphological parameters

The morphological parameters of *Pomadasys jubelini* were determined by using a measuring board. The weight of the fish was taken using an LG digital electronic scale (QE-400) and recorded in grammes. Water on the fish was dabbed off before weighing.

The following measurements were made and recorded on a data collection sheet.

i. The standard length (cm): tip of snout to posterior end of hypural bone (caudal fin base).

ii. Total length (cm): tip of snout to maximal extent of caudal fin.

iii. Girth (cm): measured at the deepest part of the fish's body exclusive of fleshy or bony structures.

iv. Head length (cm): This is length measured with the mouth closed, from the tip of the snout to the posterior edge of the opercula bone.

v. Head width (cm): This is the greatest dimension from one gill cover to the other in closed position.

vi. Inter-orbital width (cm): This is the least bony width from orbit to orbit.

vii. Gape width (cm): This is the greatest transverse distance from across the mouth opening, with the mouth closed.

viii. Gill rakers: The count is taken from the first arch and of the lower limb only

ix. Total body weight (cm): Fresh wet specimen weight.

x. Scale count: This is the count of scales on the lateral line and of scales above and below it.

3.5.2 Derivation of fin formula

It is numerical and based on the number of spines and soft rays in the dorsal, pectoral, pelvic and anal/caudal fins. The spines and rays were counted and recorded as described by Lowe-McConnell (1987). Their numbers were designated by Roman numerals and Arabic numbers respectively. The scales on the lateral line and those above it were also counted and recorded.

3.5.3 Length–weight relationship

The length-weight relationship of the fish was calculated as described by the equation:

$W = aL^b$ ---------- (Allison, 2006)

where

W = weight (g)

L = length of fish (cm)

a and b = regression coefficient and slope respectively

The log-transformed data give the linear regression equation

Log W = log a + b log L

The pattern of growth (allometric or isometric) in *Pomadasys jubelini* was verified by the value of "b" in the equation $W = aL^b$

3.5.4 Length–girth relationship

Total length–girth relationship was determined from the general power function

$M = a (TL)^j$ ----------(King, 1997)

Where:

M = Girth

a = initial growth constant

j = growth rate exponent

TL = Total length

Coefficient of a and j was estimated after logarithmically transforming all data into the form:

Log M = log a + J log TL ---------- (Pauly, 1984)

3.5.5 Condition factor

The condition factor was calculated for each fish by employing the equation

$$K = \frac{W \times 100}{L^3}$$ ----------(Bagenal and Tesch, 1978)

Where

K = condition factor

L= Total length (cm)

W = Weight of fish (g)

3.6 Age and Growth

The scales, otolith, spines, opercula and T.S of spines and opercula were used to determine the age of fish samples.

3.6.1 Collection and processing techniques

3.6.1.1 Scales

Scales of caudal peduncle were gently scraped to remove mucus, dirt and epidermal tissue then removed by scraping hardly in the direction of the head. Scales were cleaned by rubbing between fingers under running water and then examined under an Electronic Olympus microscope (model Bino Cxi IS4381) for annuli (Mann, 2004).

3.6.1.2 Otoliths

Otoliths were obtained by pulling the operculum wide open against the head of the fish then severing the gill arches from the roof of the buccal cavity. The bulge in the buccal cavity was located and cracked open to locate the otoliths which were removed with the aid of fine tipped forceps. The otoliths were washed clean of any tissue with water and air dried, then examined for annuli using an Electronic Olympus microscope (model Bino Cxi IS4381) (Le Cren, 1947).

3.6.1.3 Spines

The first and second spines of the dorsal and anal fins were spread out and the membrane joining the first two spines was cut using a scalpel, the spine was then pushed down forward and backwards continuously, then turned alternately to the right and left until disconnected from the joint. Finally, the spine was twisted and pulled out. Spines were

rinsed under running water to remove debris, mucus and remaining soft tissues. Spines were thereafter decalcified by suspending the spines in decalcification solution (formic acid -10mls, formalin -5mls, distilled water -85mls) for seven days. Decalcified spines were then sectioned using rotary microtome set at 5-7µm. Sectioned spines were mounted on slides in glycerin and viewed under the light microscope; the image was captured using Samsung camera (Model PL 120) that was mounted on the microscope (Mann, 2004).

3.6.1.4 Opercula

The operculum was cut from the fish by slipping the point of a scalpel under the posterior edge of the bone between the opercula and the sub-opercula and then twisting to lift up the operculum which was gripped between the fingers and with a twist, and pulled away from its point of articulation with the skull. The opercula were placed in boiled water for one hour to remove attached tissues and air dried, then examined for annuli. The T.S of operculum was prepared (as described for T. S. of spines) and photo micro-graphed.

3.6.1.5 Age determination (Peterson method)

The age of *P. jubelini* was also determined using the Peterson method (the integrated method) of Pauly (1984). Monthly length measurements were pooled and plotted on a graph to obtain length frequency distribution for the period of study at 5cm class intervals. The same process was repeated along the time axis with the assumption that growth pattern repeats itself from year to year. The modal lengths were obtained and used for age classification. The integrated frequency model of Pauly (1984) is based on the assumption "that growth in length of fish is rapid initially, then increasing smoothly and finally passing through most of the discrete peaks".

3.7 Assessment of Stomach Fullness and Content

The abdomen of each fish was opened lengthwise, and the gastro-intestinal tract (GIT) was cut open and placed in a Petri dish containing normal saline. The stomach fullness was estimated as described by Olatunde (1978a), using the criteria described in Table 3.1; if the stomach fullness falls in between the basic scores on the table, points were awarded appropriately. Thereafter the stomach was cut off, split open and its contents preserved in 5% formalin until examined.

3.8. Food and Feeding Habits

In the study of the stomach contents of *P. jubelini*, the frequency of occurrence method (FO), ``points'' method (PO) gravimetric method (Bachock, 2004) and numerical method (NO) were employed. The total weights (g) of the stomach content (food items) were measured and recoded. The biomass contribution of each prey was expressed as a percentage of the biomass of food consumed by *P. jubelini*.

3.8.1 Frequency of occurrence method (FO)

In the frequency of occurrence method the individual food matter in the stomach were sorted and identified. The number of stomachs in which each food item occurred was expressed as a percentage of the total number of stomachs with food examined.

3.8.2 Points method (PO)

In "points'' method, the food items in the opened stomach were broadly grouped into Pisces, Crustacea, mollusca etc. Points were then awarded to the individual food item

Table 3.1: Classification of Stomach Fullness

Stomach Size	Description	Points
Full stomach	The stomach bulges considerably with food	100
¾ full stomach	The stomach is almost full but does not bulge	75
½ full stomach	Food occupies about 50% of the stomach volume	50
¼ full stomach	Stomach wall very flabby, sometimes looks empty	25
Empty stomach	No visible food in the stomach when dissected and examined under the microscope	0

Olatunde (1978a)

3.8.3 Gravimetric method (G)

Food items were weighed and expressed as:

$$\text{Percentage weight of food item} = \frac{\text{Weight of the particular food item}}{\text{Total weight of all food items}} \times 100$$

3.8.4 Numerical method (NO)

This method involves the counting the number of each food item present in the stomach of a fish and summing these numbers to obtain the total number of all food items found in the stomach. The number of each food item is them expressed as a percentage of the total number of all food items. It is expressed as:

$$\text{Percentage number of a food item} = \frac{\text{Total number of a particular food item}}{\text{Total number of all food items}} \times 100$$

3.8.5 Index of relative importance (IRI)

The importance of various food items were determined as described by Ugwumba and Ugwumba (2007)

$$IRI = (C_n + C_w) \times F$$

Where IRI = index of relative importance

C_n = percentage of numerical composition

C_w = percentage of gravimetric composition

F = percentage of frequency of occurrence

The dietary composition of the species examined was expressed as percentage

$$\%\ IRI = \frac{(C_n + C_w) \times F}{\sum (IRI)} \times 100$$

Food item with %IRI ≥ 3 are regarded as primary

≥ 0.1 to <3 are secondary whereas ≤ 0.1 are considered as incidental food items.

3.8.6 Predator–prey relationship

The relationship between the total body length and total weight of *P. jubelini* and weight of prey was determined as described by the equation:

$Y_L = a + {}_b X_L$ ---------- (Ogari, 1988)

Where Y_L = Prey body weight (g)

X_L = *P. jubelini* body length (cm) or body weight (g)

a = intercept, b = slope

3.9 Determination of Sex and Classification of Gonads:

The abdomen of the fish was dissected to determine the sex of the fish by visual and microscopic examination of the gonads (Ikomi and Odum, 1998). The female gonads were carefully removed from the abdominal cavity and placed on a piece of blotting paper to remove excess water. Each ovary was weighed to the nearest 0.01g on an electronic digital scale. The unsexed small fish were regarded as immature.

The maturity stages of the ovaries were classified using the modified Nikolsky scheme (Bagenal and Braun, 1978) as shown in table 3.2.

3.10 The Gonado-Somatic Index (GSI)

This was calculated for each gonad

$$GSI = \frac{\text{Gonad weight (g)} \times 100}{\text{Fish weight (g)}}$$ ---------- (Welcomme, 1985)

Table 3.2: Maturity stages of ovaries

Stage I:	Immature (ovary greyish, thin and elongated eggs invisible to naked eyes)
Stage II:	Resting (ovary light yellow, eggs visible through ovary wall, oocyte diameter 0.6 – 1.5mm)
Stage III:	Maturing (ovary bright yellow, full and swollen, all eggs distinct, round and fully yoked egg diameter 1.6 – 2.1mm)
Stage IV:	Mature (ovary as in stage III but slightly flaccid with numerous deep yellow coloured eggs, some translucent and eggs diameter 1.8 – 2.1mm). In males it changes from transparent to pale rose colour.
Stage V:	Spawning (ovary flaccid, opaque coloured and shrunken. Primary oocyte in Stage I . Considerable atresia). In males, no running testis noticeable.

Source: Nikolsky (1963)

3.11 Fecundity Estimation

Fecundity of the grunters was estimated by the ``sub-sampling dry gravimetric method'' modified after Simpson (1959). Ovaries were preserved in Gilson's fluid (Appendix 17) for at least ninety (90) days after which they were removed. The eggs were then washed carefully using distilled water until they were disentangled from the ovarian tissues. The eggs were then poured into a funnel lined with a filter paper. When the water had dried off the paper, the eggs were spread on blotting paper to remove excess moisture. Clumped eggs were carefully separated and air-dried for 24-30 hours at room temperature. Fecundity estimation was obtained by weighing all the eggs of each fish. Then three samples of 200 eggs from each fish were randomly selected and weighed. Total weight of eggs was divided by the mean weight of the sub-samples and multiplied by 200 to give the fecundity estimate of the fish. The eggs were countered in the same room to ensure that moisture and temperature conditions were consistent.

3.12 Relationship between Fecundity and Length/Weight of Fish

The relationship between fecundity and length/weight of fish was obtained as described by the equation

$F = aX^b$ …… (Lagler *et al*., 1977).

Where

F = fecundity

x= body length (cm) or body weight (g)

b = the slope

a= intercept

Through a logarithmic transformation the equation becomes

$$\log F = \text{Log } a + b \log X$$

3.13 Histology

3.13.1 Fixation, dehydration and clearing

The Gastrointestinal tract (GIT) of each fish was isolated, then fixed in 10% formal-saline (90mls distilled water: 10mls formalin) for two weeks after which they were processed.

The tissues were introduced into 60%, 80%, 90% and absolute alcohol (100%) at one hour each. The tissues were then cleared in xylene for one hour. The tissues thereafter were transferred into the incubator and infiltrated with liquid paraffin for about 2-3 hours at 50°C (making tissues ready for embedding).

3.13.2 Embedding, sectioning and mounting

The tissues were embedded in paraffin wax and allowed to solidify in a paraffin block over cool water. The solidified block was trimmed to a square shape with a scalpel and then placed in the chuck of a microtome (Jung 113-1-20) set at 5-6µcm and trimmed. The sections were transferred into a hot water bath to spread the tissues into ribbons. The paraffin ribbons were then mounted on microscope slides that were smeared with egg albumen for easy adhesion of tissues and slides were gently pressed over a flame then transferred into incubator to dry for 12 hours.

3.13.3 Staining with haemotoxylin and eosin

Sections were deparaffinized in 2 changes of xylene for 2 minutes each. To remove xylene, sections were transferred into 90%, 80%, and 70% alcohol for 2 minutes each. Sections

were rinsed in distilled water then transferred into haemotoxylin solution for 5minutes then into eosin for 1 minute. The sections were again dehydrated through 70% - absolute alcohol and sections were immersed in 2 changes of xylene for one minute each for clearing. Sections were mounted in D.P.X.

3.13.4 Microscopic observation

Prepared slides of the gastrointestinal tract, operculum and spines were mounted and examined on the Electronic Olympus microscope (model Bino Cxi IS4381) that has Samsung camera (model PL120) attached, to capture features of biological importance.

3.14 Statistical Analyses

SPSS (2004) was used to deduce means, Standard Deviation (SD), Standard Error (SE) of the physico-chemical parameters of water and rainfall. Variances of water parameters, sample populations, lengths and weights, in the stations were analysed using ANOVA, then means were ranked by using the Least Significant Difference (LSD). Pearson's correlation was employed to determine any association between physicochemical parameters of water and fish meristics. Student's *t*- test was used to test for any significant difference between the seasons and sex ratio.

CHAPTER FOUR

4.0 RESULTS

4.1 Physico-Chemical Characteristics of the Water in the New Calabar-Bonny River

4.1.1 Hydrogen ion concentration (pH)

The pH value ranged from 5.9-7.2 in Station 1, 5.3–7.2 and 5.20–7.25 in Stations 2 and 3 respectively (Table 4.1). The means and standard error of pH were 6.43 ± 0.08, 6.36 ± 0.08, 6.43 ± 0.10 for Stations 1, 2 and 3 respectively. The lowest pH was recorded in the wet season (5.19) and highest (6.51) in the dry season (Table 4.2). There were no significant differences ($P>0.05$) in pH among the three stations and between the seasons (Table 4.2).

4.1.2 Temperature (T°C)

The temperature obtained was between 27.50°C and 30.10°C, (28.43 ± 0.18°C) in Station 1, (28.05 ± 0.04°C) in Station 2 and (28.17 ± 0.21°C) in Station 3 (Table 4.1). The lowest temperature of 26.2°C was observed in Station 2 while the highest 29.30°C was observed in Station 3. The dry season had a higher mean temperature of 29.02 ± 0.007 °C compared to the wet season (27.63 ± 0.01°C) (Table 4.2). There was no significant difference ($P>0.05$) in temperature among the Stations but there was a significant difference ($P\leq0.05$) between the mean temperature of the wet and dry season (Table 4.2).

4.1.3. Salinity (ppt)

The salinity of Station 1 ranged between 13.50 ppt and 27.20 ppt (18.81 ± 0.79ppt) (Table 4.1). Station 2 had a salinity range of 4.19 ppt–22.00ppt while the mean salinity at Station

Table 4.1 Mean Physico-chemical parameters of water of New Calabar-Bonny River from June 2011 to May 2013

Parameters	**Station 1**	**Station 2**	**Station 3**	**Mean**	**SE**
pH	6.43	6.36	6.43	6.41	0.01
T°C	28.43	28.05	28.17	28.22	0.09
Salinity (ppt)	18.81^{b}	11.36^{b}	0.70^{a}	10.29	9.10
Dissolved Oxygen (mg/l)	6.70^{a}	6.59^{a}	9.97^{b}	7.76	0.05
Alkalinity (mg/l)	13.31	13.60	10.93	12.61	0.70
Total Dissolved solids (ppm)	1012.2	956.0	273.90	747.2	37.90
Conductivity (µs/cm)	105.37^{b}	18.25^{b}	12.37^{a}	418.00	20.00
Turbidity (NTU)	14.29^{b}	10.00^{b}	5.13^{a}	9.81	2.20

Means with the same superscript within the rows are not significantly different (P>0.05)

Table 4.2 Seasonal variation in physico-chemical parameters of water of New Calabar-Bonny River June 2011 – May 2013

	Wet season	**Dry season**
Parameter		
pH	6.40 ± 0.01	6.42 ±0.01
T°C	27.63 ± 0.01[a]	9.02 ± 0.01[b]
Salinity (ppt)	9.24 ± 0.36[b]	8.29 ± 0.38[a]
Dissolved oxygen(mg/l)	6.57 ± 0.00	6.43 ± 0.01
Alkalinity (mg/l)	11.98 ± 0.03[a]	13.41 ± 0.03[b]
Total dissolved solids (ppm)	10.56 ± 0.17[a]	15.14 ± 0.17[b]
Conductivity (µs/cm)	761.88 ± 0.27[b]	226.36 ± 0.44 [a]
Turbidity (NTU)	11.79 ± 0.22[b]	7.03 ± 0.29[a]

Means with the same superscript within the rows are not significantly different (P>0.05)

3 ranged between 0.00 ppt–0.25 ppt. The highest salinity of 27.20 ppt was observed at Station 1 in the month of December, 2011. An annual mean of 10.29 ± 9.10 was recorded that was significantly different (P≤0.05) within the Stations. Salinity was low in the wet season and high in the dry season.

4.1.4 Dissolved oxygen (DO)

The total mean dissolved oxygen concentration in the New Calabar–Bonny River ranged between 5.30 mg/l–7.89mg/l (7.76±0.05 mg/l). Station 3 had the highest mean DO concentration of 9.97±0.15mg/l while Station 2 had the lowest of 6.59±0.13mg/l (Table 4.1). There was no significant difference (P>0.05) in DO among the stations during the period of study. Dissolved oxygen was high in the wet months and low in the dry season.

4.1.5. Alkalinity

Alkalinity ranged between 0.00 mg/l–30.10 mg/l(12.61 ± 0.12mg/l) (Table 4.1). Station 2 had the highest alkalinity level (13.60 ± 1.81mg/l) while Station 3 had the lowest (10.93 ± 0.28 mg/l). There was no significant difference (P>0.05) among the Stations. The alkalinity pattern of the river was variable within the seasons

4.1.6. Total dissolved Solids (TDS)

The Total dissolved solids concentration ranged from 20.00 ppm–2471.00ppm (747.70 ± 37.90ppm). Station 1 had the highest mean TDS concentration (1012.2 ± 185.40 ppm) while Station 3 had the lowest mean TDS concentration (273.90 ± 53.98 ppm) (Table 4.1).

4.1.7 Conductivity

The conductivity of The New Calabar–Bonny River ranged between 1.8 µs/cm to 290µs/cm and the mean conductivity was 418.00 ± 20.0µs/cm. Conductivity was highest in Station 1 (105±22.2µs/cm) and least in Station 3 (12.37±1.97µs/cm)(Table 4.1). Significant difference (P≤0.05) in conductivity was observed between the Stations and between seasons

4.1.8 Turbidity

The range of turbidity in the New Calabar-Bonny River was from 0.00 NTU–37.00 NTU with an annual mean of 9.81 ± 2.20 NTU (Table 4.1) Station 3 recorded the lowest mean turbidity (5.12 ± 0.72 NTU) while Station 1 recorded the highest mean turbidity (14.29 ± 2.91 NTU). Turbidity was low in the dry season and high in the rainy season.

4.1.9 Seasonal variation of physico-chemical parameters of water

The seasonal variations in physic-chemical parameters of water is given on (Tables 4.2).

In the wet season, the pH recorded was between 5.20 and 7.20 (6.39± 0.01), while in the dry season the mean was 6.42 ± 0.01 with a range of 5.90 to 7.25. There was no significant difference (P>0.05) in pH between the seasons.

Temperature ranged from 25.90°C–29.35°C (27.63 ± 0.01). In the dry season, the mean temperature ranged between 27.2°C and 30.10°C and the mean obtained was 29.02°C ± 0.01. There was significant a difference (P≤0.05) in temperature between the seasons.

The value of salinity obtained during the wet season was between 0.00 and 19.75ppm (9.29 ± 0.37ppm), while the dry season had a higher range of 0.20–27.1ppm (8.29 ± 0.38ppm). A

significant difference ($P \leq 0.05$) in salinity was obtained between the seasons. The dissolved oxygen in water ranged from 6.01mg/l to 7.22mg/l in the wet season (6.57 ± 0.004mg/l) while it was between 6.63mg/l and 6.83mg/l (6.43 ± 0.08mg/l) in the dry season. There was no significant difference ($P > 0.05$) in the dissolved oxygen between the seasons.

Alkalinity in the wet season ranged from 5.60 mg/l to 20.70 mg/l (11.98 ± 0.03mg/l) while the dry season had a higher range of 5.5 mg/l to 22.80mg/l (13.41 ± 0.03mg/l). There was no significant difference ($P > 0.05$) in alkalinity between the wet season and the dry season. The mean total dissolved solids in the wet season was 712.46 ± 0.56 ppm and ranged from 20.00–2352.00ppm, while the dry season had a lower mean of 493.34 ± 272.12ppm and ranged from 104.00–2471.00ppm. There was no significant difference ($P > 0.05$) in TDS between the wet season and the dry season. The mean seasonal variation for conductivity was 761.88 ± 0.27µs/cm for wet season and 226.36 ± 0.44µs/cm for dry season. Significant difference ($P \leq 0.05$) was observed for conductivity between the seasons. The mean turbidity value was 11.79 ± 0.22 (NTU) for wet season and 7.03 ± .29(NTU) for the dry season.

Turbidity is low in the dry season and high in the wet season. Significant difference ($P \leq 0.05$) was observed in turbidity between the wet season and dry season.

4.1.10 Correlation of the physic-chemical parameters of water of New Calabar-Bonny River (June 2011–May 2013)

The correlation coefficient of mean physico-chemical parameters of water is presented in (Table 4.3). Temperature had a high positive correlation with pH (r = 0.76).

Salinity exhibited low negative correlation between pH (r = -0.29) but low positive correlation with T°C (r = 0.39).

Dissolved oxygen had positive correlation with pH (r = 0.49) but negative correlation with T°C (r = -0.17) and salinity (r = -0.97) which was not significant (P>0.05).

Alkalinity showed negative correlation with pH (r = -0.55) and DO (r = -0.99), positive correlation with alkalinity and T°C (r = 0.10) and salinity (r = 0.95).

Total dissolved solids correlated negatively with pH (r = -0.31) and DO (r = -0.98), it had a low positive correlation with T°C (r = 0.36), but a very high correlation with salinity (r = 0.99), and alkalinity (r = 0.96).

Conductivity had negative correlation with pH (r = -0.18), T°C (r = -0.24) and DO (r = -0.94), high positive correlation with salinity (r = 0.99), alkalinity (r = 0.91) and TDS (r = 0.99).

Turbidity correlated negatively with pH (r = -0.00) and DO (r = 0.86), but positively with T°C (r = 0.63), salinity (r = 0.95), alkalinity (r = 0.83), TDS (r = 0.95) and conductivity (r = 0.98).

Table 4.3: Correlation matix of physico-chemical parameters of water in New Calabar-Bonny River June 2011 – May 2013

	pH	T°C	Salinity (ppt)	Dissolved Oxygen (mg/l)	Alkalinity (mg/l)	Total Dissolved solids (ppm)	Conductivity (µs/cm)	Turbidity (NTU)
pH	1							
T°C	0.76	1						
Salinity (ppt)	-0.29	0.39	1					
Dissolved Oxygen (mg/l)	0.49	-0.17	-0.97	1				
Alkalinity (mg/l)	-0.55	0.10	0.95	-0.99	1			
Total Dissolved solids (ppm)	-0.31	0.36	0.99	-0.98	0.96	1		
Conductivity (µs/cm)	-0.18	0.49	0.99	-0.94	0.91	0.99	1	
Turbidity (NTU)	-0.00	0.63	0.95	-0.86	0.83	0.95	0.98	1

4.2 Rainfall

The monthly rainfall data for New Calabar-Bonny River was obtained from the Federal Meteorological Unit, Port-Harcourt Rivers State. Using the data, the sampling period was delineated into wet and dry seasons. The general rainfall pattern of the area is shown on (Figure 4.1). The rainfall was between 4.8mm and 489mm, and was highest in July (489.40mm) and lowest in December (4.80mm). The dry season comprised months with rainfall less than 100mm (November to March) while wet season comprised months with rainfall of more than 100mm (April to October). There was a significant difference ($P \leq 0.05$) in the rainfall between the seasons.

4.3 Abundance of *Pomadasys jubelini*

A total of 413 specimens of *Pomadasys jubelini* were obtained from the three stations sampled during the period of this study (Table 4.4). Station 1 had the highest number of fish sampled (188), this was obtained in May 2013 (wet season). No fish was caught in December 2011. More females were obtained than males at this station in a ratio of 1: 1.6.

In Station 2, a total of 134 fish were caught, with the highest number in June 2011. No fish were caught in December of 2011 and 2012 (Figure 4.2). More females than males were obtained in Station 2 throughout the sampling period in the ratio of 1: 1.6

The total number of fish obtained in Station 3 was 91. The highest number caught was in June 2011 while no fish was obtained in December 2011 and 2012. Again more females were obtained than the males in ratio of 1: 2.8. Generally, catches were higher in the wet season (April to October) than in the dry season (November to March) (Figure 4.2).

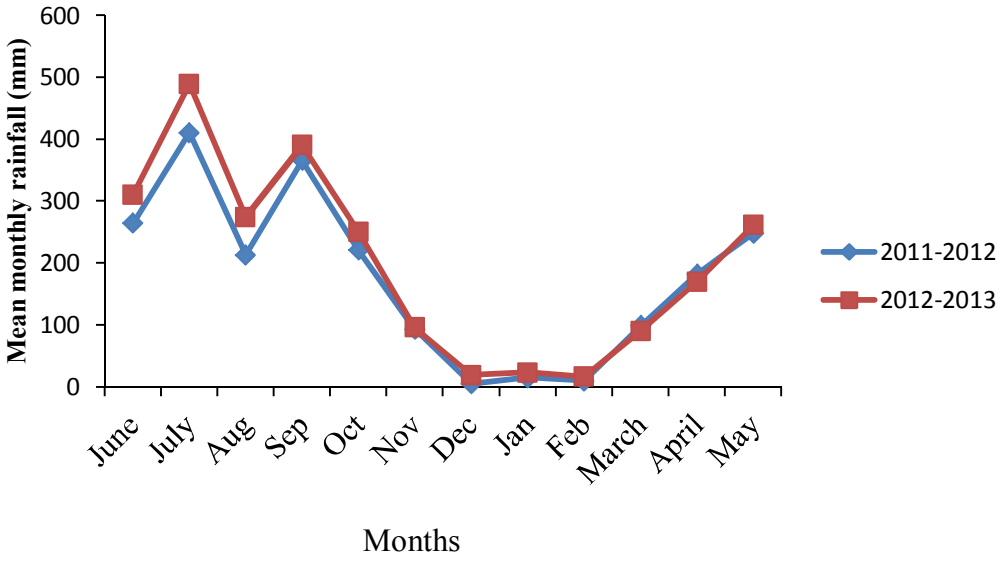


Figure 4.1: Mean monthly rainfall of New Calabar-Bonny River (2011-2013)

Source: Federal Meteorological Centre Port-Harcourt, Rivers State

Table 4.4: Abundance of male, female and immature *Pomadasys jubelini* at the three Stations in the New Calabar–Bonny River (2011–2013)

Stations	Male	Female	Immature	Total	Sex Ratio
Station 1	41	91	24	182	1:2.2
Station 2	30	159	60	134	1:5.3
Station 3	22	35	66	97	1:1.6
Total	93	194	126	413	1:2.1
Sex ratio	1	2.1			

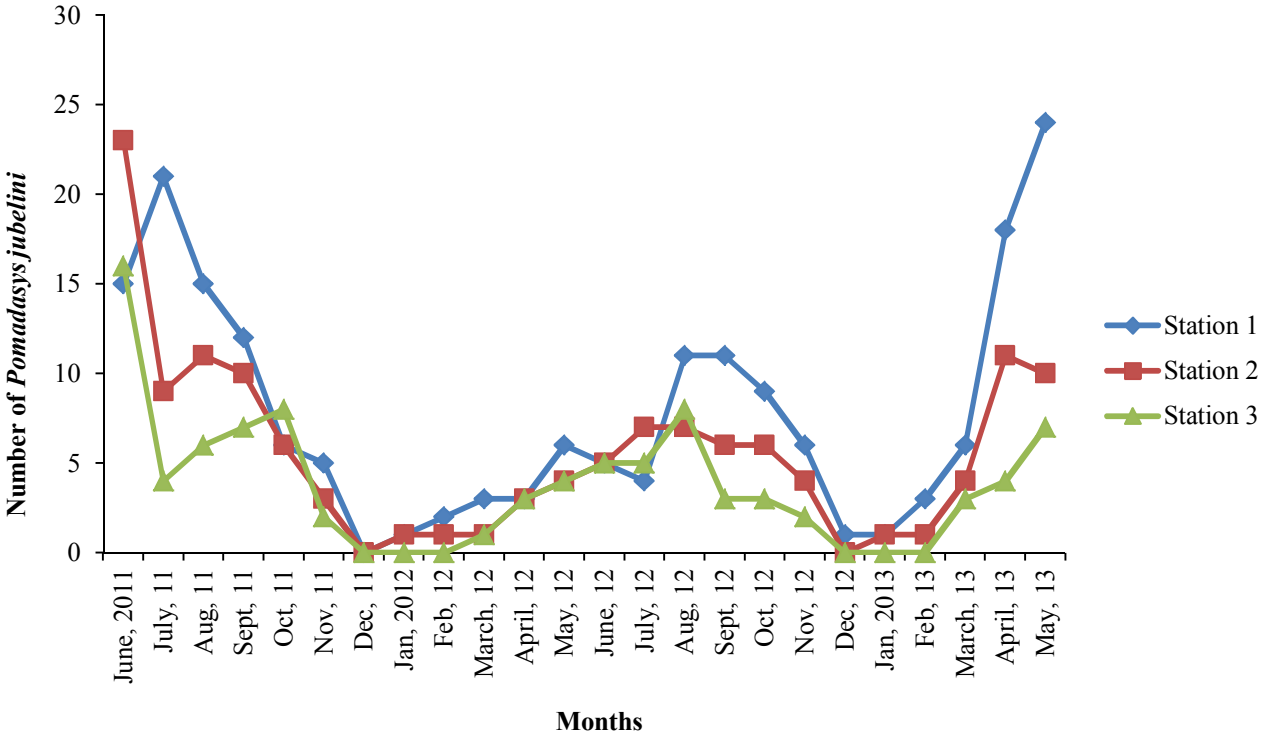


Figure 4.2: Distribution of *Pomadasys jubelini* at the three stations of the New Calabar–Bonny River 2011-2013

In summary, out of the total fish sampled, 93 were males, 194 were females and 126 were immature (Table 4.4). The highest number of fish was caught in June 2011. More fish were caught in the rainy (wet) season (April - October) than in the dry season (November to March). Throughout the study period, more females were obtained than the males in a female to male ratio of 2.1:1.

4.4. Class Structure

The juveniles constituted the class size 5.10–15.00cm, of which 112 (70%) were immature, making it the largest proportion of the fish sampled. 20 (12.5%) males 28 (17.5%) and females were identified within the juvenile class size. The sub-adults (15.10–30.00cm) were made up of 7 (4.5%) immature fish, 59 (37.8%) males and 90(57.7%) females. Adults (30.10–55.00cm) comprised 15 (21.4%) males and 55 (78.6%) females (Table 4.5).

4.5. Morphometric and Meristic characteristics of *Pomadasys jubelini*

A total of 15 specimens were measured and the morphometric parameters were taken (Table 4.6). The largest fish obtained measured up to 47.9cm (SL) and weighed 2145.1g while the smallest fish had a length of 10.1cm with a weight of 20.4g. Gills had 12 to 13 gill rackers. The anal fin had 3 spines, the first is extremely short while the second is very stout and thick but is the longest. The anal fin has between eight and nine bonny rays. The pectoral fin length is about one third of the total length of the fish with no spines present however the pelvic fin is very broad (almost twice its length), it is made up of one spine and between five to seven rays. Five rows of scales were observed above the lateral line.

Table 4.5: Size class for *Pomadasys jubelini* in the New Calabar–Bonny River

Stages	Size class (cm)	Unsexed	Males	Females	Total
Juveniles	5.00-15.00	112	20	28	160
Post juveniles	15.10-30.00	7	59	90	156
Adults	30.10-55.00	0	15	55	70
Total		119	94	174	

Table 4.6: Morphometric and meristic parameters of *Pomadasys jubelini* in the New Calabar-Bonny Rive
2011-2013

Characters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. TL (cm)	39.8	34.1	40.2	31.2	21.6	23.2	45.1	41.8	55.3	14.1	14.1	14
2. SL (cm)	33.5	28	33.3	26.1	17.1	18.9	36.7	33.2	47.9	13.5	11.8	10.1
3. W (g)	833.4	430.6	892.5	372.8	111.2	146.6	1066.3	825	2145	49.7	18.9	20.4
4. HW(cm)	14	11.3	14.9	10.5	6.3	7.2	16.2	13.5	32	4.5	3	4
5. HL (cm)	8	7.1	9.3	6.9	5.1	5.6	10.4	13.5	12	3.6	3.2	3
6. GL (cm)	13.2	12.7	15	12.3	15.1	18.2	32.8	29.1	11	10.2	7.9	9
7. DFL (cm)	18.2	14	18	14.1	9.6	9.6	19.2	17.6	23.6	7.1	7.8	5.7
8. DFH (cm)	5.6	5.3	5.5	4.3	3.4	3.7	5.9	5	6.4	2.4	1.9	2
9. PFRN	16	16	16	16	16	16	16	16	14	14	15	12
10 PFH (cm)	5.1	4.8	6.8	3.4	2	2.5	6.1	4.8	12	1.2	0.5	0.3
11 PFL (cm)	10.6	8.7	10.4	8.5	5.7	6.1	12.2	11.1	15.6	4.4	3.8	3.5
12.GRN	12	13	13	12	12	12	13	13	13	13	12	12
13.VFW (cm)	4.2	4.6	4.6	4.1	1.5	2.5	5.6	5.6	6.7	1.4	0.9	0.6
14.VFL (cm)	7.4	5.9	9.6	6.3	4.2	5.1	8.5	7.9	10.5	3.1	1.2	1.2
15.VFRN	7	7	7	7	6	6	6	6	5	5	5	5
16.ASL (cm)	6.2	5.5	6.4	8.6	4.3	4.5	6.5	6	6.7	3	2.9	2
17.CFL (cm)	8.1	7.1	7.3	6.4	5.8	5.8	9.9	8.9	12.1	0	3	2.9
18.CFRN	16	16	16	16	16	16	16	16	18	0	18	18
19.IOD (cm)	5	4.1	5.1	4.6	2.5	2.8	4.1	3.8	6.8	0	3.1	2.6
20.GW (cm)	6.2	4.2	7.4	6.1	1.9	4.1	6	3.9	8.1	2.8	1.4	1.3

KEY
TL, Total length; SL, Standard length; W, Weight; HW, Head Width; HL, Head Length; GL, Girth Lengt
Length; DFH, Dorsal Fin Height; PFRN, Pectoral Fin Ray Number; PFH, Pectoral Fin Height; PFL, Pecto
GRN, Gill Rakers Number; VFW, Pelvic Fin width; VFL, Pelvic Fin Length; VFRN, Pelvic Fin Ray Nun
Spine Length; CFL, Caudal Fin Length; CFRN, Caudal Fin Ray Number; IOD, Inter-orbital Distance; GW

4.5.1 Correlation coefficient (r) of the Morphometric and Meristic parameters of *Pomadasys jubelini*

Total length had a high correlation with the standard length (0.99), weight (0.94), head width (0.88), head length (0.94), dorsal fin length (0.99), dorsal fin width (0.96), pectoral fin width (0.93), pectoral fin length (0.99), pelvic fin width (0.88), and pelvic fin length (0.95) (Table 4.7). The gape width had relatively high correlation with total length (0.83), Standard length (0.84), weight (0.74), head width (0.85), head length (0.73), dorsal fin length (0.85), dorsal fin width (0.82), pelvic fin length (0.91), anal spine length (0.83), and inter-orbital distance (0.79). Low values (<0.40) were obtained from the correlations between pelvic fin ray number and the other parameters, caudal fin ray numbers and the other parameters (Table 4.7).

4.6 Length–Weight Relationship (LWR)

The standard length of *Pomadasys jubelini* ranged from 8.50cm-47.60 while the weight ranged from 16.0g–2320.0g. The largest male fish weighed 890.1g, while the largest female fish weighed 2320.0g. Females were longer and heavier than males. Strong positive correlations (r) for male and female fish were 0.92 and 0.97 respectively. The b values were not greater than 3, but generally it was observed that fish weight increased as its length increased (Figures 4.3 and 4.4).

Table 4.7: Correlation matrix of morphometric and meristic parameters of *P. jubelini*

Parameters	TL	SL	W	HW	HL	GL	DFL	DFH	PF RN	P FH	P FL	GR	V FW	V FL	VF RN	A SL	C FL	CF RN	IOD	GW
1. TL (cm)	1																			
2. SL (cm)	0.99	1																		
3. W (g)	0.94	0.95	1																	
4. HW (cm)	0.88	0.89	0.87	1																
5. H (cm)	0.94	0.93	0.85	0.81	1															
6. G (cm)	0.60	0.57	0.53	0.25	0.68	1														
7. D (cm)	0.99	0.99	0.94	0.88	0.93	0.57	1													
8. D (cm)	0.96	0.95	0.84	0.82	0.86	0.57	0.94	1												
9. PFRN	0.42	0.41	0.21	0.16	0.45	0.48	0.43	0.51	1											
10. PFH (cm)	0.93	0.94	0.91	0.98	0.84	0.33	0.92	0.89	0.27	1										
11. PFL (cm)	0.99	0.99	0.94	0.92	0.94	0.55	0.99	0.94	0.39	0.95	1									
12. GRN	0.60	0.61	0.59	0.56	0.66	0.40	0.61	0.48	0.17	0.59	0.62	1								
13. VFL (cm)	0.88	0.88	0.89	0.62	0.81	0.73	0.87	0.82	0.41	0.71	0.84	0.56	1							
14. VFL (cm)	0.95	0.94	0.84	0.87	0.91	0.52	0.94	0.94	0.49	0.92	0.95	0.59	0.75	1						
15. PFRN	0.40	0.38	0.15	0.20	0.37	0.18	0.41	0.49	0.74	0.28	0.37	0.24	0.31	0.48	1					
16. ASL (cm)	0.79	0.79	0.63	0.67	0.74	0.41	0.80	0.81	0.64	0.71	0.79	0.35	0.66	0.83	0.69	1				
17. CFL (cm)	0.86	0.84	0.76	0.77	0.79	0.53	0.84	0.86	0.33	0.78	0.85	0.32	0.68	0.82	0.25	0.66	1			
18. CFRN	0.33	0.29	0.27	0.25	0.26	0.18	0.31	0.31	0.12	0.25	0.28	-0.25	0.25	0.22	0.14	0.24	0.59	1		
19. IOD (cm)	0.87	0.87	0.83	0.82	0.75	0.30	0.88	0.81	0.32	0.84	0.86	0.35	0.72	0.80	0.43	0.75	0.80	0.63	1	
20. GW (cm)	0.83	0.84	0.74	0.85	0.73	0.24	0.85	0.82	0.37	0.87	0.86	0.54	0.59	0.91	0.54	0.83	0.67	0.14	0.79	1

KEY
TL, Total length; SL, Standard length; W, Weight; HW, Head Width; HL, Head Length; GL, Girth Length; DFL, Dorsal Fin Length; DFH, Dorsal Fin Height; PFRN, Pectoral Fin Ray Number; PFH, Pectoral Fin Height; PFL, Pectoral Fin Length; GRN, Gill Rakers Number; VFW, Pelvic Fin width; VFL, Pelvic Fin Length; VFRN, Pelvic Fin Ray Number; ASL, Anal Spine Length; CFL, Caudal Fin Length; CFRN, Caudal Fin Ray Number; IOD, Inter-orbital Distance; GW, Gape Width

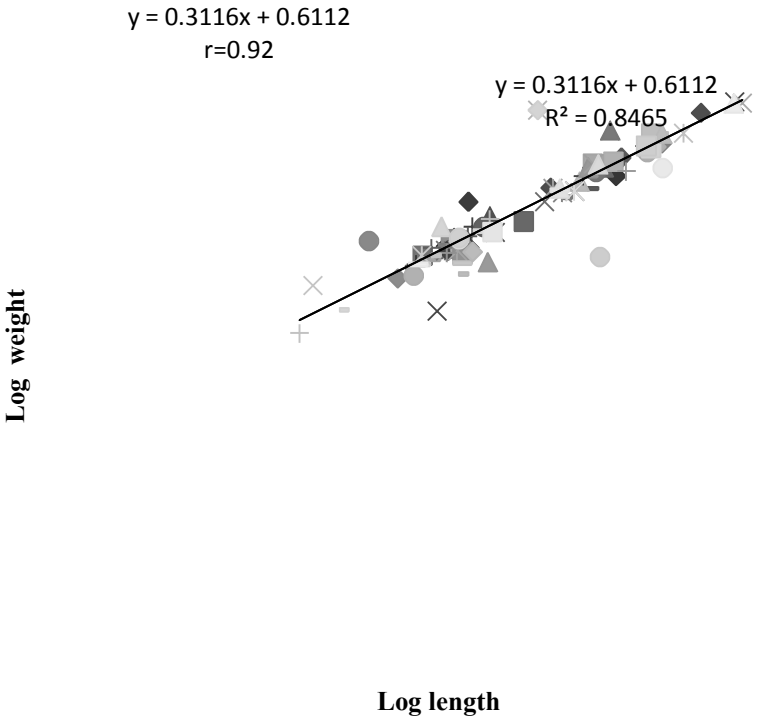


Figure 4.3: Length–weight relationship of male *Pomadasys jubelini* (2011–2013)

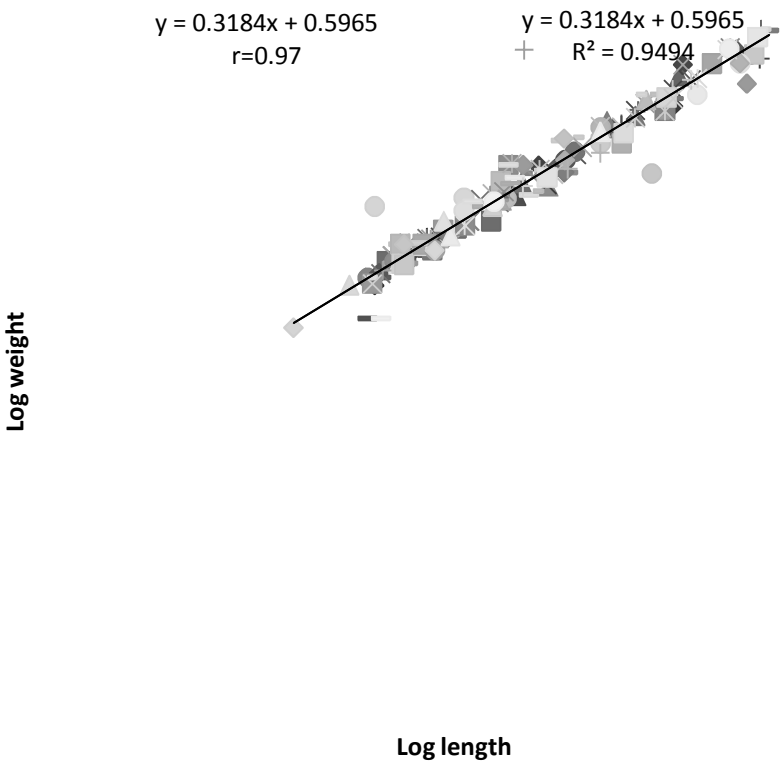


Figure 4.4: Length–weight relationship of female *Pomadasys jubelini* (2011–2013)

4.7 Condition Factor (K)

The mean monthly condition factor (K) ranged from 0.01–1.33. The highest values were obtained in December, January, February and March in the female population (Figure 4.5). In the male population, condition factor increased during the rainy season (June, July, August and September) but declined in the dry season. Condition factor of *P. jubelini* increased with increase in size of fish with respective to sex.

4.8 Length–Girth Relationship (M)

The length of *Pomadasys jubelini* sampled ranged from 10.20–55.3cm. The largest male fish had lengths of 41.20cm and 33.3cm for Standard length (SL) and Girth length (GL) respectively, while the largest female fish had lengths of 55.30cm and 45.30cm for SL and GL respectively. Strong positive correlations (r) for male and female fish were 0.91 and 0.82 respectively, $b > 1$ both for male and female population (Figures 4.6 and 4.7).

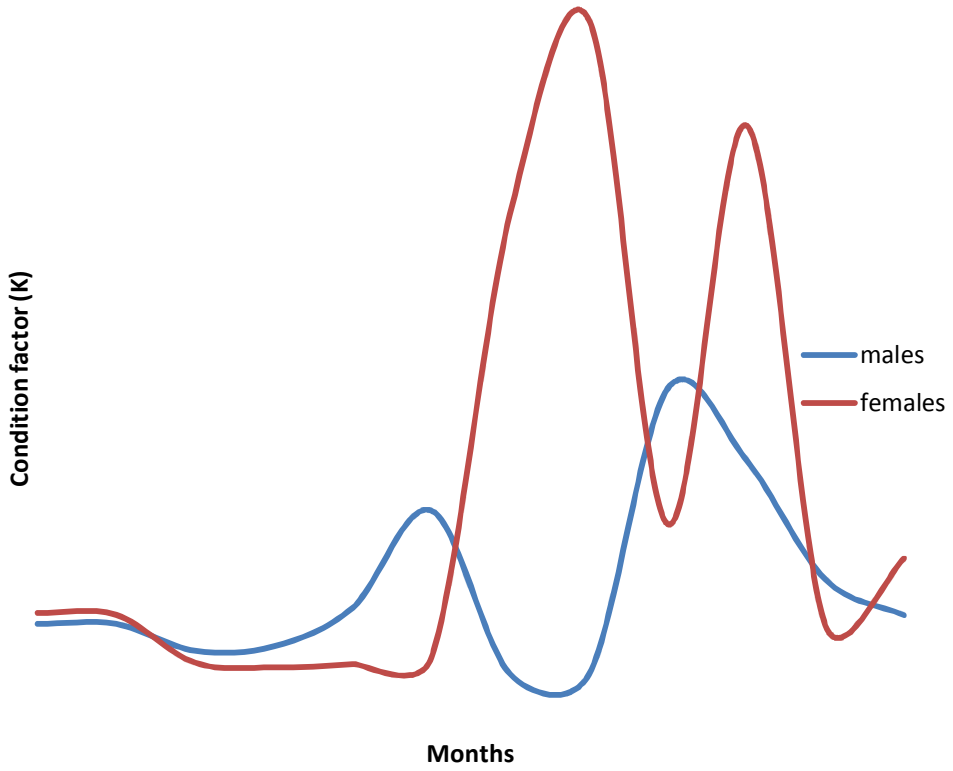


Figure 4.5: Condition factor of male and female population of *Pomadasys jubelini* (2011–2013)

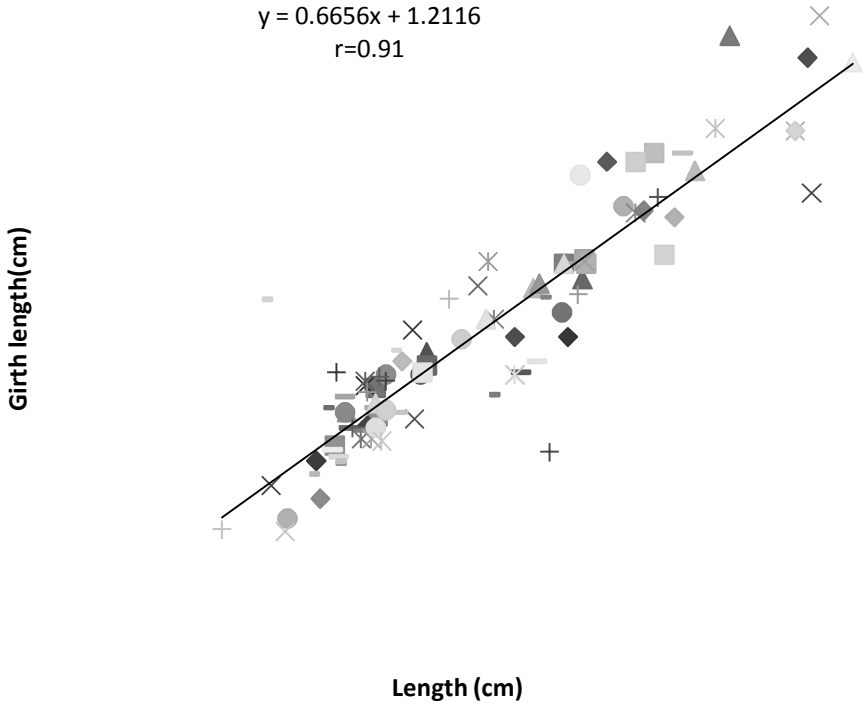


Figure 4.6: Length–girth relationship of male *Pomadasys jubelini* (2011–2013)

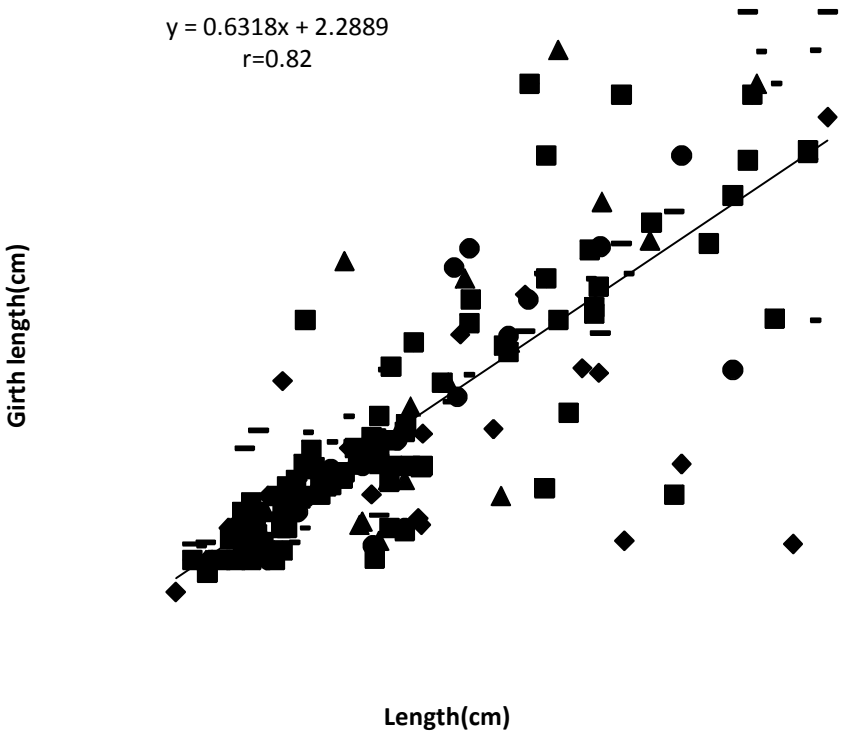


Figure 4.7: Length–girth relationship of female *Pomadasys jubelini* (2011–2013)

4.9 Age and Growth

4.9.1 Fins

Pomadasys jubelini possess median (unpaired) and paired fins. The median fins comprise of the dorsal fin, anal fins and the caudal fins. The number of fins (spines and rays) of *P. jubelini* is presented in Table 4.8.

a) The Dorsal fin:
   This is located on the mid dorsal part of the body and extends to the caudal region. It has 12 spines and 16 rays (Plate IIa).

b) The Anal fin:

   This fin has 3 spines (the first is the shortest and the second is the longest) and 8 soft rays (Plate IIb).

c) The caudal fin:

   The caudal fin lies at the end of the body; its shape is emerginate and has 15–18 soft rays (Plate III).

d) The pectoral fin:
   This fin is located close behind the operculum. It has 9–12 soft rays with no spine. It can grow up to one third of the fish's total body length. Picture inserted below is 11.60cm (Plate IV).

e) The Pelvic fin:

   The pelvic fin is located below the pectoral fin base and consists of 1 spine and 5–7 soft rays (Plate V).

Table 4.8: Number of spines and rays associated with fins of *Pomadasys jubelini*

Fins	Spines	Rays
Dorsal fin	12	16
Anal fin	3	8
Pectoral fin	-	9-12
Pelvic fin	1	5-7
Caudal fin	-	15-18

Fin formula = DXII 16, AIII 8, P 12, V 1 5, C 15

$$\begin{array}{r} 32\ \underline{5} \\ 9 \end{array}$$

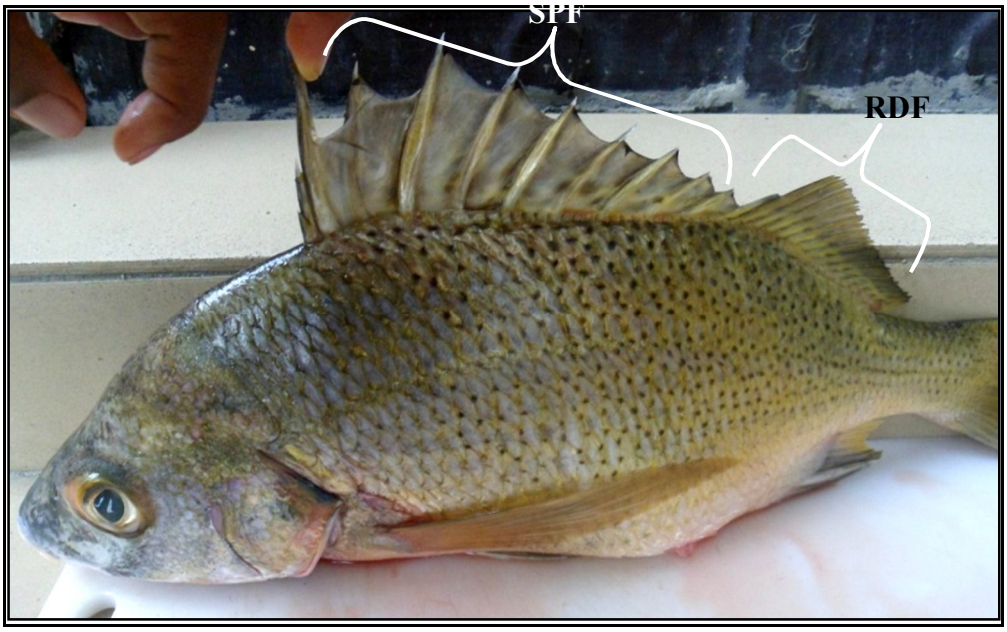


Plate IIa: *Pomadasys jubelini*: SPF, Spined Dorsal Fin; RDF, Rayed Dorsal fin

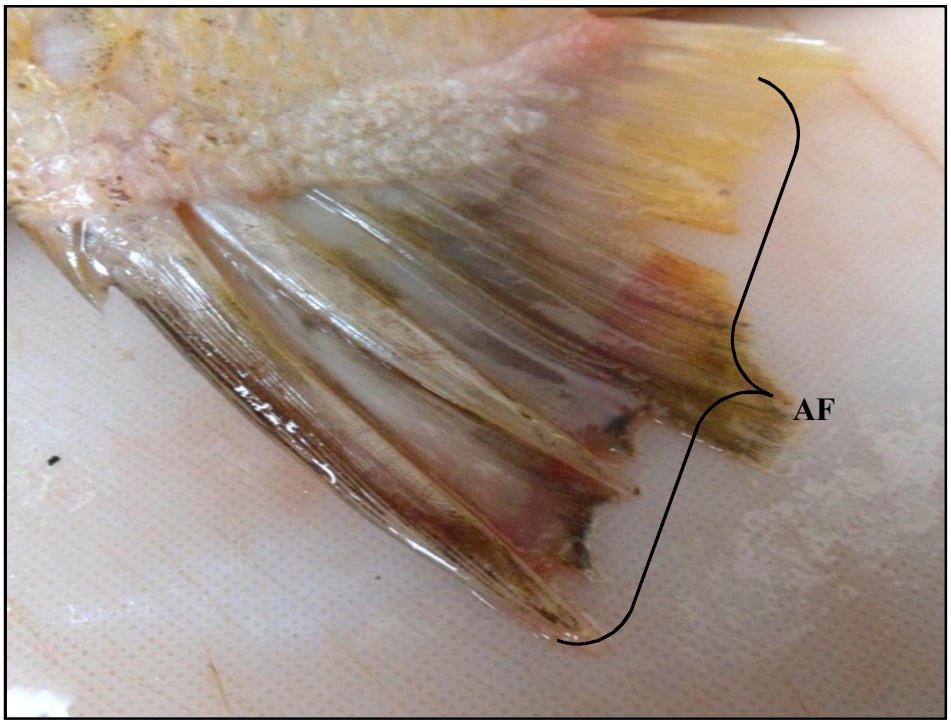


Plate IIb: Anal fin of *Pomadasys jubelini.* AF, Anal Fin



Plate III: Caudal fin of *Pomadasys jubelini*



Plate IV: Pectoral fin of *Pomadasys jubelini*



Plate V: Pelvic fin of *Pomadasys jubelini*

4.9.2 Scales

Pomadasys jubelini possess ctenoid scales. The posterior margin is ridged or toothed or comb-like. The body and head are covered in ctenoid scales (Plate VI). No discrete annuli were observed on this scale.

4.9.3 Otolith

The otolith of *Pomadasys jubelini* is white and cup shaped. The interior part of the otolith is filled with smooth projections while the outer surface is a curved and has three overlapping layers (Plates VII, VIII). There were no visible annuli on the otoliths.

4.9.4 The Operculum

The operculum is thick (cartilaginous) and translucent. The operculum has no annuli (Plate IX).

4.10 Age Composition

4.10.1 Length–at–age

The relative ages and modal lengths (length-at-age) of *Pomadasys jubelini* were obtained through Pauly's integrated plots. The ages attained in the immature sample ranged from 0+ to 1+. In the males population ages attained ranged from 0+ to 4+ years while in the female population ages attained ranged from 1+ to 4+ years. It was observed that the growth in length and weight was higher in females. No fish were obtained for 5+ years during the period of this study (Table 4.9).



Plate VI: Ctenoid scale of *P. jubelini*

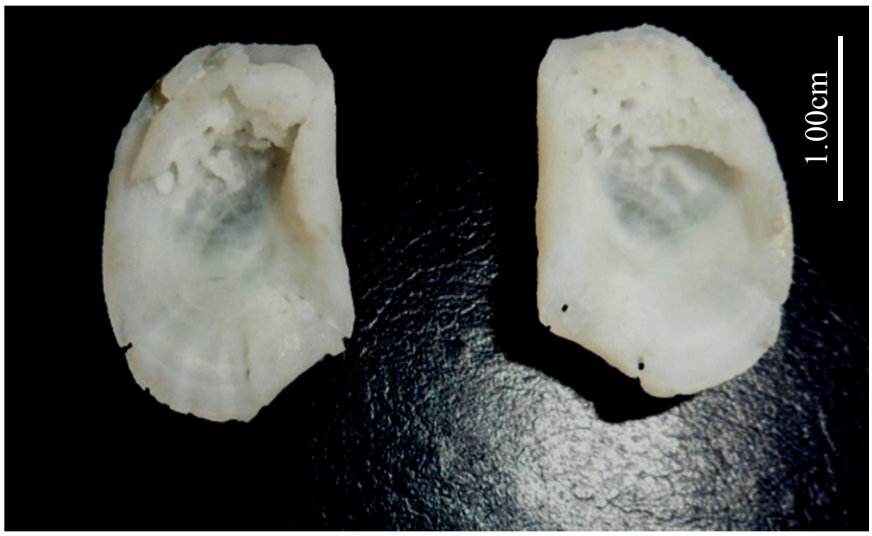


Plate VII: Interior surface of otolith of *P. jubelini*

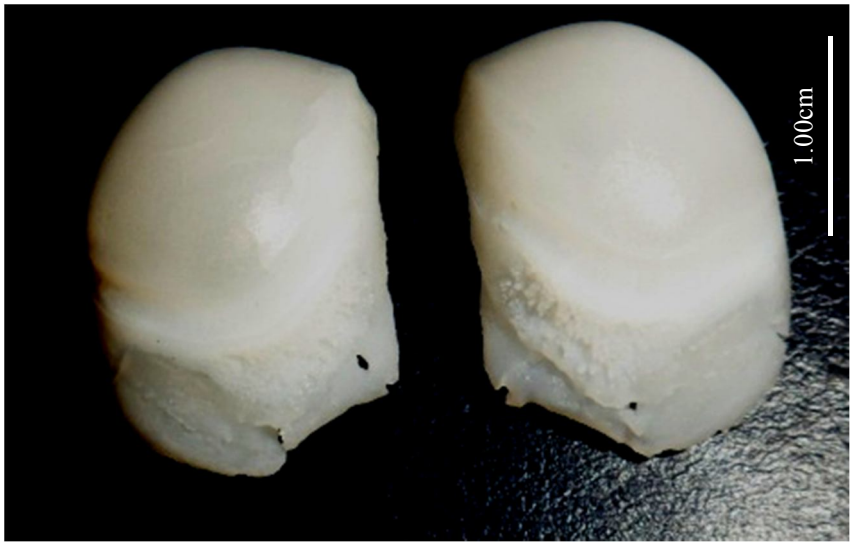


Plate VIII: Exterior surface of otolith of *P. jubelini*

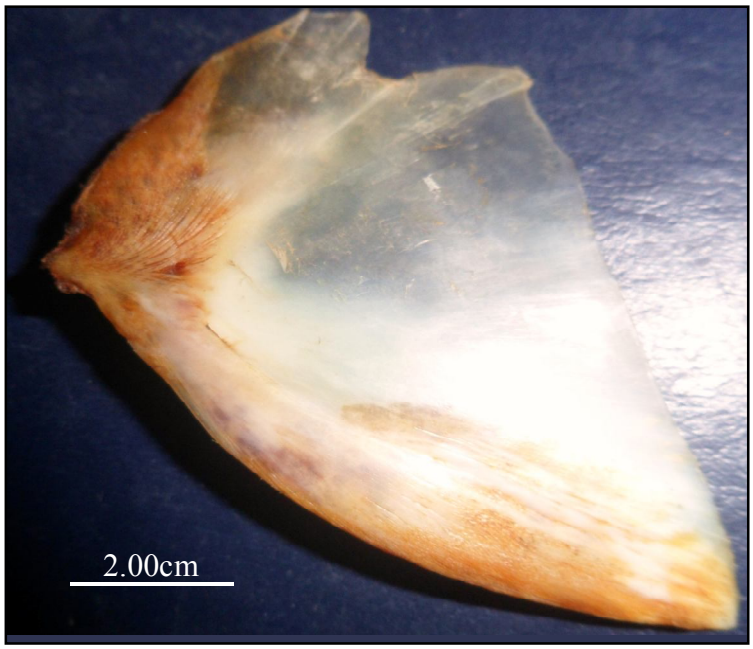


Plate IX: The operculum

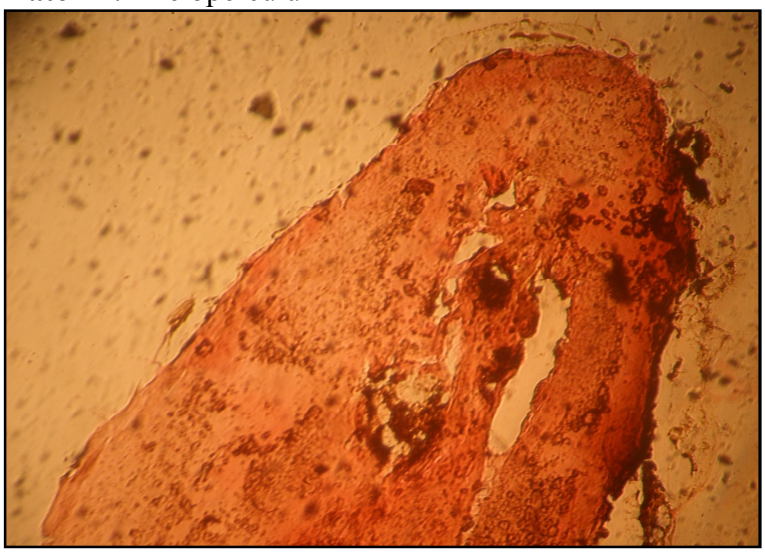


Plate X: Transverse Section of Operculum
(Haematoxylin and Eosin ×40)

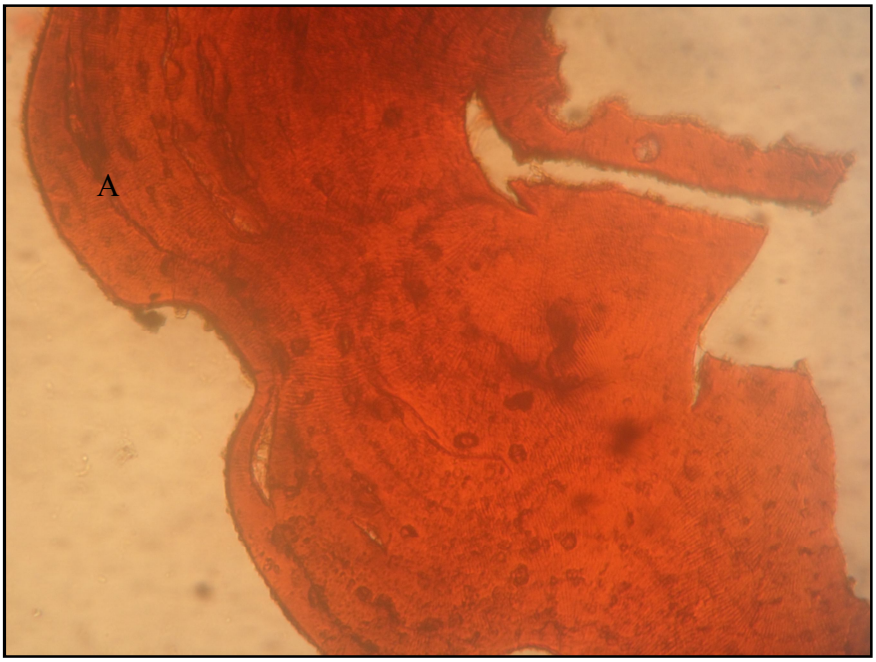


Plate X: T.S. Dorsal spine. A- Annuli. (Haemotoxylin and Eosin×40)

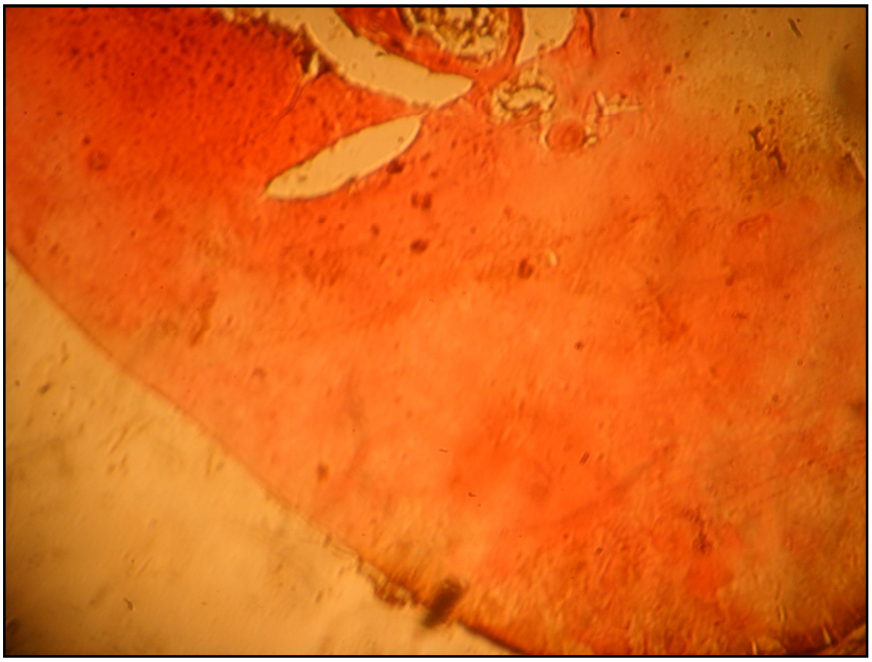


Plate XI: T. S of Anal spine. (Haemotoxylin and Eosin ×40)

Table 4.9: Mean age composition of *Pomadasys jubelini* in the New Calabar-Bonny River (2011-2013)

Age (years)	Modal length (cm)	No. of fish	Age composition (%)
Immature			
0+	4.00	62	49.20
1+	14.50	60	47.62
2+	18.00	4	3.17
3+	20.00	0	0.00
4+	0.00	0	0.00
Male			
0+	6.50	2	2.15
1+	26.50	53	56.90
2+	34.40	22	26.67
3+	38.50	12	23.66
4+	44.59	4	4.30
Female			
0+	10.00	0	0
1+	31.50	118	61.45
2+	40.50	32	16.66
3+	47.50	22	11.45
4+	55.00	20	0.21

4.11 Mouth

Pomadasys jubelini has a terminal mouth which is wide and protractile, with scales around it. The snout is pointed and elongated (Plate XIII). The mouth opens as wide as 20% of its total length (Plate XIV). It also has a tongue which arises as a fold from the floor of the buccal cavity. There are no teeth on the tongue (Plate XIV).

4.12: Teeth

The mouth of *P. jubelini* shows multiserial bands of setiform teeth on the lower and upper jaws. The teeth of the upper jaw are premaxillary (teeth present in the front margin of the upper jaw) (Plate XVa) while the lower jaw has teeth arranged in a mandibular position (teeth present on the margin of the lower jaw) (Plate XVb).

Teeth are present on the pharyngeal bones at the back of the mouth (in the throat) on the ventral and dorsal surfaces. The ventral surface is made up of a pair of pharyngeal teeth. These teeth are in the form of smooth pebbles (Plates XVI, XVII and XVIII).

4.13 Gill of *P. jubelini*

The gills are made up of four arches on each of the left and right sides (a total of 8). The gill arch is thick and cartilaginous and has thick, long, sparsely arranged spiky gill rakers (18 on the arch (Plate XIX).



Plate XIII: The mouth of *Pomadasys jubelini* (Lateral view)



Plate XIV: The mouth gape of *Pomadasys jubelini*



Plate XVa: The upper jaw of *P. jubelini* exhibiting premaxillary teeth (arrows).

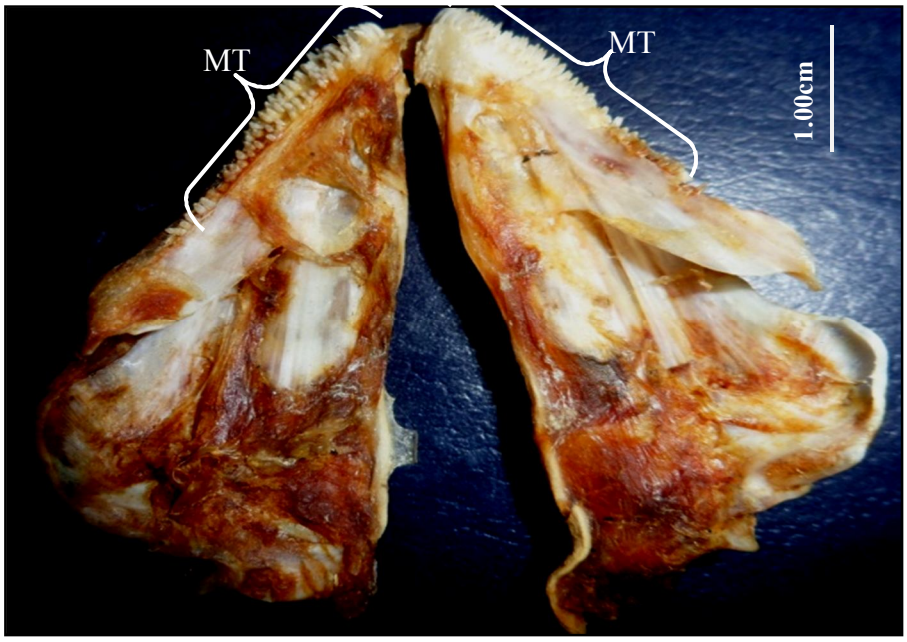


Plate XVb: The lower jaw of *P. jubelini* exhibiting mandibular teeth
MT, Mandibular teeth

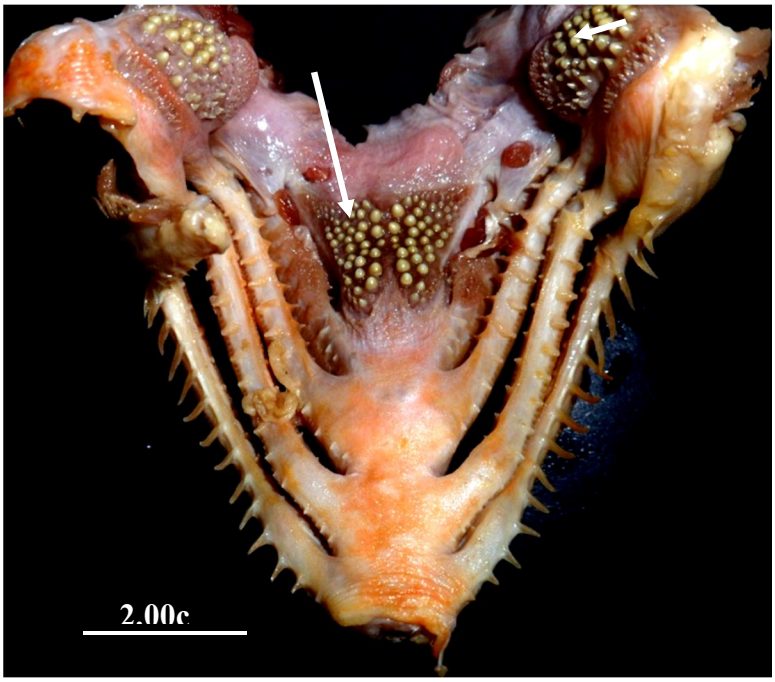


Plate XVII: The pharyngeal teeth (arrow) of *P. jubelini* as situated in the pharynx.



Plate XVII: The lower pharyngeal band of teeth is triangular in shape

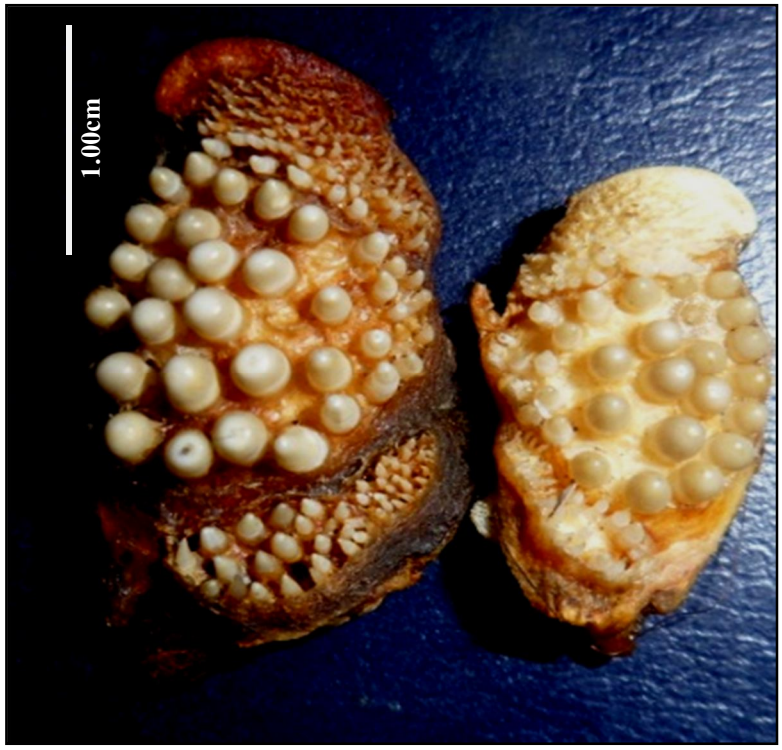


Plate XVIII: The upper pharyngeal teeth of *P. jubelini*



Plate XIX: One gill arch of *Pomadasys jubelini*

4.14 The Gastro-Intestinal Tract (GIT) of *Pomadasys jubelini*

The GIT of *P. jubelini* is made up of a large, long and distensible oesophagus which leads directly into the stomach. The stomach is large, thick–walled, flask-like and elongated with the anterior part larger than the posterior. The duodenum is slim and leads to the pyloric caeca.

The pyloric caeca is the anterior part of the intestine which gives rise to a number of finger-like, tubular outgrowths (6-7). The intestine is not distinguished into small and large, it is short, about 50% of the total length of the fish and it is not coiled. The rectum is much slimmer then the intestine and ends in the cloaca of the fish (Plate XX).

4.15 Histology of the Gastro-intestinal tract of *Pomadasys jubelini*

The alimentary canal from oesophagus to the rectum consist of the following layers

a. Serosa: the outermost layer of which connective tissue are superimposed
b. Outer longitudinal muscle layer, a thin sheet of muscular bundle having longitudinal fibre.
c. Inner circular muscle layer: a thick layer of striated and smooth muscle fiber
d. Submucosa: This layer is made up of connective tissue embedded with blood vessels, ducts and fibers
e. Muscularis mucosa: A thin layer of fibre separating the submucosa from the mucosa
f. Mucosa: A membrane of variable thickness usually from folds of different lengths depending on the region to which it belongs

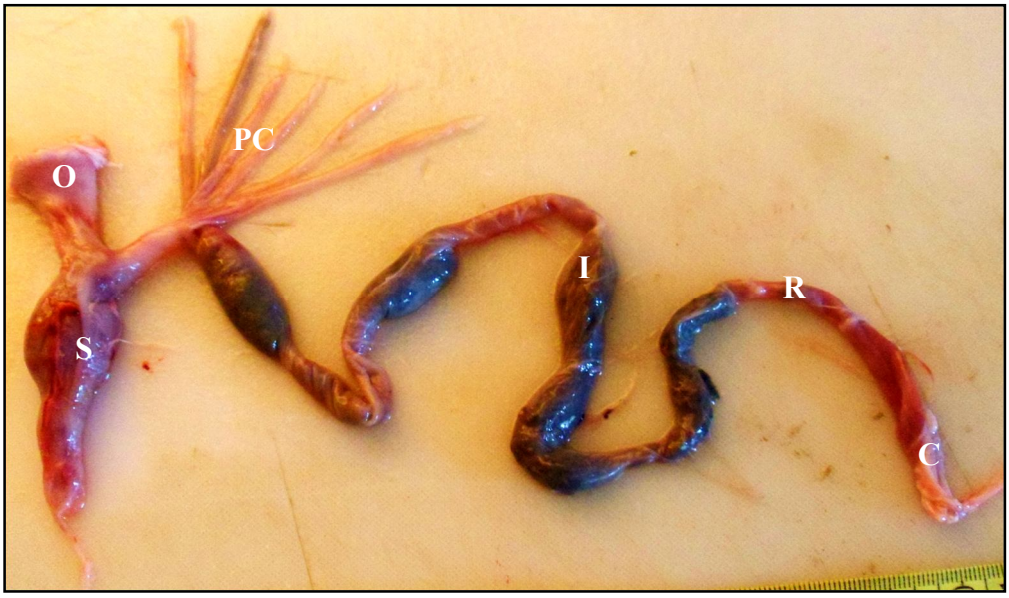


Plate XX: The gastrointestinal tract of *Pomadasys jubelini*. O, Oesophagus; S, Stomach; D, Duodenum; PC, Pyloric Caeca; I, Intestine; R, Rectum; C, Cloaca

4.15.1 The oesophagus

The outer longitudinal layer is represented by irregular bundles of fibre which permits distention while the inner circular muscle layer is of enormous thickness. These layers of tunica muscularis (longitudinal and circular muscle layers) account for the thickness of the oesophageal wall. The submucosa consists of compact connective tissue, blood vessels, fibres and gland ducts; this merges with the muscularis mucosa to extend as part of the large mucosal fold (Plate XXI). Lots of oesophageal pits containing blood vessels are present.

4.15.2 Stomach

This is made up of four layers, the outer longitudinal muscle, inner circular muscle, the submucosa and mucosa. The circular muscle appears to be connected by lose connective tissues; it is wider and thicker than the longitudinal muscle layer. The submucosa is made up of loose connective tissue within which blood vessels and ducts occur. The mucosa is different from other parts of the GIT. It is thick due to presence of gastric glands which are round - shaped. The mucosa is thrown into large longitudinal folds with many pits. The epithelium of the mucosa is made up of undifferentiated glandular and columnar cells. Goblet cells with uniform secretory cells and gastric ducts are also present (Plate XXII).

4.15.3 Pyloric caeca

The caeca have a thin layer of longitudinal muscle, a thick circular muscle layer, muscularis mucosa, the submucosa and mucosa which is filled with connective tissue. The epithelial lining is made up of columnar absorptive cells with goblet cells for mucus secretion.

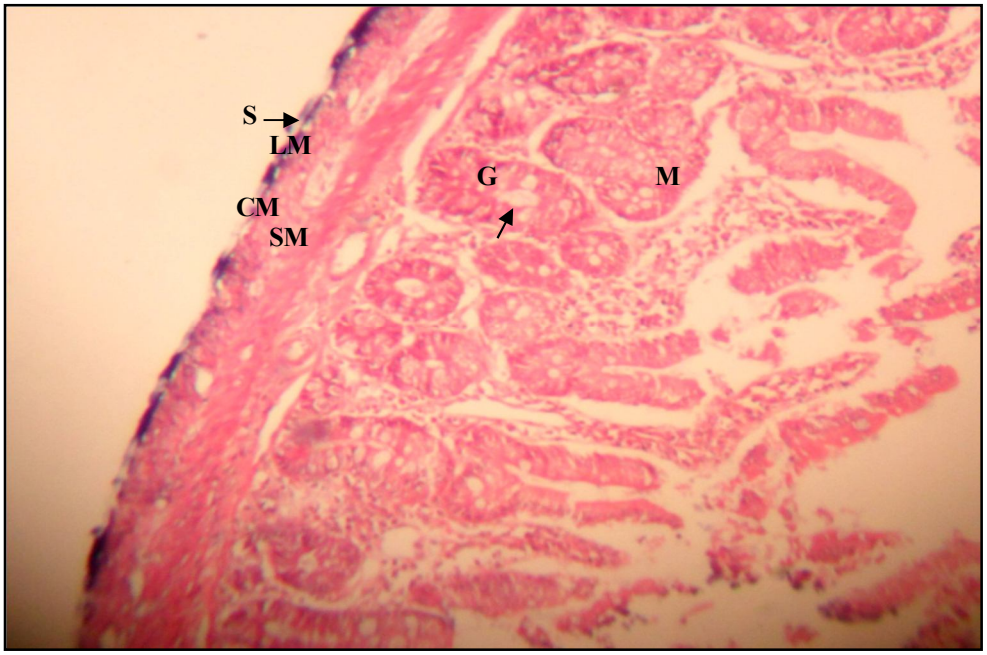


Plate XXI: Transverse Section of the Oesophagus of *Pomadasys jubelini* S, Serosa; LM, Longitudinal muscle layer; CM, Circular muscle layer, SM, Submucosa; M, Mucosa; G, Goblet cell (Haemotoxylin and Eosin, ×40)

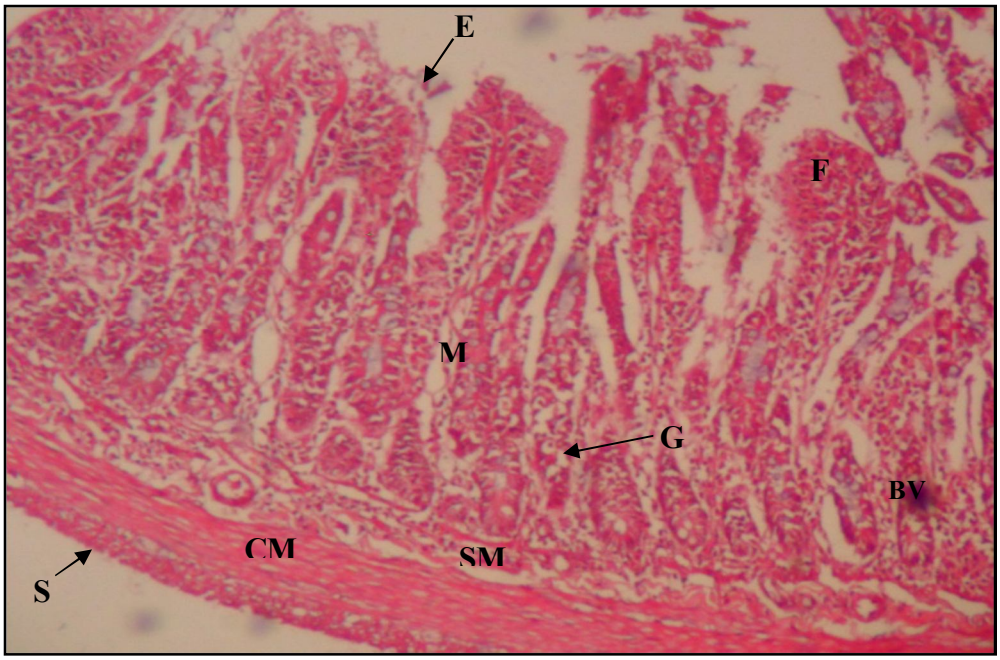


Plate XXII: Transverse Section of the Stomach of *Pomadasys jubelini* S - Serosa, CM – Circular muscle, SM – Submucosa, G – Goblet cells, M - Mucosa, BV - Blood cell; F, Fold ET, Epithelial tissues; (Haemotoxylin and Eosin, ×40)

The mucosa is elaborated into numerous filiform folds with a basal columnar membrane which is closely packed and clearly visible (Plate XXIII).

4.15.4 Intestine

The intestine is lined by a simple columnar epithelium consisting of absorptive cells and mucus-secreting cells; the serosa is thin, the inner circular muscle layer is wider than a less well developed longitudinal layer which is loosely packed by connective tissue (Plate XXIV). The muscularis mucosa is not conspicuous. The mucosa is thrown into numerous elongated folds unlike those of the oesophagus and stomach which are made up of short, thick and few folds.

4.15.5 Rectum

The muscle layer of the rectum is much thicker than that of the oesophagus, stomach, pyloric caeca and intestine. The mucosa is considerably folded, they appear shorter and wider. Goblet cells are also present in this region though fewer than in the intestine (Plate XXV).

4.16: Food and Feeding

The stomachs of 411 *Pomadasys jubelini* were examined for food items; 183 (44%) contained food items while 230 (56%) had empty stomachs. *Callinectes amnicola* (73.1%) and *Macrobrachium macrobrachion* (24.08%) were the important primary food components whereas *Scomberomorus tritor* (1.51%), *Sardinella maderensis* (0.69%) and *Ethmalosa*

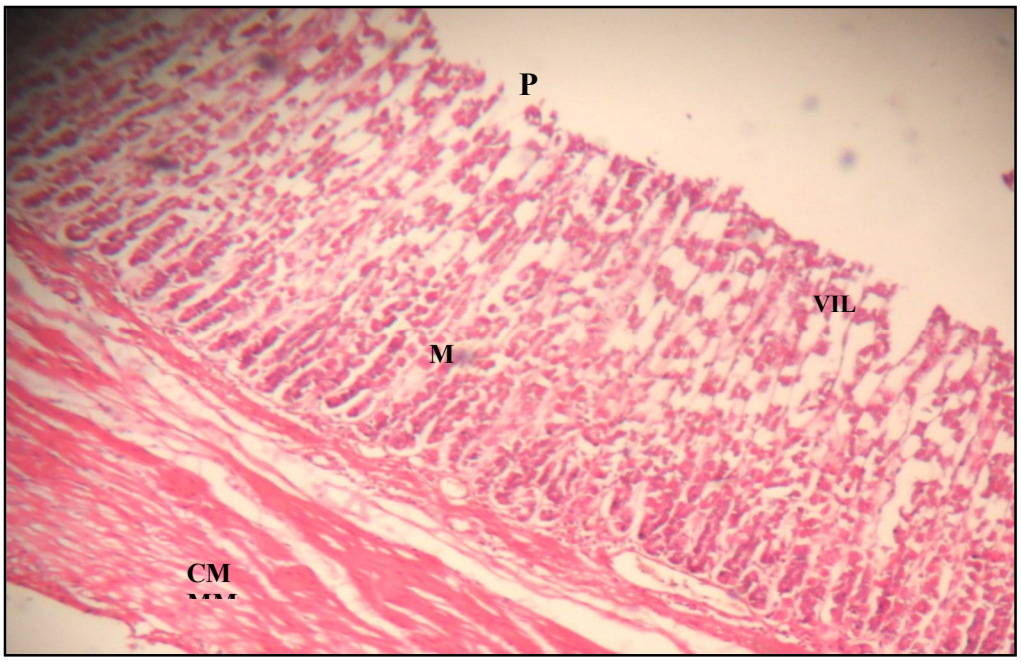


Plate XXIII: Transverse Section of a Pyloric caecum of *Pomadasys jubelini* CM – circular muscle, M – mucosa, VIL – Villi, P – Pits, (Haemotoxylin and Eosin, ×40)

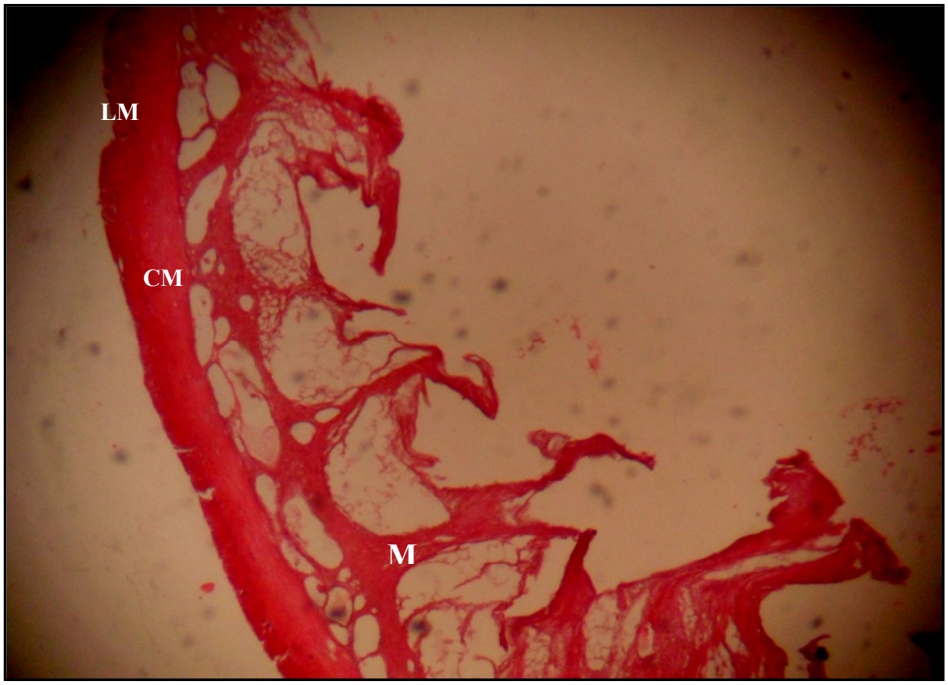


Plate XXIV: Transverse Section of the Intestine of *Pomadasys jubelini*
LM – Longitudinal muscle, CM – Circular muscle,
M – Mucosa, (Haemotoxylin and Eosin, ×40)

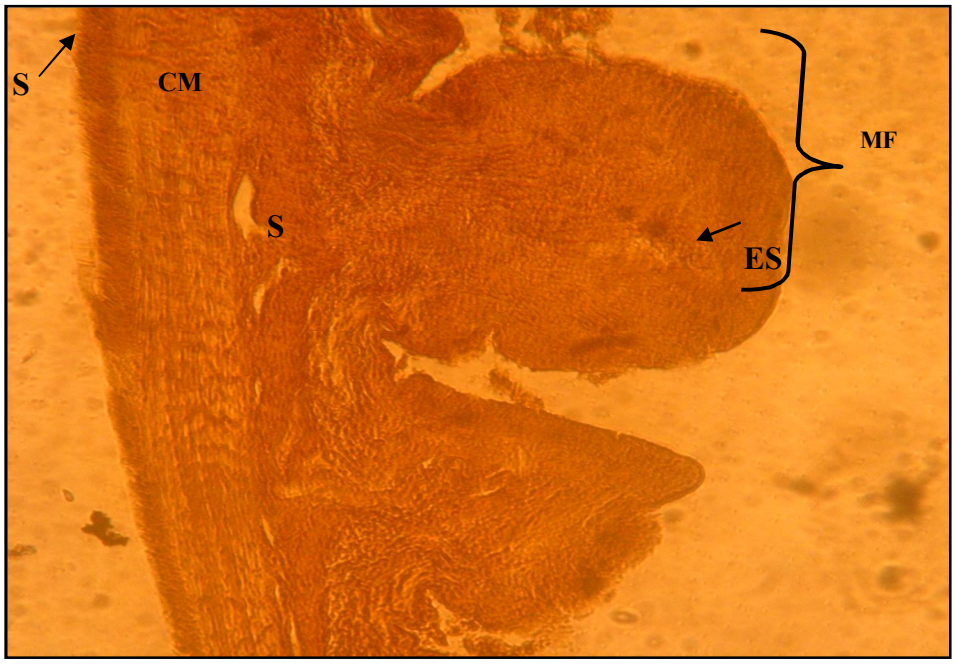


Plate XXV: Transverse Section of the Rectum of *Pomadasys jubelini*
S – Serosa, CM - Circular muscle, SM – Submucosa,
MF – Mucosal Fold; ES - Epithelial sheath
(Haemotoxylin and Eosin, ×40)

fimbriata (0.56%) were secondary items. *Littorina anguilifera* was an incidental food item (0.02%) (Tables 4.10 and 4.11).

Macrobrachium macrobrachion, *Callinectes amnicola,* Sa*rdinella maderensis* and *Scomberomorus tritor* occurred regularly in the stomachs of the fish throughout the period of the study irrespective of sex and size of fish; *Ethmalosa fimbriata* and *Littorina anguilifera* occurred sparingly. The total amounts of food items were higher in the wet season (April to October) than in the dry season (November to March) (Figure 4.8). There was no significant difference ($P > 0.05$) in the quantities of food observed between the wet and dry seasons.

The relationships between the body weight and total length of *P. jubelini* as against prey weight are shown on Figures 4.9 and 4.10. As the length and weight of fish increased, the weight of prey also increased. The positive relationships obtained are described by the linear equation $Y_L = a + {}_b X_L$

4.17: Reproduction

4.17.1: Size at maturity and fecundity

In this study, three out of six and two out of six documented stages of gonad development were observed in female and male *P. jubelini* respectively (Table 4.12). Mature males with milt while mature females with ripe ovaries (stage IV) were found in September and October. The smallest gravid female was 1736g (total length 50.60cm) while the largest gravid female weighed 2125g (total length of 50.20cm). The estimated fecundity ranged from 9,085 eggs to 37,926 eggs (Table 4.13). The Gonado-Somatic Index (GSI) ranged from 1.33% to 4.41% (Table 4.13). There was a poor correlation ($r = 0.14$) between Length and Fecundity, but a

Table 4.10: Percentage composition of food items consumed by *Pomadasys jubelini* (June 2011- May 2012)

Food items	NO	%NO	FO	%FO	PT	PT%
Ethmalosa fimbriata	22	20.4	19	22.9	1450	25.6
Sardinella maderensis	6	5.6	4	4.8	300	5.3
Scomberomorus tritor	8	7.4	7	8.4	350	6.2
M. macrobrachion	23	21.3	12	14.5	675	11.9
Callinectes amnicola	47	43.5	39	47	2800	49.3
Littorina anguilifera	2	1.8	2	2.4	100	1.8
Total	108	100	83	100	5675	100

Key:
NO = Numerical method
FO = Frequency of occurrence method
PT = Points method

Table 4.11: Percentage composition of food items consumed by *Pomadasys jubelini* (June 2012- May 2013)

Food items	**NO**	**%NO**	**FO**	**%FO**	**G**	**%G**	**IRI**	**%IRI**
Ethmalosa fimbriata	5	3.81	5	4.50	9	5.41	41.60	0.56
Sardinella maderensis	7	5.34	7	6.30	4.7	2.82	51.50	0.69
Scomberomorus tritor	8	6.10	8	7.20	15.6	9.39	111.7	1.51
M. macrobrachion	36	27.48	34	30.63	51	30.70	1782.1	24.08
Callinectes amnicola	74	56.48	56	50.45	84.32	50.75	5410.7	73.1
Littorina anguilifera	1	0.76	1	0.90	1.5	0.90	1.5	0.02
Total	131	100	111	100	16.12	100	7399.1	100

Key:
NO = Numerical method
FO = Frequency of occurrence method
PT = Points method
G = Gravimetric method
IRI = Index of relative importance

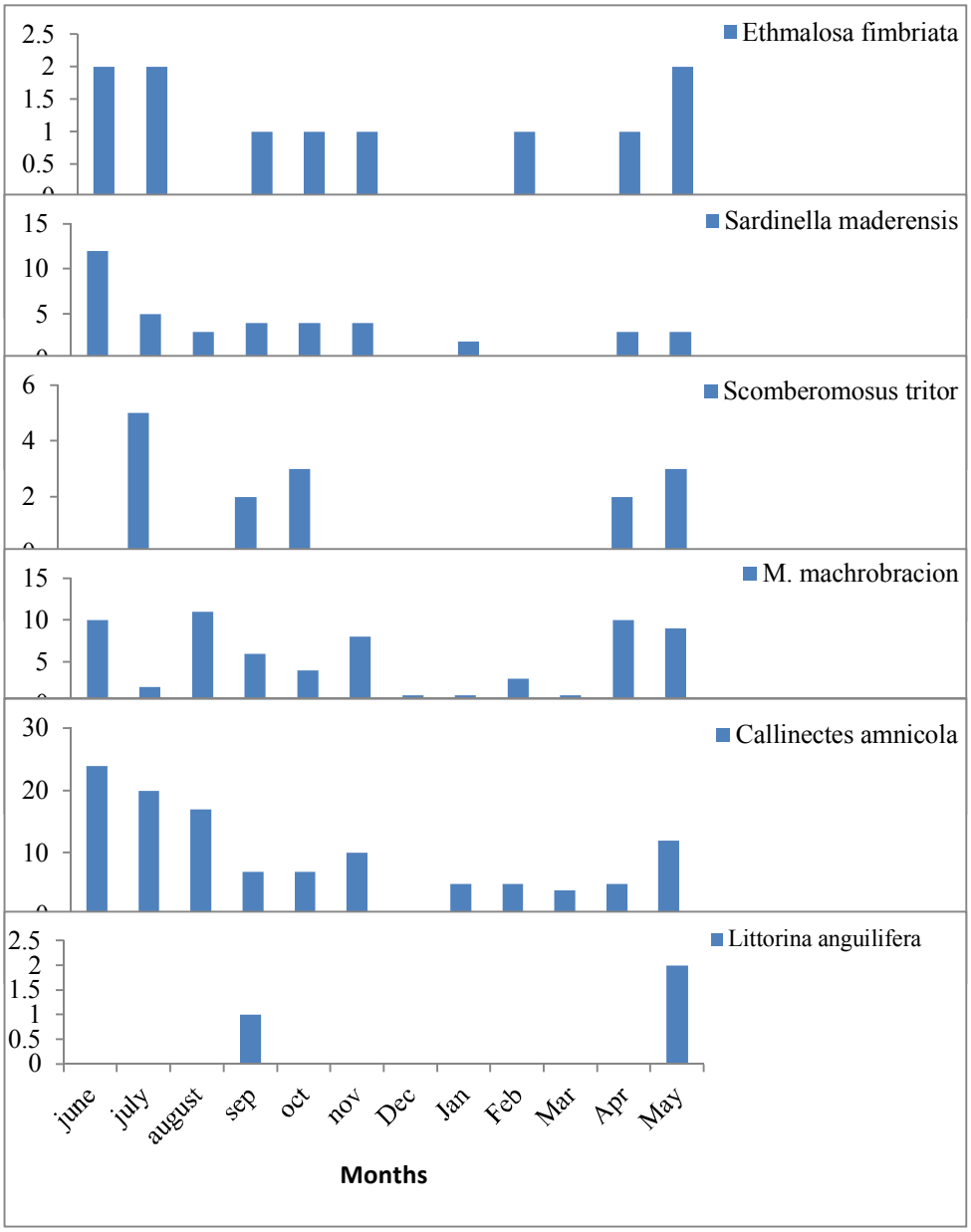


Figure 4.8: Monthly variation in composition of diets of *P. jubelini*

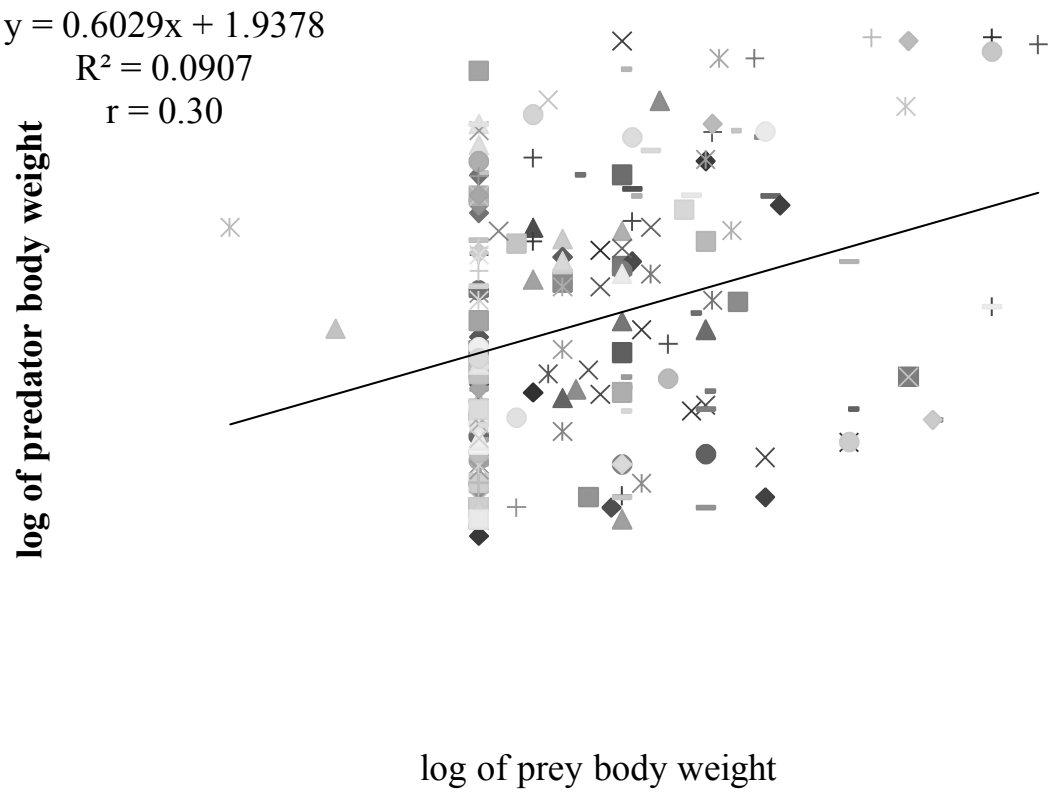


Figure 4.9: Relationship between body weight of *P. jubelini* and weight of prey (2011-2013)

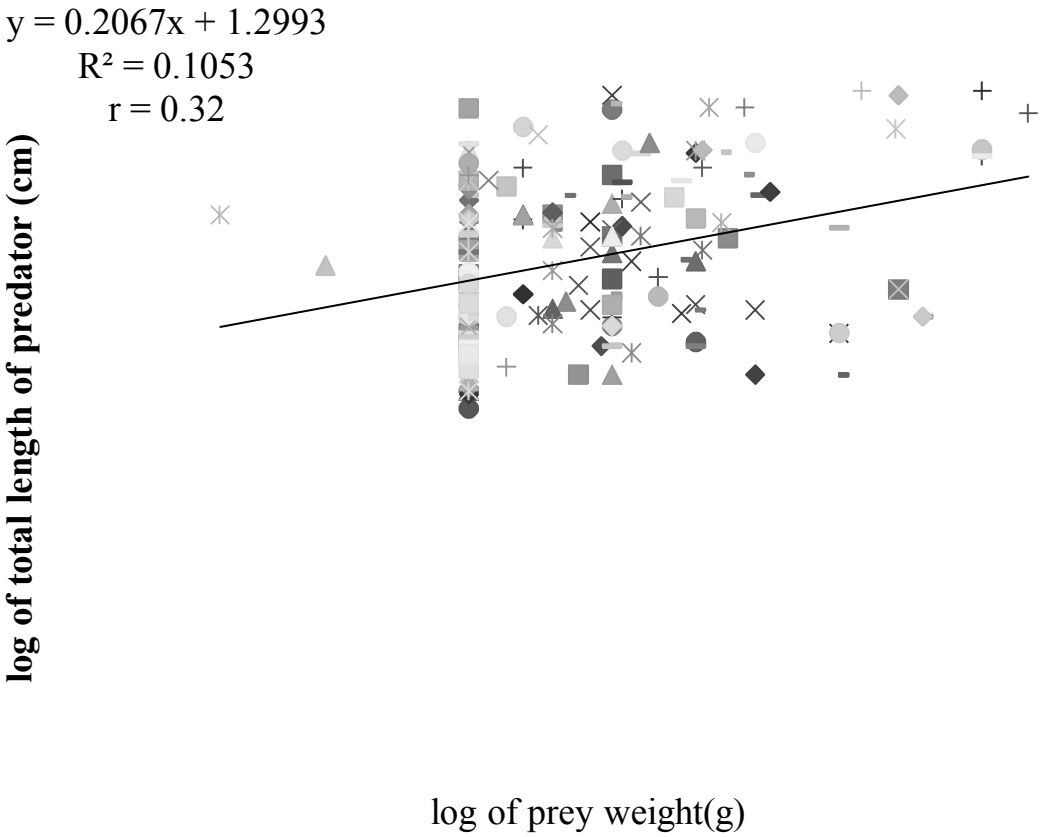


Figure 4.10: Relationship between length of *P. jubelini* and weight of prey (2011-2013)

Table 4.12 Stages of gonad development of *Pomadasys jubelini*

Stages of gonad development	Macroscopic characters	
	Testis	Ovaries
I Immature	Not seen	Not seen
II Resting/Quiescent	Not seen	Ovaries were tiny, translucent and creamy, Oocytes were not visible
III Maturing	Testis were large, opaque and cream colouration	Ovaries were large, opaque and light yellow in colour. Blood vessels were visible on the surface of the ovaries
IV Mature	Testis was enlarged and whitish in colour. Milt was released on application of pressure	Ovaries were larger than in the stage iii above, yellowish and the eggs were clearly visible
V Spawning	Not seen	Not seen
VI Spent	Not seen	Not seen

NB. Refer to Table 3.2 for the known and documented characteristics of the stages of gonad development.

Table 4.13: Gonadosomatic Index (GSI) of *Pomadasys jubelini*

	Total length (cm)	Weight (g)	GSI (%)	Fecundity
	40.30	1860.00	3.25	19,720
	43.10	2001.00	4.38	34,164
	50.60	1736.10	1.33	9,085
	50.20	2125.10	4.25	37,926
	49.80	1927.00	4.41	28,363
Mean	46.80	1929.84	2.89	25,852

high positive correlation (r = 0.94) was established between Weight and Fecundity (Figures 4.11 and 4.12).

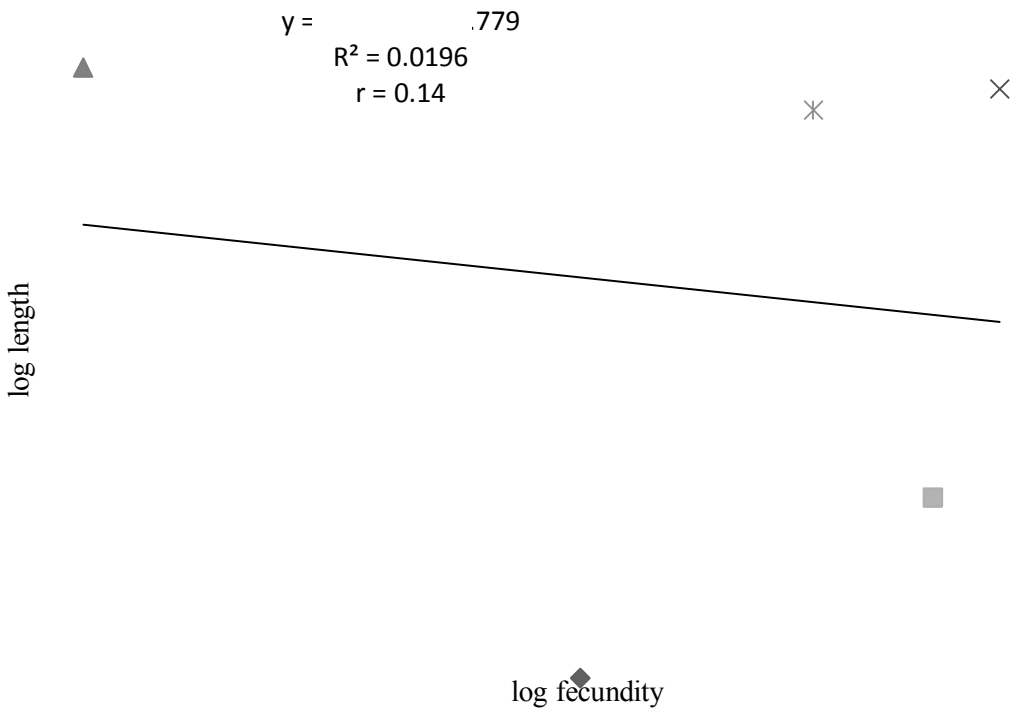


Figure 4.11: Relationship between total length (cm) and fecundity of *Pomadasys jubelini*

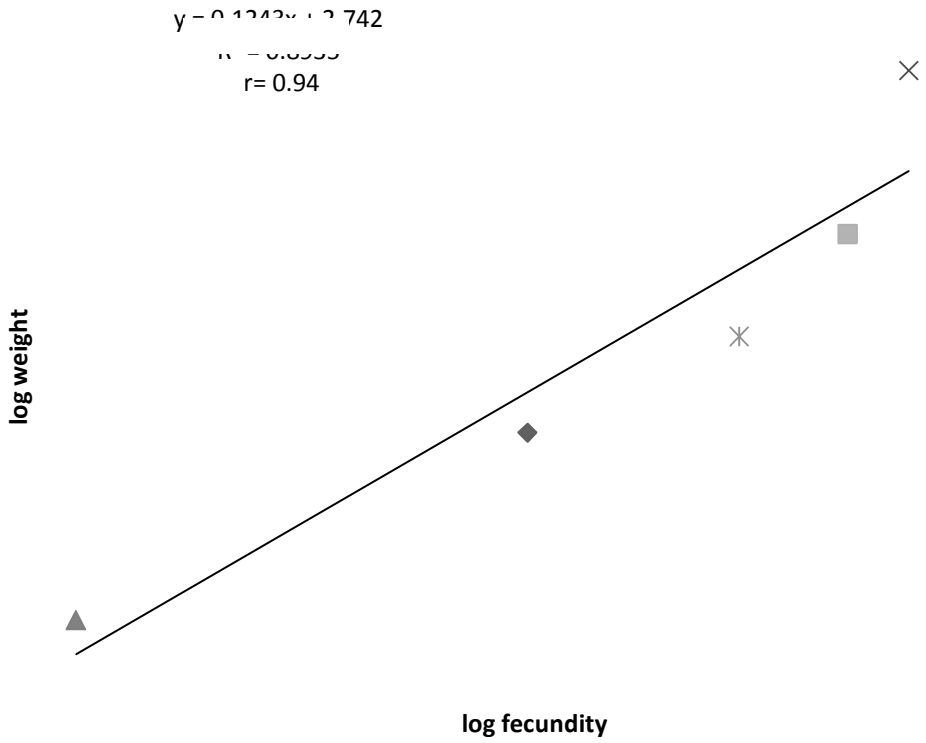


Figure 4.12: Relationship between total weight (g) and fecundity of *Pomadasys jubelini*

CHAPTER FIVE

5.0 DISCUSSION

The water in the New Calabar-Bonny River exhibited a wide range of hydrogen ion concentration (pH), from acidic to alkaline (5.20–7.80) throughout the period of study. The acidic environment occurred in the inland part of the river while the estuarine area was alkaline. Similar findings were reported by Adeniyi (1986), Chindah (2003) and Chindah and Braide (2004). The mean pH values obtained in this study are within the limits that support aquatic life, particularly fish (Boyd, 1979). Kosa (2007) and Garricks (2008) have reported that the water of the rivers of the Niger Delta area tend to be slightly acidic throughout the year with minor differences in pH, ranging from 5.5 to 7.45. In this study, there was a significant difference in pH between the wet and dry season.

The water temperature recorded in the New Calabar-Bonny River (26.20°C–30.10°C) falls within the range for optimal survival and growth of fish as observed by Sikoki and Veen (2004), this water temperature range is also considered normal, but the location of the New Calabar-Bonny River in the Niger Delta was described as humid/semi hot equatorial climate (NEDECO, 1961). This finding is comparable to that of Erondu and Chindah (1999) for the upper section of the new Calabar River (25.5°C–27°C). The same trend was observed by Davies *et al*. (2008) at Woji creek, Deekae (2009) in Luubara Creek (25.05^{o}C–32.20^{o}C) in the Niger Delta. Garricks (2008) and Amakiri (2011) obtained a water temperature range of 25.50°C–29.50°C in the Sombreiro River, Rivers State, Nigeria. The slight variations in temperature could be attributed to changes in climatic conditions, rainfall, volume of water and anthropogenic activities like domestic and industrial use of the river.

The seasonal variation in temperature observed in this study suggests that temperature values were significantly higher in the dry season than the wet season. In the dry season there is little or no cloud, thereby allowing direct heat from sunlight to increase water temperature. The temperatures for the wet season (27.63°C) and dry season (29.09°C) were similar to the report of Jamabo (2008) in the Mangrove swamps of the Upper Bonny River for wet and dry seasons respectively. This was slightly different from the reports of Allison (2006) and Amakiri (2011) on wet season temperatures of 26.64°C and 26.0°C and dry season temperatures of 27.18°C and 31.0°C respectively. This lack of uniformity in seasonal variation of water temperature could be attributed firstly to climate change, the nature of the river at a particular time, water current and time of day. The temperature between the wet season and dry season varied significantly ($P \leq 0.05$); the positive relationship observed between temperature and conductivity shows its correlation (the higher the temperature, the higher the conductivity of the water) (www.epa.gov).

The salinity at Abonema Wharf (Station 1) (13.50 and 27.10ppt), indicates that this part of the river is predominantly salt water. The closeness of Station 1 to Bonny River might be responsible for its saltiness. Iwofe (Station 2) had salinity between 4.14 ppt and 22.0 ppt, this area is tidal and experiences a mixture of salt water and fresh water while Choba (Station 3) had salinity level of 0.00 ppt–2.50 ppt, which shows that the station is mainly a freshwater environment (upstream). The significant differences in salinity among the stations, (higher in the rainy season than the dry season) are likely related to the rainfall regime because although rain falls all year round, with only a few dry months. Sikoki and Zabbey (2006) observed that Woji Creek provided a gradual transition from saltwater to freshwater due to the influx of seawater downstream. Fluctuations in salinity observed in this study were not uncommon as

estuaries are known for their fluctuating environmental variables (Venberg and Venberg, 1981; EPA, 2013). Salinity showed positive and significant correlations with pH and temperature. The salinity level obtained for this river during the course of the study is within the range for optimal survival of fish.

The slight variation in Dissolved oxygen content observed among the stations (6.56 mg/l–9.97mg/l (7.76±1.57mg/l)) is within the range desired for fish production, as reported by Anyanwu. (1988). The oxygen level observed in this study compared favourably with that in New Calabar-Bonny River, Woji Creek and Luubara Creek in Nigeria observed by Erondu and Chindah (1991), Ekeh and Sikoki (2003), Hart and Zabbey (2006) and Deekae (2009). Higher DO values recorded during the rainy season than in the dry season were considered normal since there is an inverse relationship between temperature and dissolved oxygen in water (Deekae, 2009). At high temperatures, the solubility of oxygen decreases which explains the lower mean DO value recorded during the dry season. Allison (2006) and Amakiri (2011) also recorded high oxygen concentrations in the wet season than the dry season for the Nun River and the Lower Sombreiro River respectively.

Generally, the alkalinity in the New Calabar–Bonny River might be considered as low but adequate to neutralize acid (www.epa.org; www.aqua.org). The alkalinity of the river in the dry season was higher than the wet season. This could be attributed to the increased evaporation and concentration of ions in water during the dry season. Davies *et al.* (2008) reported higher concentrations of alkalinity during the dry season than the wet season in Woji creek, Nigeria. There was no significant difference ($P>0.05$) in the concentration of alkalinity amongst the stations and between seasons.

The wide range of total dissolved solids (TDS) observed during this study were similar to the findings of Idodo-Umeh (2002) in River Areba in Olomoro, Delta state (5.71-6.23ppm); Sridhar and Ademoroti (1984) (7.20mg/l) in River Ogun and 7.0–22.50ppm in Sombreiro River (Amakiri, 2011). It is however noted that water with TDS less than 50mg/l is regarded as freshwater and those higher than 500mg/l are undesirable for drinking and many industrial uses. Generally, the high values obtained and the variations observed among the stations in this study might be due to the kind of domestic and industrial activities taking place at the various stations. These activities are largely cement production and packaging, oil and gas pipeline maintenance and Indomie Noodles production. There was significant difference ($P \leq 0.05$) observed among the station and between seasons.

The conductivity of water in this study varied widely from as low as 1.8 µs/cm to 2900µs/cm (418±145.50 µs/cm). The freshwater section of the river (Station 3) had a range of 1.8–37 µs/cm which compared favorably with the range obtained by Deekae and Henrion (1993) for the freshwater section of the New Calabar-Bonny River (22-350µmhos). The wide range of conductivity value obtained in the study is an indication that the river could be freshwater, saltwater and or a mixture of both. Based on the classification of Egborge, (1994), waters with conductivity values less than 100 µs/cm are fresh water. Waters above 100 µs/cm to 500 µs/cm are brackish while those above 500 µs/cm are saltwater (http://www.standardmethods.org/). It is evident from the findings of this study that Station 1, Station 2 and Station 3 of the New Calabar-Bonny River are freshwater, brackish and saltwater respectively. It is possible that the rise in conductivity during the wet season is due to increased concentration of ions associated with the influx of materials from the surrounding area during rainfall. High conductivity values during the wet season in the major rivers of

Kainji Park, Areba Olomoro in Isoko and in Okumu River in Delta State have been documented by Egborge (1994), Idodo-Umeh (2002), Deekae and Henrion (1993) and Ajibade *et al*. (2008).

The low but fluctuating levels of turbidity during the study period (higher during the rainy season), can be attributed to torrential rains and increased flow of the river during the sampling period. Although turbidity was low, it had higher values than those obtained in the lower Sombreiro River and Luubara creek by Garricks (2008) and Deekae, (2009). According to Lucinda and Martin (1999), turbidity is caused by wind, current and erosion that sweeps sediments from land into water. This situation is more often experienced during the rainy season because of the continuous rainfall hence the runoff from surrounding catchment areas carrying a lot of suspended materials into the river, leading to high turbidity values. Turbidity depends on the amount of dissolved or suspended matter in the water which affects light penetration and hence photosynthetic activity for primary production (www.epa.org); (http://www.standardmethods.org/). Furthermore, the suspended particles in the water are always in motion due to water circulation whereas in the dry season the particles tend to settle as there is little turbulence.

In the dry season, low rainfall (4.80 and 99.1mm) is usually recorded while the wet season has high rainfall between 169.7 and 489.4mm. The results obtained during this study were basically within the range (160 and 300mm) just as reported by Ileoje (1972) and Powell *et al*. (1985) for wet season and below that for dry season. There was significant difference ($P \leq 0.05$) in the rainfall between the seasons.

The catching of higher numbers of *Pomadasys jubelini* in the wet season than in the dry season in all stations agrees with the findings of Erondu and Chindah (1991) for *Pellonula leonensis*

in the lower Anambra River and Soyinka *et al*. (2010) in the Badagry Lagoon South West Nigeria. This is however, contrary to the findings of Olatunde (1979) and Shinkafi and Daneji (2011) who obtained higher numbers of *Pellonula pellucida* in Lake Kainji and *Synodontis eupterus* in River Rima respectively, in the dry season. This difference in seasonal abundance of fish could be attributed to the ecological environment, geographical location, volume of recruitment pattern, fluctuation of water level, difference in physicochemical parameters of the water body and level of resource exploitation. In this study, more *P. jubelini* were obtained in Station 1 (more salty area) and less abundant in the Station 3 (freshwater) suggesting that this fish has a preference for salt water than fresh water. Similar observations were made on this fish species by Ugwamba and Ugwamba (2007); Adebiyi (2013); Froese and Pauly (2013).

The observation that catches of *P. jubelini* in the New Calabar-Bonny River was dominated by females was also made by Onimisi (2008), Deekae (2009), Amakiri (2011) on *A. occidentallis*, *M macrobrachion* and *C auratus* respectively although the first is a freshwater fish. The ratio in favour of the females portrays an advantage in the area of propagation and reproduction for higher and greater yield of this fish species. In *Sarotherodon eupterus* the sex ratio of 1: 0.96 was skewed towards the advantage of the male (Shinkafi and Daneji, 2007). Abayomi and Arawomo (2001) reported a higher sex ratio in favour of males of *Clarias gariepinus* in Opa reservoir. In the Lagos coast, the sex ratio of *Pomadasys jubelini* was 1:0.85 (male to female) (Adebiyi, 2013). This difference may be due to differential survival associated with environmental conditions. Furthermore in the tropics, the important factors that affect the distribution and abundance of fish are temperature, salinity, nourishment and substrates (Castro *et al*., 2005). Generally, in nature, a 1:1 male to female ratio is anticipated but temperature has been implicated in determining the sex ratio at the point of sexual

differentiation in flounders (*Verasper moserk*) and in the sole (*Limanda yokohamae*), in both cases, sex ratio was close to 1:1 or skewed (Goto *et al*., 1999; 2000). In this study on *P. jubelini*, it was not clear if natural mortality rate or genetics was responsible for the skewedness in favor of female fish; whatever the case, may be further study in this direction is desirable.

The dominant size class of immature *Pomadasys jubelini* (5.00–15.00 cm) implies that the fish does not reach maturity and begin reproductive functions until it reaches about 15.00cm in length. This explains why most of the fish showing gonad development weighed 80g and had length of 17cm and more. In Senegal, sexual differentiation and maturity was observed in *P. jubelini* with length of 13.00cm (Froese and Pauly, 2012). Granados-Flores *et al*. (2010) stated that sexual differentiation of *M. brevipinnis* is apparent at the age of two years and also observed that the fish reaches its sexual maturity at approximately 22cm. From the study conducted in the Lagos coast it was indicated that immature *P. jubelini* are smaller than 13.90cm and weighed less than 26.8g (Adebiyi, 2013). Morphology of the gonads of *Synodontis eupterus* from river Rima North Western Nigeria, revealed that 8% of the fish population were sexually undifferentiated (Shinkafi and Daneji, 2011).

The male and female populations of *P. jubelini* had their dominant class sizes at 15.00–55.00cm, though the largest male fish measured 41.80cm (TL) while the largest female was 55.30cm (TL). This shows that the New Calabar-Bonny River contains different sizes of *Pomadasys jubelini*, an indication of recruitment into the cohorts, and that the river is a good breeding ground for this species. As the class size increased there was a decline in the number of fish caught, an indication that the larger fish were caught or experienced natural mortality, and likely amphidromous, migrating in search of breeding ground or predation. Amakiri

(2011) observed that large *Chrysichthys furcatus* declined in the catch of fishermen and was merely associated with incidental decline.

The maximum standard length of *Pomadasys jubelini* obtained in this study (55.30cm) and weight (2320g) are much higher than the lengths of 20–30cm and 50cm in Lake Kainji. Length and weight of 32.10cm and 882.4g have also been reported in River Ase (Nigeria) and in Senegal, (Reed *et al*., 1977, Idodo-Umeh, 2007, Froese and Pauly, 2013). This variation in length and weights may be related to the growth stages, the level of exploitation of the fish species in the different water bodies, predation by other fish species, nature of the aquatic environment and abundance of food for the fish species. The maximum size attainable for a fish is generally location specific (King, 1997).

The length-weight relationship of *P. jubelini* in the New Calabar River showed positive correlations in both sexes for both years of the study, indicating an increase in weight with increase in length. The regression exponent ($b<3$) for both sexes and in both years shows a negative allometric growth pattern, that is, the fish becomes heavier for its length as it grows longer (Tesch, 1968), or more preferably, an increase in stoutness as the fish increases in length was observed in this study. Negative allometric growth has been reported in *Arnoglossus thori, Solea solea, Clarotes laticeps* and *Alectis alexandricus* (Bahar *et al*., 2008; Abowei and Davies, 2009; Deekae *et al*., 2010) In *Auchenoglanis occidentalis* in Zaria dam, the value $b>3$ (positive allometry), was obtained by Oniye and Onimisi (2010); while in *Chrysichthys auratus* in River Benin, the value $b=3$ (isometric growth) was obtained by Ikomi and Odum (1998). The length-weight relationship of fish is affected by a number of factors such as season, habitat, gonad maturity, sex, diet and annual differences in environmental conditions (Bagenal and Tesch, 1978, Alfred-Ockiya, 2000). Such differences in b values

could be attributed to or combination of several factors including the difference in the number of species, sizes of species, geographical location and season (Froese, 2006).

The mean condition factor (K) varied during the different months and was higher during the dry season which coincided with when the level of turbidity of the river was lowest; with the period when larger sizes and less number of fish were caught; in addition the fish obtained during this period had no eggs. Generally, larger size fishes are efficient food finders with higher foraging ability, particularly when they neither are nor involved in nest building, pre-spawning activities or incubating eggs. The smaller fishes are more in number but with low condition factor which is very common during the wet season (May – September), again a general trend in fish recruitment into a cohort or a developing fishery (Gulland, 1983). *Chrysichthys nigrodigitatus* in Epe Lagoon and *Alectis alexandricus* in Bonny River have low condition factor (Fafioye and Oluajo, 2005; Deekae, 2010)

The length–girth relationship of *Pomadasys jubelini* exhibited positive allometric growth (J>1.0) except in the males. King (1991), Abowei and Davies (2009) and Abowei and Hart (2009) also observed allometric growth in *Illisha africana and Clarotes laticeps.* Values of the length exponent in the length-girth relationship of this species being allometric imply that the girth of the fish species increased faster than the cube of its total body length.

Pomadasys jubelini demonstrated a population with 4 to 5 cohorts. The fish age fell within one to four years. Most of the fish sampled were above one year and predominantly two years. This is similar to the findings of Froese and Pauly (2013), which reported that the maximum age attainable by *P. jubelini* is four to five years. It has however been shown that the maximum size attainable in fishes is generally location specific (King, 1991). Abowei and Hart (2007) attributed the differences in maximum size and age of *Chrysichthys nigrodigitatus*

in the Lower Nun River to high fishing pressure, environmental pollution and degradation. In this study the maximum sizes and ages attained by *P. jubelini* could be attributed to domestic and industrial activities taking place within and around the New Calabar-Bonny River, which included high fishing pressure, environmental pollution and degradation. The New Calabar-Bonny River is often subjected to outboard engine operation and possible pollutants from cement factories and Shell production and distribution unit which is also located along the river.

The lack of discrete annuli on the ageing structures (otolith, operculum, scales and T.S. of anal and dorsal spines) in *P. jubelini* may be due to availability of food and characteristic high temperature throughout the year in the tropics. In the temperate and sub-temperate parts of the world, where there is distinct summer and autumn, plenty of food is available, fish feeds and grows rapidly and rings (annuli) formed are widely spaced. But in winter, food is limited, growth is slow, rings formed are close to each other and compact, hence the scales, operculum, otolith and T.S of anal and dorsal spines show alternate dark and light bands (Mohr, 2004; Khana and Singh, 2006).

The occurrence of mature and gravid females with high gonado-somatic indices for both male and female within September and October suggests that spawning periods coincides with the warmer time of the year and towards the end of the rainy season. This is similar to the high gonado-somatic indices of *P. jubelini* recorded for both male and female in July, August and September suggesting that spawning period coincides with the rainy season (Fehri-Bedoui and Gharbi, 2008; Al-Nahdi *et al*., 2010; Adebiyi, 2013). According to Al-Ogaily and Hussain (1990) high gonadosomatic indices were recorded for the trout sweet lip grunt *Plectorhynchus pictus* in March, April and May. Spawning occurred throughout the year in bastard grunt

Pomadasys incisus (Pajuelo *et al*., 2003).This is unlike the spawning period of *P. jubelini* observed in this study in September and October.

The stages of gonad development observed in this study were maturing and mature for males, and quiescent, maturing and mature stages for females. Other stages of gonad development were not encountered. Similar gonad developmental stages were also observed in *P. jubelini* by Adebiyi (2013). In *Pomadasys commersonni* all the stages of gonad developments were observed in both male and female fish except the ripe running stage (Al-Nahdi *et al*., 2010). Fehri-Bedoui and Gharbi (2008) observed immature, resting, maturing, mature, spawning and spent stages of gonad development in bastard grunt, *Pomadasys incisus* while in the silver grunt *Pomadasys argenteus,* eight gonad developmental stages were reported. These were the immature, resting, developing mature, gravid, spawning and spent and recovering spent stages (Abu-Hakima, 1984). Fewer gonad developmental stages recorded in this study could be as a result of the nature of the New Calabar–Bonny River which is not completely a salt water river as reported elsewhere by other authors.

Pomadasys jubelini has a low fecundity, unlike other high fecund fish with millions of eggs. The fecundity of *P. jubelini* increased with increasing size of the fish (length and weight). The minimum and maximum fecundity estimates obtained in this study are similar to the findings of (Adebiyi 2013) in the Lagos coast Nigeria. The fecundity of *P. jubelini* in this study was lower than the fecundity of *Pomadasys commersonni* with a range of 214,510 to 1,421,520 eggs (Al-Nahdi *et al*., 2010), eggs of 3-6 years old trout sweet lip, *Plectorhynchus pictus* with a range of 495,450–855,067 (Al-Ogaily and Hussain, 1990) and the silver grunt *Pomadasys argenteus* with eggs ranging from 625,848 – 2, 424,864 (Abu-Hakima, 1984). Abayomi and Arawomo (2001) reported the fecundity of *C. gariepinus* in Opa reservoir in the range of 1,567

to 65,000 eggs. Oniye and Onimisi (2011) reported that *H. b. occidentalis* in Zaria dam had fecundity estimates of 2,025 to 4,192, while *Tilapia mariae* in the New Calabar River has fecundity of 339 to 1881 (King, 1991) which was lower than that observed in this study. The weak correlation (r=0.008) between the total length and the fecundity of *P. jubelini* indicated that increase in fish length does not necessarily correspond to increase in fecundity. Ikomi and Odum (1998) and Allison (2006) made similar observations in the studies of *Chrysichthys auratus* (r=0.12) and *P. pellucida* (r=0.17) respectively. However there is a significant correlation (r=0.97) between fish weight and fecundity. This suggests that as fish weight increases, fecundity also increases. Similar observations were made by Tsadu *et al*. (2001) on *Bagrus bajad.* King (1997) also reported that as weight of fish increased, the number of eggs produced per gram also increased and remarked that growth continued after fecundity had stabilized. These reports indicate that fecundity varies with either increasing length or weight of fish and also varies among species and size. The mean GSI value obtained in this study revealed that this species uses up to 2.89% of its total body weight for egg production. *Physalia pellucida* was 1.7% while *Hyperopisus bebe* use 2.25% (Allison, 2006; Oniye and Onimisi, 2010).

The terminal mouth possessed by *P. jubelini* which opened up to 20% of its total body length allows the fish to seize its prey easily. The presence of the multiserial bands of setiform teeth enables the fish to grip its prey firmly in the mouth for suffocation, before swallowing. The pharyngeal teeth on the roof and floor of the mouth are modified into pebble-like stones that are adapted for crushing bone, shells and crustaceans before swallowing. The thick, long, cartilaginous, sparsely arranged and spiky gill rakers confirm that *P. jubelini* is carnivorous (Pandey and Shukla, 2005).

The length of the gut was observed to be related to the feeding habit of *P. jubelini*. The long and distensible oesophagus is characteristic of carnivorous and predatory fish species. The flask-shaped stomach is swollen at the anterior part and reduced at the posterior part (Ugwumba and Ugwumba, 2007). This swollen anterior part (intestinal bulb) is meant for storage. Ugwumba and Ugwumba (2007) also stated that the digestive tract is modified to suite its feeding habit. Other fish species possessing a flask shaped stomach are the *Tor tor, Catla catla* and the *Labeo rohita* (Pandey and Shukla, 2005). Generally, the thick-wall of the flask-shaped stomach aids in masticating food. 6-7 pyloric caeca were observed in all the specimens studied. The number and shape of caeca might be peculiar to this species and it is used as one of the structures for its identification. Srivastava (1988) stated that intestinal caeca serve as accessory food reservoirs and may also play an important role of secreting enzymes for food digestion and absorption. The number of pyloric caeca varies from species to species. For example, only a single caecum is found in *Polypterus* while up to a hundred are found in mackerel (Pandey and Shukla, 2005). The intestine of *P. jubelini* is short and nearly straight, it is about 50% of its body length, which is known to be common to carnivores (Lagler *et al*., 1978). The rectum is much slimmer, though histologically, a continuation of the intestine ends with the cloaca.

The presence of numerous oesophageal folds and muscle layers (longitudinal and circular) observed in *P. jubelini* allows for the expansion of the oesophagus hence the swallowing of large substances is made possible (Clarke and Witcomb, 1979). The goblet cells /mucus secretory pits observed along the entire length of the gut secrete mucus and perform different functions in different regions of the gut. It takes the place of the salivary gland in the buccal cavity and oesophagus (Andrew, 1959), The mucus aids digestive activities in the first part of

the intestine and lubricates faecal material in the rectum (Banan-Khojasteh *et a*l. 2009) as well as give protection to the intestinal epithelium against mechanical damage. The presence of numerous goblet cells is typical of carnivorous species (Domeneghini *et al*., 2002; Dai *et al*., 2007; Banan-Khojasteh *et a*l., 2009)

The large mucosal folds in the stomach are a usual occurrence in carnivorous species (Osman and Caceci, 1991). These large folds allow fishes to accommodate a large quantity of food items as a result of the stomach's ability to distend.

The presence of the epithelial lining which is made up of columnar cells and goblet cells for mucous secretion in the pyloric caeca is an indication that the pyloric caeca is not only used for storage but it is also used for absorption. The filiform folds with basal columnar membrane are slender, elongated and closely packed. In the intestine, the villi provide a large surface area for absorption (Clarke and Witcomb, 1979). The hind (rectum) region of the gut revealed sparse, stunted and spaced folds with the presence of villi. This situation reveals that digestion takes place within the whole length of the gut (Clarke and Witcomb, 1979; Banan Khojasteh *et a*l., 2009).

The dense region of blood vessels and connective tissues in the sub mucosa is prominent. This connective tissue varies in thickness from one region of the gut to another.

The muscular layers of the gastro-intestinal tract of *P. jubelini* vary in thickness from one region to another. The outer longitudinal muscle and inner longitudinal muscle layer make up the muscular layers (tunica muscularis). The prominence of these muscle layers indicates the thickness of the gut of carnivorous fishes. Banan Khojasteh *et a*l. (2009) stated that the muscles of the gut are striated and thick and the circular muscle is more prominent than the longitudinal muscle

The high proportion of empty stomachs (56%) observed in *P. jubelini* in this study, is characteristic of predatory species which has also been been reported by Balogun (2000), Bachok *et al*. (2004) and Chukwu *et al*. (2009) in the study of *L. niloticus*, pelagic and marine species and *S. afra* respectively. This is common phenomenon, and may reflect short periods of feeding followed by rapid digestion. The stomach of *P. jubelini* is well-developed and modified into a hard flask-like grinding structure which is short and distensible.

The dominant food items found on the stomach of *P. jubelini* were *Macrobrachium macrobrachion, Sardinella maderensis*, *Scomberomorus tritor* and *Ethmalosa fimbriata* which mainly were found in larger size classes (adults) of the fish while *Macrobrachium macrobrachion* (shrimps)*, Littorina anguilifera* (clam) and *Callinectes amnicola* (freshwater crabs) were found in smaller sizes (juveniles). This finding concurs with those of Idodo-Umeh (2003) and Froese and Pauly (2013). The restriction of fish prey choice of *Pomadasys jubelini* to only the three species (*Sardinella maderensis*, *Scomberomorus tritor* and *Ethmalosa fimbriata*) could be a strong pointer toward specificity in their feeding habit (prey selection), at least in the New Calabar-Bonny River.

Callinectes amnicola was the main food item (prey) by number (56.48%) and weight (50.75%), thereby contributing mainly to the relative importance of food in the stomach of *Pomadasys jubelini* in the New Calabar-Bonny River. Several carnivorous species have shown a shift from generalist to specialist in their feeding habit. Landry (1997) reported marked changes in the diets of cod with progression from copepods and planktonic crustaceans in the juveniles to herring in the adults. Balogun (2000) reported the transition in the feeding habits of *Lates niloticus* in Lake Kainji from invertebrates and small-size prey fishes at juvenile stage to piscivorous diets at the sub-adult and adult stages. Carnivorous fishes choose their food

items and do not necessarily feed on the most abundant items even if suitable (Kulbicki *et al*., 2005). Beukers-Stewart and Jones (2004) also showed that many carnivorous species specialize in their feeding habits as they approach maximum size. These changes in diet go with changes in biotope as adult fish can cover wider areas to feed whereas small fishes are restricted for various reasons, including predation, energy saving and swimming abilities. However, there seems to generally be a special liking for specific food items with age among most carnivores (Landry, 1997). The fact that most of the food items found the stomachs were often intact indicates that it swallows its prey whole thus imposing maximum limit on the size of its prey.

The findings here that the sex of the fish did not have any effect on the kind and quantity of food ingested and that the season did not have any positive or negative impact on the availability of food ingested by the fish suggests that this river is a good breeding ground for the different prey species whose abundance can be maintained all year round. These findings concur with earlier reports of Deekae and Henrion (1993) and Deekae, (2009) on the multivariate analysis of species distribution in the New Calabar River on the abundance of *M. macrobrachion* in Luubara Creek.

The linear and positive relationship between predator weight and prey weight indicates that an increase in the general size (body weight or length) of *P. jubelini* results to an increase in the weight of prey consumed. Olatunde (1978a) remarked that various dietary items decreased or increased in importance with age, and said that this change could be attributed to the size of the prey organism in relation to the size of the predator and to the ease of obtaining prey. This same comment applies to the results obtained in this study because during the early stages of life of *P. jubelini*, the food items selected were small but as the fish increased in size a similar

increase was also noted in the size of its prey. The findings of Balogun (2000) on *L. niloticus* also showed that an increase in the size of fish was related to an increase in the prey size; Balogun (2000) also observed that prey were often found intact in the stomach of *L. niloticus*, indicating that like *P. jubelini*, it swallowed its prey whole.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Based on the findings of this study, the values obtained for the physico-chemical parameters of water of the New Calabar-Bonny River are within the range recommended for tropical waters and the Niger Delta river system, and for proper management and growth of fish.

Fluctuations in salinity observed in this study are not uncommon as estuaries are known for their fluctuating environmental variables; the river course is divided into three sections; the salt water, brackish and fresh water.

The male to female ratio of 1:2.1 shows that there were more females than males in the population. This female dominance allows for continuous propagation of the species.

The size range recorded for *P. jubelin*i in this study is comparable to findings in other locations thus, in the New Calabar-Bonny River, *P. jubelini* can also attain maximum growth.

The length-weight relationship of *P. jubelini* in the New Calabar-Bonny River showed positive correlations (0.92-0.97) in both sexes, indicating that increase in weight corresponds to increase in length. The regression exponent ($b<3$) for both sexes shows a negative allometric growth pattern, that is an increase in stoutness as the fish increases in length.

The condition factor (0.01–1.87) obtained in this study varied during the different months and was higher during the dry season which coincided with when the level of turbidity of the river was lowest; with the period when larger sizes and less number of fish were caught; in addition the fish obtained during this period had no eggs (post spawning periods).

The length–girth relationship of *Pomadasys jubelini* exhibited positive allometric growth ($J>1.0$) Values of the length exponent in the length-girth relationship of the species being

allometric implied that the girth of the fish species increased faster than the cube of their total body length thus fish is in good condition, can obtain food and conserve energy with increase in size.

The fecundity of *P. jubelini* increased with increase in size of the fish (length and weight). The fecundity range of 9,085 to 37,926 obtained in this study can be classified as minimal when compared to other members of the family.

The mean GSI obtained reveals that this species uses up to 2.87% of its total body weight for egg production also increases with increase in length of fish.

The anatomic characteristics is typical to only *Pomadasys jubelini*, this characteristics are often used in identification and classification of this fish.

High percentage of empty stomachs without food is a trend common in predatory species because of rapid digestive rates. The food items consumed by *P. jubelini* were *Macrobrachium macrobrachion, Sardinella maderensis*, *Scomberomorus tritor, Ethmalosa fimbriata, Littorina anguilifera* (clam) and *Callinectes amnicola* (crabs). Most of the prey observed in the stomach of *P. jubelini* was intact, indicating that it swallows its prey whole thus imposing maximum limit on the size of its prey.

The linear and positive relationship between predator weight and prey weight indicates that an increase in the general size (body weight or length) of *P. jubelini* results to an increase in the weight of prey consumed.

The length of the gut was observed to be related to the feeding habit of *P. jubelini*. The intestine is short and allows for faster digestion of meaty substances.

The striated muscularis in the oesophagus with smooth muscle in the stomach, pyloric caeca, intestine and rectum consist of inner circular muscle layer and an outer longitudinal layer. The circular muscle is more prominent.

6.2 Conclusions

Some physico-chemical parameters of water such as temperature, salinity, total dissolved solids, alkalinity, conductivity and turbidity show significant differences ($P \leq 0.05$) between seasons; pH, and Dissolved oxygen do not vary significantly ($P > 0.05$) between the seasons. The values of the physico-chemical parameters of the water are within the range for proper management and growth of fish.

The New Calabar-Bonny River has three distinct zones; Fresh water, Estuarine and Saline environment.

Pomadasys jubelini exhibits a negative allometric growth pattern that is, increase in weight of the fish does not correspond with increase in length; fish grows more in weight (stoutness) than in length.

The age and growth of *Pomadasys jubelini* differs between the sexes. The females grow larger than males; an attainable age of 0+ to 4+ is established. The hard structures used for age determination did not show accurate and readable annuli. The male to female ratio is 1:2.1.

Pomadasys jubelini is a total spawner; producing numerous small size eggs once a year, its fecundity is minimal when compared to other species of *Pomadasys*, cichlids and clariids. Spawning occurs in freshwater and the young migrate to the saltwater zone as they grows to maximum size.

Pomadasys jubelini is a carnivorous fish species that shows transition from consumption of invertebrates at the immature and sub adult stages to piscivorous diets at adult stage.

6.3 Recommendations

It is therefore recommended that

i There is need for the proper government agencies to monitor and control activities that may pollute the New Calabar-Bonny River in order to promote the breeding grounds of *P. Jubelini* and other fish species.

ii Further studies on the population dynamics of *P. jubelini* is desirable to determine if larger sizes of this fish species exist within the coastal area adjacent to the New Calabar-Bonny River.

iii Juveniles of *P. jubelini* are recommended for cage culture in the marine environment, and its feed should be composed of invertebrates and smaller fish species.

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