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SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

Baseline Assessment of Demersal Fish Stocks of the Western Region of Ghana

2017

THE UNIVERSITY OF RHODE ISLAND
GRADUATE SCHOOL OF OCEANOGRAPHY
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ACRONYMS

ADW	Atlantic Deep Water
CPUE	Catch per Unit Effort
CRC	Coastal Resource Center
ECC	Equatorial Counter Current
FAO	Food and Agriculture Organization
FC	Fisheries Commission
FSSD	Fisheries and Scientific Survey Division
GDP	Gross Domestic Product
MSY	Maximum Sustainable Yield
SACW	South Atlantic Central Water
TSW	Tropical Surface Water

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1: INTRODUCTION

1.1 Background the Coast of Ghana

The coast of Ghana lies along the Gulf of Guinea in West Africa, with its southernmost point at about 4º44’ north of the equator. The coastline is about 550km long and it extends from 6º 06’ and 1º 12’ E in the east, where it is bordered by the Republic of Togo, to 5º05’Nand 3º06’ W in the west, where it is bordered by Cote d’lvoire. The landward extension of the coastal zone has been defined in the Ghana Coastal Zone Indicative Management Plan as the ‘line joining the landward limits of the lagoons, marshes, and estuarine swamps together with the intervening interfluves areas. This definition extends the coastal zone to approximately 10km inland and is enclosed by 30m contour (Armah and Amlalo, 1998). The landward coastal area is generally low lying and extends not more than 200m above mean sea level (Willes-Mensah *et al*., 2002). The continental shelf is narrow and extends between 20km at its narrowest part and 90km at its broadest part into the Gulf of Guninea. The coastal area experiences tropical climate conditions with a warm eastern belt, a comparatively dry central belt and a wet southwestern corner which is hot and humid (Environmental Protection Agency, 2004). Rainfall distribution is bimodal with one peak in May/June and a second peak in September/October. The lowest rainfall occurs in January. The period between December and March is dry and is known as the Harmattan. The major rivers draining the coastal area of Ghana are the Volta, Pra, Tano and the Ankobra. These rivers contribute sediment to the coastal area. Patterns in sediment loads of the rivers generally follow the rainfall regime, with two peaks occurring during the rainy seasons (Willes-Mensah *et al*, 2002). However, long-term data on sediment loads, necessary for more reliable estimates to be made, (particular for the Volta), is non-existent (Boateng *et al*., 2012). The hydrology of the coast is modified by oceanic gyral currents of the North and South Atlantic Oceans, which spurn a counter current, the Equatorial Counter Current (ECC) that flows in an eastward direction. This ECC becomes known as the Guinea current as it runs from Senegal to Nigeria. The tide on the coast of Ghana is regular and semi-diurnal, but the average range varies along the coast from 0.58 m at neap tide to 1.32m at Spring tide. The tidal wave however has virtually the same phase across the coast of the country. Tidal currents are low and generally have a small influence on coastal processes and morphological changes, except within tidal inlets (AESC, 1997). There are five principal water masses off the coast (Allersma and Tilsman, 1997), namely:

- The Tropical Surface Water (TSW) which is warm of variable salinity extending down to a maximum of about 45m, depending on the seasonal position of the thermocline;
- The South Atlantic Central Water (SACW) which is cool but more saline, extending 5m to 35m below the thermocline to a depth of 700;
- The Atlantic Deep Water (ADW) from 700-1500; the North Atlantic Deep Water (NADW) from 1500m to 3500m and the Antarctic Bottom Water (ABW) extending from 3500m to 3800m.

Whilst there is little change in the subsurface waters, the TSW experiences seasonal changes culminating in minor and major upwelling events, alternating with periods of stratification. The minor upwelling events occurs between January and February, when the surface waters tend to be slightly cooler. The end of June heralds an increase in the easterly wind direction in the Western Equatorial Atlantic that brings up cold South Atlantic Central Water (SACW) to replace the TSW resulting in the breaking of the thermocline and the onset of the major upwelling. Marine ecology along the coast is influenced largely by the seasonal upwelling which brings cold, nutrient rich water to the surface resulting in increased primary production which attracts large shoals of small pelagic fish species forming the basis for large seasonal fisheries along the coast.

1.2 Marine Fisheries in Ghana

Fisheries are one of the most important food production sectors in the Western Gulf of Guinea and Ghana, and a vital element of the country's food production capacity and agriculture (Ofori, Diako & Amoa-Awuah, 2012). The sector in Ghana principally encompasses marine fisheries, inland (fresh water) fisheries and aquaculture fisheries as well as related activities in fish storage, preservation, marketing and distribution. Fisheries constitute an important sector in national economic development. The sector is estimated to contribute 3 % of the total Gross Domestic Product (GDP) and 5 % of the GDP in agriculture. About 10 % of the country's population is engaged in various aspects of the fishing industry. Marine fisheries account for over 80 -90% of the fish consumed in Ghana (Ofori *et al.* 2012). Annually, about 60 million Dollars is earned from the export of fish and the sector directly engages about 10% of the total country's population of 24 million. The sector provides about 60% of the national animal protein demand and fish consumption is 25kg/capita/yr, which is higher than the global average of 17.1kg (MOFA 2011 as cited in Ayivi, 2011). In Ghana, marine capture fisheries are the main source of fish landings and accounts for 77% of the total country's fish production. The stocks exploited by the different fishing fleets operating in the Ghanaian coastal waters are shared by the neighboring countries, including; Benin, Togo and La Cote d'Ivoire. The stocks consist of the pelagic and demersal species. The large and small pelagic consists of the tunas, sardinella species, Scomber *japonicas* (Chub mackerel) and anchovy (Engraulis encrasicolus). The differences in annual landings of the various fleets in the sector are mainly caused by the quantities of these species. The natural fluctuation however, in abundance of small pelagics is much affected by the strengths of seasonal upwelling (Koranteng 1991). The increased number of fishing vessels, gear and efficiency of gear operations has led to increase fishing effort of the small pelagic overtime. (Minta, 2003). Small pelagics have been reported to be overexploited in spite of the recent increase in landings (Mensah and Quaatey 2002).

Demersal stocks exploited in the Gulf of Guinea are categorized into coastal and deep-water demersal (200-300m). Coastal demersal species inhabit depths of about 40 meters and the deep water demersal below the thermocline (Koranteng, 1996). The distribution and abundance of demersal fish depend on factors such as the depth and the substrate of the seabed (Ayivi, 2011). Demersal stocks include Sparidae (Sea breams), Sciaenidae (Pseudotolithus sp.), Lujanidae (Snappers), Polynemidae (Threadfins), Haemulidae (Bigeye grunts) and many others. These are high value demersals exploited in Ghana and are believed to be unsatisfactorily assessed. However, the increase in overall fishing pressure over the decades, due to their value and the fluctuating catch rate of the small pelagic, could lead to a possible overexploitation of the resource (Ayivi, 2012). Determining the status of fish stocks means estimating one or more biological characteristics of the stock, such as abundance (numbers of fish) or biomass (weight), and comparing estimated to reference values that define desirable conditions. An essential characteristic of a fish stock is that its population parameters remain constant throughout its area of distribution and stock assessment should be carried out separately (Wang and Liu, 2006 as cited in Konan et al. 2015). In tropical and subtropical waters, it is not possible to determine age by counting rings in hard parts of the fish body, such as otoliths or scales. The lack of strong seasonality makes the distinction of seasonal rings and year rings problematic for tropical species. However, with the development of the length based stock assessment methodologies, it is possible to investigate population dynamics of fish stocks in tropical waters (Pauly 1984 cited in Konan et al. 2015). The resource is exploited in inshore waters and on the continental shelf to a depth of about 75m. The resource is targeted by all three prominent fishing fleets; by the canoe fishery though line fishing, bottom-set gill nets and beach seine nets; by the semi-industrial fleet through low season trawling, and; by the industrial fleet through trawling. By the early 1970s, researchers were already noting the heavily exploited status of demersal stocks in this region, and appealing for urgent reforms in governance systems (Gulland et al. 1973). More recent reviews of the state of demersal stocks in Ghana (e.g. Koranteng and Pauly 2004) report clear trends in the reduction of biomass of longer lived and predatory fishes, suggesting overexploitation of the fishery. These results come from national catch statistics, but also from fishery-independent sources; a series of research trawl surveys conducted between 1963 and 2000. These independent surveys showed a particularly marked decline in the abundance of demersal resources in the 0-30m depth zone. It is against this background that research conducted by University of Cape Coast, in partnership with the Sustainable Fisheries Management Project (SFMP), through cooperative research with fishers is being undertaken to assess the status of demersal stocks. The research focuses on the Western Region of Ghana and its demersal fishery (Pra and Ankobra).

1.3 Why the western region and the four selected demersals?

The Western Region covers an area of approximately 239,221 square kilometers, which is 10% of Ghana total area. The region has 17 agricultural districts. The regional capital is Sekondi-Takoradi which is the seat of Regional Directorate of Agriculture. The region has about 75% of its vegetation within high forest zone of Ghana and lies in the equatorial climate zone that is characterized by moderate temperatures. It is the wettest part of Ghana with an average rainfall of 1600 mm per annum (MOFA, 2011). The population of the region is 1,924,577 representing about 10% of total population of the country with farming the population. The population growth according to the 2010 census is 3.2%. The major occupations in the region are farming, fishing, animal husbandry i.e. (58%). The region is endowed with considerable natural resources which give it a significant economic importance within the context of national development. The Western Region is one of the most economically active regions in the country. Both agriculture and industry feature prominently in the region’s economic activities, and influence the demographic complexities of the various districts The region is charactized with more productive water bodies such as the Ankobra, Pra, Tano, Whin, Nyan etc. which have a high influx of nutrients making the waters more productive. The region is noted for its vigorous fisheries activities due to the expansion of the continental shelf and is inundated with fishing fleets. It is the most productive region among the four coastal regions in Ghana and it contributes about 36 percent of the total annual catch of the country (Fisheries Commission, Western Region).

1.4 Why the four selected demersals?

The research concentrates on four demersal species namely, Brachydeuterus auritus, Pseudotolithus senegalensis, Galeoides decadactylus and Pagellus belottii, due to their high economic value and abundance. These four species were selected because they have been reported to be a significant component and most abundant species of the coastal demersal stocks, especially Brachydeuterus auritus and Pagellus bellottii (IUCN, 2014). These four demersals contribute about 40-50% to the annual total demersal stock catches, hence the species can serve as indicators for the demersals stocks (Figure. 1). Similarly, as Sardinellas, anchovies and mackerels are observed to make up the vast majority of the pelagics, these demersal species also contribute a majority of the demersal stocks in Ghana. Demersal stocks contribute less to the landings as compared to the pelagics, however, they are more valued economically and they play major role in terms of economic contributions to the fishery sector.

The Ghanaian fishery is characterized by a high percentage of pelagic species. Consequently, more attention has been dedicated to assessing these stocks relative to demersal fish species which contribute to about 20% of the country's fish landings (Ayivi, 2012). The current status of most of the demersal stocks is not known even though economically, the stocks contribute significantly to the fishery. It is therefore necessary to assess the stocks for proper management. The four species were however, selected based on the reason given above to serve as indicators for assessment of the demersal stocks.

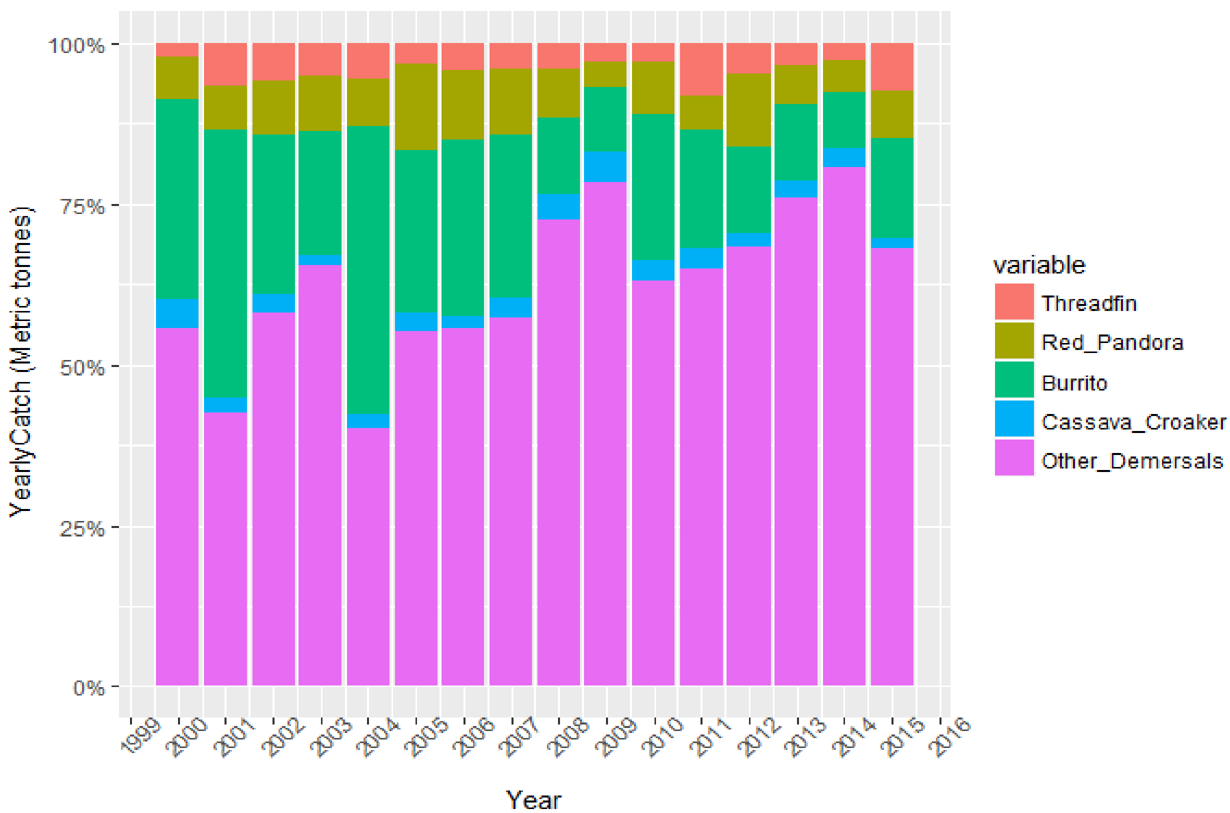

Figure 1: Percentage contribution of four selected demersal to total demersal stocks (Source: Ghana Fisheries and Scientific Survey Division, FSSD)

SECTION 2: HISTORY AND ECOLOGY OF THE FOUR SELECTED DEMERSAL SPECIES

2.1 Galeoides decadactylus

Galeoides decadactylus is one of the three species of the family Polynemidae commonly called threadfins, found in warm tropical surface waters of the Atlantic Ocean on the continental shelf of West Africa. It is distinguished among its family by the lower portion of its pectoral fin detached to from nine to ten short free rays and slightly compressed with its standard length about three times longer than the body. It is a semi-diadromous fish which migrates to spawn in estuaries and lower reaches of rivers (CECAF/ECAF Series 1986). The species feeds generally on crustaceans and small fishes. It lengths ranged from 150 mm total length for males to 255 mm for secondary females, and grows rapidly during the first year. Galeoides decadactylus is an important component of the commercial trawl fishery in the eastern Atlantic, constituting between 10 and 20% of the total landings by weight. The annual catch from the area averaged 15,600 tonnes from 2000 to 2006, mainly caught by Nigeria, Ghana, and Gabon (Motomura, 2004).

2.2 Pagellus Bellottii

Pagellus bellottii is widespread and one of the most abundant sparid species on the West African coast. It forms a significant component of the multi-species coastal demersal fisheries in the Eastern Central Atlantic. The species is widely distributed in the eastern Atlantic, Angola, and around the Canary Islands (Carpenter, 2007). It is found in schools, especially in the upper 100 m. It is omnivorous, with a predominantly carnivorous diet (including crustaceans, cephalopods, small fish, amphioxus and worms) (Carpenter, 2007). Pagellus bellottii is a commercially important component of the industrial and artisanal fisheries in West Africa. It is a significant component of the demersal fisheries in Ghana and Senegal (Koranteng 1984; Koranteng and Pitcher 1987; IUCN, 2014). The species is one of the most valuable demersal species landed at the ports and beaches of Senegal. It constitutes one of the most valuable components of the demersal stocks (Fall *et al.* 2006). This species is caught with bottom trawls, also on line gear and in traps (Canary Islands). Red Pandora is also used for fishmeal and oil.

2.3 Brachydeuterus auritus

The big-eye grunt, B. auritus is a member of the family Pomadysidae, is an extremely valuable component of the fishery, both in terms of abundance and quality, accounting for over 5% of the total marine fish catch. This species is found in the eastern Atlantic, from Morocco to Angola but it more common from Senegal to Angola. They inhabit the coastal waters off the West African coast from Mauritania (260N) to the south of Angola (17S). Its distribution ranges between 10 and 100 m depth, but it is most commonly found in inshore waters between 30 and 80 m. The species is gonochoristic and its fertilization is external with no parental control. Food items of the species include juveniles of other fishes such as anchovies, amphipods, diatoms and fragments of invertebrates (Barro, 1979 in Bannerman, 2002). Juveniles also occasionally move to the estuaries to feed. The species is of major commercial importance to the fisheries of major areas where it occurs. In Ghana, it is an extremely valuable component of the fishery, especially in the artisanal fisheries, both in terms of abundance and quality, accounting for over 5% of the country's total marine fish (Bannerman and Cowx, 2002). It is very common in beach seine landings along the coast of Ghana.

2.4 Pseudotolithus senegalensis

Pseudotolithus senegalensis belongs to the family Scianedae and inhabit coastal and continental shelf waters from West Coast of Africa (from Morocco to Angola but rare North of Senegal). The species is gonochoric and fertilization is external. *P. senegalensis* spawns from November to March in waters of 22 to 25ºC in the Gulf of Guinea. Small individuals or Juveniles are found in shallow waters but rarely enter estuaries (IUCN, 2014). The juveniles prefer shallow waters and move to mid-waters when bottom temperatures fall below 18ºC. They inhabit mud, sandy and rocky bottoms from the shoreline to 70m depth. They occur in warm water above the base of the thermocline. The species has smaller food spectrum (Blay, Awittor and Agbeko, 2006) and feeds on fish, shrimps, crabs and cephalopods.

SECTION 3: FEEDING HABITS OF THE FOUR SELECTED SPECIES

Fish feeding habits and fish nutritional needs are required for understanding food exploitation and foraging strategies among organisms in the marine environment. Investigation on the feeding regime of commercial fishes may help to identify habitats or sites of higher fish abundance for successful commercial capture. Information on the food habits of the different age groups in a fish stock is essential for assessment of the stock (Wallace & Fletcher, 1996) as it defines the trophic requirements of the various developmental stages. It is also an important requirement for the ECOPATH model (Christensen & Pauly, 1992) used in elucidating aquatic ecosystem functioning and generating critical biological information for fisheries management (Mendoza, 1993; Silva *et al*., 1993). In Ghana, the food and feeding habits of only a few marine species of economic importance have been studied which includes the four selected demersals (Blay & Eyeson, 1982; Yankson & Azumah, 1993; Blay, 1995ab).

Pseudotolithus senegalensis and Brachydeuterus auritus are reported to be stenophagous, as they feed on a narrow range of food items consisting of larvae and fingerlings of fish, shrimps, amphipods, diatoms and crustaceans. Their preference for a particular food item among this food spectrum suggests possible food resource partitioning between the two species as a means to minimize competition (Barro, 1979 in Barnnerman 2002, Blay et al.2006). Pagellus bellottii is omnivorous, however with a predominantly carnivorous diet. The food item includes crustaceans, cephalopods, small fish, and amphioxus and worms (Carpenter, 2007). Galeoides decadactylus generally is a euryphagus fish (i.e. feeding on a wide range of organisms). The species is reported feed on varieties of active and sedentary benthic animals (Holden and Reed 1991; Gbesan et al. 2010). The diet constitutes mainly crustaceans, pisces, annelids, small fish and molluscs. A comparison of the food of the species with food fed on by the four selected species showed that all feed on small fishes and crustaceans but varied crustacean as reported by Marcus (1986). This also reduces inter specific competition among the species.

SECTION 4: AIM OF RESEARCH

The aim of the research was to establish a baseline assessment of the demersal resources in the Western region in relation to it socioeconomic importance.

SECTION 5: METHODOLOGY

5.1 Study Area

The Western Region is located in south Ghana and extends from the Ivory Coast border in the west to the Central region of Ghana in the east. Its cities include the capital of Sekondi-Takoradi on the coast, coastal Axim, and a hilly inland area including Elubo. The Western Region covers an area of approximately 2, 3921 square kilometers, which is about 10 per cent of Ghana's total land area (Ghana Statistical Service, 2013) and a coast line of about 205 kilometers. The region has about 75 per cent of its vegetation within the high forest zone of Ghana, and lies in the equatorial climatic zone that is characterized by moderate temperatures (Ghana Statistical Service, 2013).

The region is endowed with considerable natural resources, which give it a significant economic importance within the context of national development. The Western Region is one of the most economically active regions in the country. Both agriculture and industry feature prominently in the region's economic activities, and influence the demographic complexities of the various districts. The major livelihood occupation in the region is agriculture which includes fisheries (Ghana statistical service, 2013). The Pra and Ankobra estuaries are part of the most productive rivers in the region with intense fisheries activities. The major landing sites within the Pra- Ankobra stretch includes Shama, Sekondi fishing habour, Takoradi fishing habour, Axim, Discove and Ankobra.

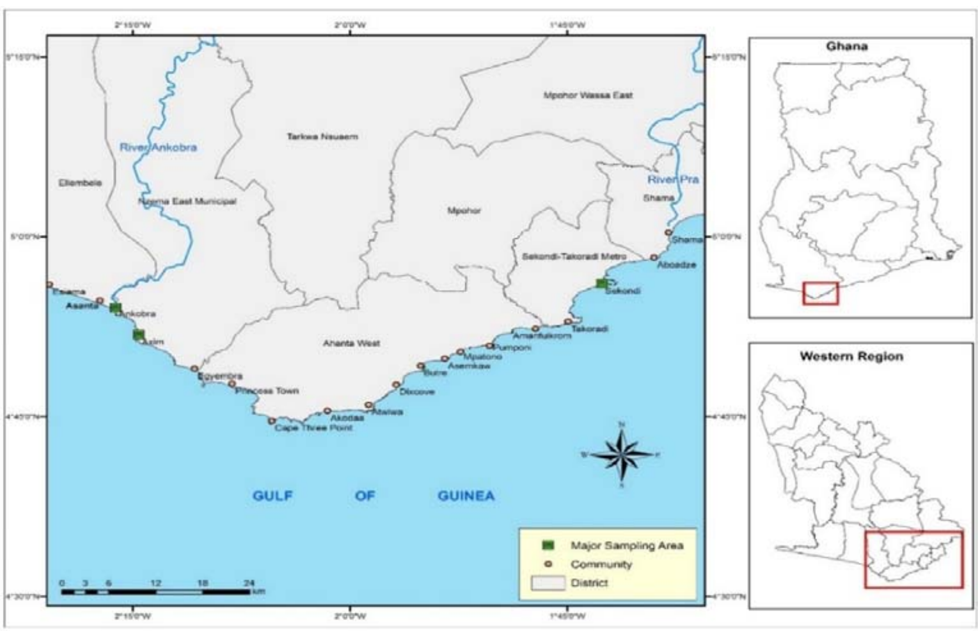

Figure 2 Map of the western region showing the stretch between Ankobra and Pra estuaries.

SECTION 6: DATA COLLECTION

6.1 Surveys

The study involved monthly data collection which began with a scooping survey on the 21st - 22nd March, 2015. The trip aimed at initiating a pilot project on cooperative research, which involves the participation of stakeholders in the research and data collections procedures. This participatory approach included stakeholders of the fisheries from Anlo Beach, Ankobra and Sekondi, to learn and actively assist with this research. A follow up trip was made on 21st to 24th April, 2015 to identify various landing sites and select demersal species, important to the fisheries. A database with contact information of fishermen and fish processors involved in this research was developed.

Major landing sites as well as areas noted for intense beach seine activities within the Pra and Ankobra stretch were selected. These include Anlo Beach, Sekondi, Axim and Ankobra all the way to Essiama. Four demersal species of commercial importance (Brachydeuterus auritus, Galeoides decadactylus, Pentanemus quinqarius and Pseudotolithus senegalensis) were initially selected as indicators of the demersal fish stocks in the region based on their abundance and/or economic contribution to the fisheries. However, after four months of biological data collection, it became clear that the Pentanemus quinqarius catches were very low, composed mainly of juveniles and was replaced with Pagellus bellottii, another economically important fish in Ghana.

Figure 3 Some interactions with stakeholders and fisher folks during the survey

6.2 Cooperative research

The baseline study was a cooperative research which involved some stakeholders, specifically fishermen and fish processors of the Western Region in the data collection procedures. The purpose was to invite stakeholders to participate in fisheries research which often is the source of management decisions. The training also aimed at helping fishermen and fish processors understand the science behind management decisions and the need to comply with fisheries regulations.

Consequently, fishermen and fish processors who showed interest during the reconnaissance survey were involved in the data collection procedures. The interested stakeholders were taught on the purpose of the research, and they were trained on how to collect basic fisheries data (total length, fork length, standard length and body weight). They were also trained on sex determination and macroscopic inspection of maturity of the species. The intention was to involve them throughout the data collection period and to have a hands-on knowledge on fisheries research procedures. As data collection went on, fishers who came around to observe and showed interest in the research were also brought on board for training and became part of the research team. Stakeholders were continually trained during monthly data collection until they could take fisheries information without any assistance.

Figure 4 Some fishers and fish processor being trained how to collect fisheries data

6.3 Fish sampling

Fish sampling took place from April 2015 to May 2016. Fish specimens were collected from the commercial landings of fishermen. During this period, monthly length-frequency data was obtained for each of the four species. Specimens were identified using an identification manual (Schneider, 1990). Total length, standard length and fork length were measured to the nearest 1cm using fish measuring board. Body weight of specimens was also taken, using an electronic balance.

Thirty specimens of each species were randomly selected, each month, for age and reproductive analysis. Gonads of the thirty specimens were removed and their sex and reproductive maturity determined using a macroscopic staging system. Male and female gonads for all species were staged from I to VI depending on how they appeared.

Otoliths and scales were also removed from the specimens for age analysis. Otoliths were washed in 10% alcohol and scales were also washed in ordinary water to remove tissues that may interfere with rings of hard parts. Cleaned otoliths and scales were preserved for further studies.

Figure 5 Data collection on fish species on field

6.4 Catch and Effort data

A twenty five-year series (1990 to 2015) of catch and effort data was obtained from the Fisheries and Scientific Survey Division (FSSD) of the Fisheries Commission (FC) to assess the populations of demersal stocks. The data comprised monthly catch and effort data on all marine stocks targeted in the Ghanaian fisheries. Data was synthesized to obtain the relevant information on the demersal stocks of the country. Catch and effort data was used to estimate the maximum sustainable yield and its corresponding effort for each of the species.

6.5 Socio Economics Data Collection

A structured interview schedule was developed to solicit for information on expenditure and revenue and also to characterize the fishing gears and vessels used in the demersal fishery. The choice of the interview schedule was to allow the solicitation of information from fishers who could not read or write. The instrument used both open and close ended questions to obtain information from selected fishing communities in the Western, Central and Greater Accra region. Information solicited covered all the three sectors in the Ghanaian fishing industry.

SECTION 7: DATA ANALYSES

7.1 Length-Weight Relationship

A regression analysis was conducted to ascertain the relationship between total length and body weight of the fish species. The significance of the deviation of the regression coefficient b from the isometric value 3.0 was tested at 0.05 significance level using the formula $ts = \frac{b-3}{sb}$, where Sb is the standard error of b. (Morey et al., 2003).

7.2 Growth and Mortality Parameters

Monthly length-frequency data was analyzed using ELEFAN program in FiSAT II software to estimate growth and mortality parameters. The growth parameters L_∞ and K were estimated using the von Bertalanffy growth model expressed as $L_t = L\infty\ [1 - e{-}K\ (t - to)]$

Where, L_t is the predicted length at age t, L∞, the asymptotic length, K the growth coefficient, and t_o is the theoretical age at length zero.

The growth performance index of the populations was calculated using the equation ϕ = Log K +2 log L_∞. The theoretical age at length zero was also estimated using the equation

$\log10\ (-t0) = -\ 3.922 - 0.2752\ \log10\ L\infty - 1.038\ \log10\ K$

The longevity (tmax) of the of the species was also estimated using tmax = 3 / K

The total mortality of the fish population was obtained from the length converted catch curve incorporated in FiSAT program. Natural mortality was also estimated from the Pauly's empirical equation incorporated in FiSAT, which is expressed as

Log M= -0.0066 - 0.279 log L + 0.6543 log K + 0.4634log

Where, T is the mean annual temperature of the habit under study.

The mean water temperature used in estimating natural mortality, was computed from the 2015 and 2016 water temperature data from FSSD. The fishing mortality coefficient (F) and exploitation ratio (E) were estimated using the relationships Z-M and E = F/Z respectively.

7.3 Yield and Biomass per Recruit

The relative yield per recruit (Y'/R) and biomass per recruit (B'/R) were estimated according to Beverton and Holt (1957) using the Knife-edge option. The length at first capture for the estimation of the biological reference points ($E_{0.1}$, E_{50} and E_{max}) was taken as the estimate of the L_{50} from the probability of capture curve incorporated in FiSAT.

7.4 Catch and Effort Data

Scatter plots were generated from the catch and effort data to ascertain trends of catch and effort over the 25years. The catch per unit effort was computed as CPUE= Catch /Effort to ascertain trends in abundance of the fish populations.

7.5 Maximum Sustainable Yield

The maximum sustainable yield (MSY) and the corresponding effort (F_{MSY}) were estimated according to the Schaefer's production model. MSY was estimated according to the formula $MSY=0.25*a^2/b$ and $F_{MSY=}$ $-0.5*a/b$

Where an and b are the intercept on the Y axis and the slope of the parabolic curve $Y= af + bf^2$. However, Y is the catch and f is the effort. The solver tool in Excel was used to adjust the an and b values which was computed.

7.6 Reproductive Biology Data

The chi- square test was used to test for the significant difference between the number of males and females of each fish population.

Ogive curve was generated for specimens that were stage III and above to determine the mean length at maturity (L_{50}). The 50% mark on the cumulative axis was traced to its corresponding length to extrapolate the $L_{50.}$

Percentage proportion of spawning individuals (stage V) was determined for each month's sample to ascertain the spawning periods of each species.

7.7 Socio Economic Data

Microsoft Excel was used to analyze the information solicited through the interviews. Percentage frequencies were computed and used to generate ranges of the expenditures, revenues and gears deployed by fishers. The information was used to describe the fishery types of the Western Region.

SECTION 8: RESULTS

8.1 Sample

The sizes of the species collected during the study period ranged from 8-23 cm TL for Brachydeuterus auritus, 13-46 cm TL for Pagellus bellottii, 5-45 cm TL for Galeoides decadactylus and 9-91 cm TL for Pseudotolithus senegalensis. The total specimens collected for each species are presented in table 1. Otoliths and scales were not processed for analysis because of late arrival of age and growth equipment and limited time for completion of research.

Table 1 Sample size for the four demersal species

Species	Total sample	Otoliths	Scales
Brachydeuterus auritus	2763	818	409
Pseudotolithus senegalensis	1891	800	400
Galeoidis decadactylus	2004	800	400
Pagellus bellottii	1143	600	300

SECTION 9: GROWTH, MORTALITY AND EXPLOITATION RATIOS

9.1 Length-Frequency Distribution

Figures 3 to 6 present the overall length-frequency distribution of the four selected species based on gears. Data was collected from trawl, beach seine and hook and line fishery. All the distributions showed a unimodal class. *B.* auritus sample was dominated by 16.0 cm TL for trawl net and 10.cm TL for beach seine (Figure 6). *P.* bellottii sample was also dominated by 22.cm TL size class for trawl fishery and 23 cm TL for hook and line. The distribution for trawl fishery showed a modal class of 30 cm TL and beach seine showed a modal class of 20 cm TL for *G.* decadatylus. Both trawl and beach seine showed a modal class of 30 cm TL for *P.* senegalensis.

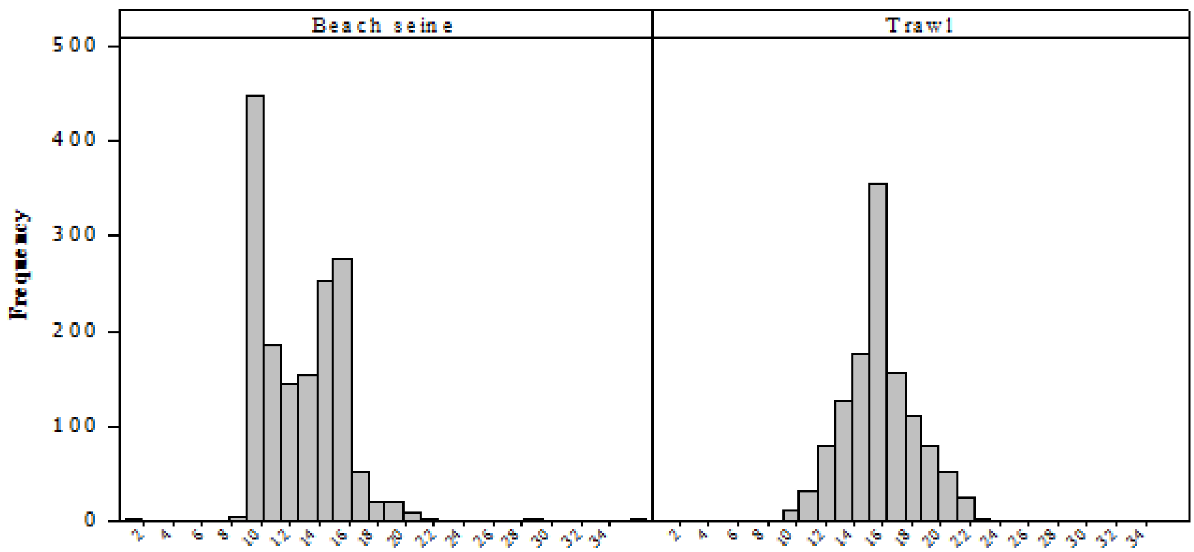

Figure 6 Length-frequency distribution of B. auritus

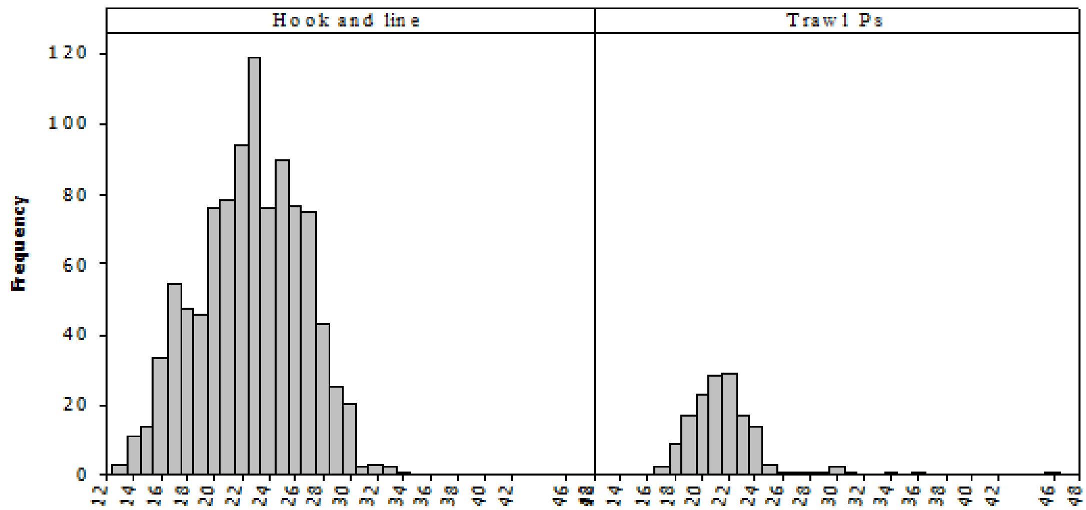

Figure 7 Length- frequency distribution of P. bellottii

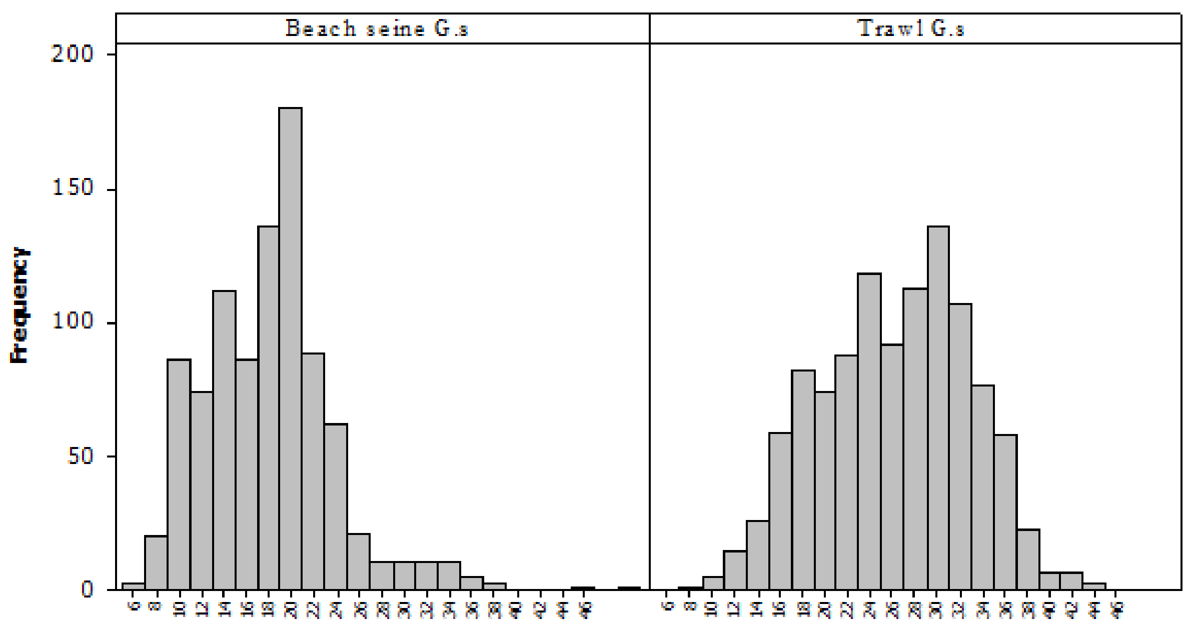

Figure 8 Length frequency distribution of G. decadactylus

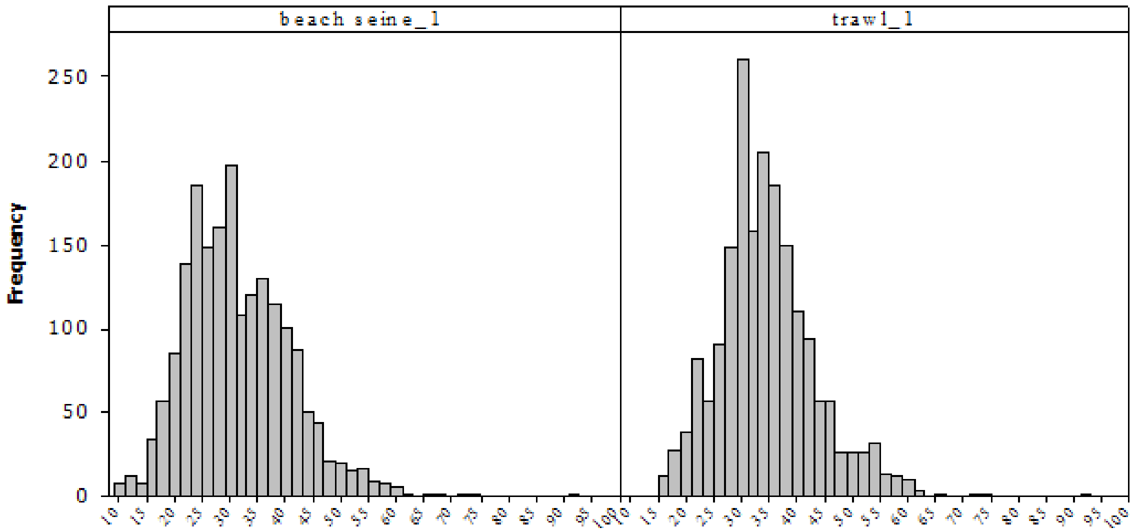

Figure 9 Length-frequencies distribution of P. senegalensis

9.2 Length–Weight Relationship

The length–weight relationships of the overall samples of the four species were described by $W=0.017TL^{2.9063}$ (r = 0.96) for Brachydeuterus auritus, (Figure 6), $W=0.019TL^{2.9102}$ (r = 0.95) for Pagellus bellottii, (Figure.7), $W=0.0101TL^{3.0313}$, (r = 0.98) for Galeoides decadactylus, (Figure 8), and $W=0.0075TL^{23.0375}$ (r = 0.96) for Pseudotolithus senegalensis, (Figure 10). Generally, the growth rate (b) for the relationships indicated that all the species grew isometrically. Thus, the growth rates did not differ from the theoretical value of 3.0 ($P >$ 0.05). Species did not show significant difference ($P > 0.05$) between the growth rate of different sexes, males and females, except Pagellus bellottii where the growth rate of females was significantly ($P < 0.05$) different from the theoretical value of 3.0 indicating a negative allometric growth.

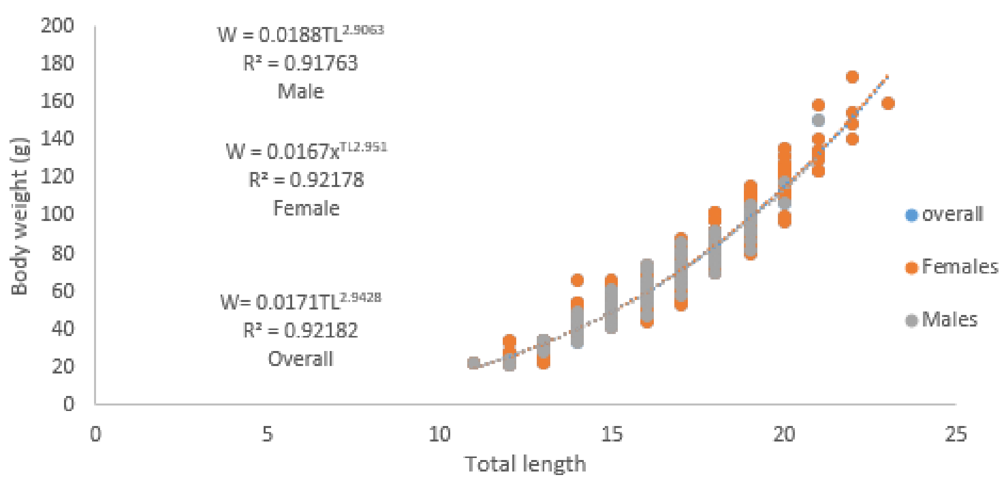

Figure 10 Length -weight relationship of B. auritus

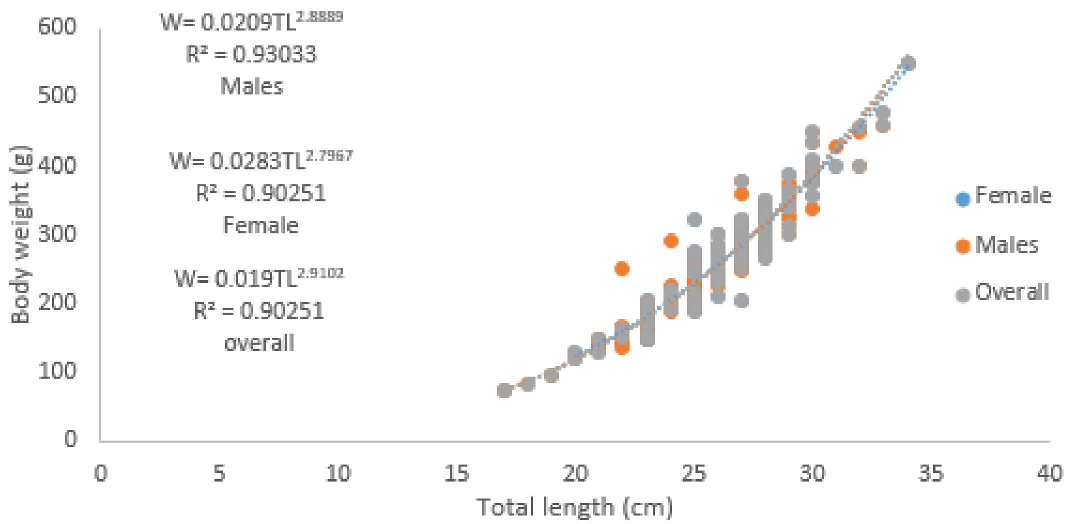

Figure 11 Length-weight relationship of P. bellottii

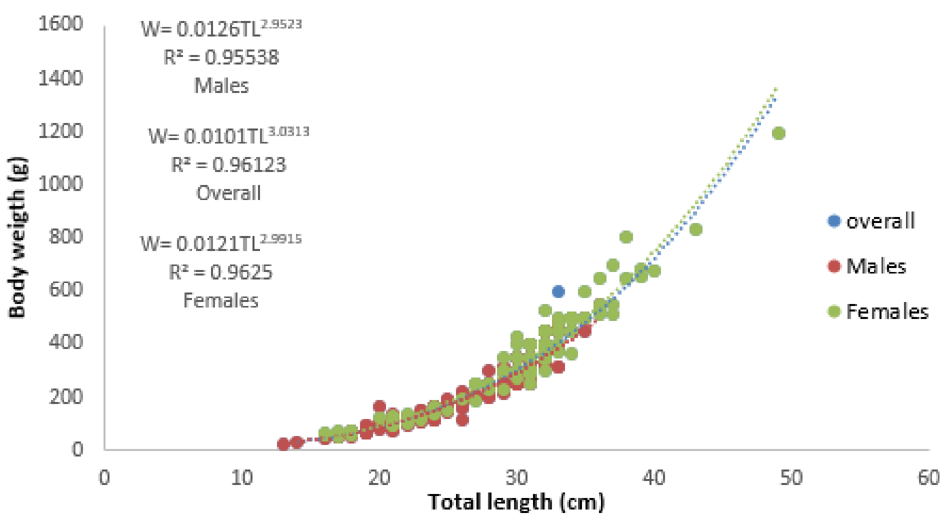

Figure 12 Length-weight relationship of G. decadactylus

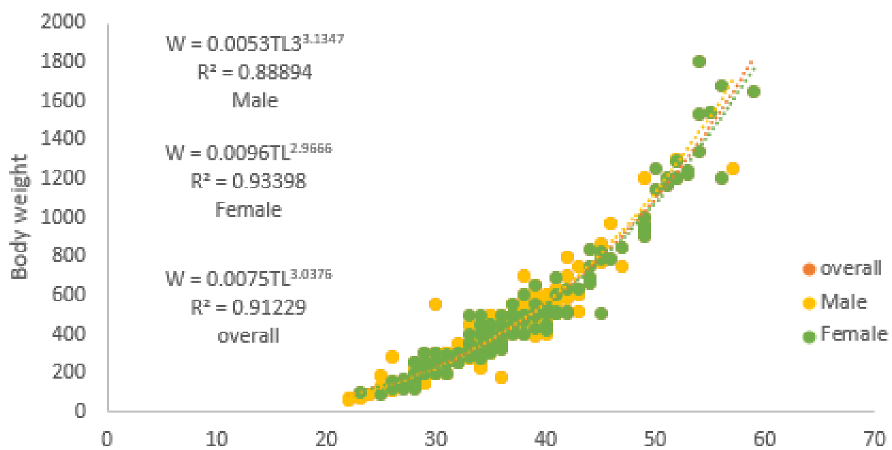

Figure 13 Length-weight relationship of P. senegalensis

Table 2 Summary of Length- Weight relationship for the four demersals

Species	**Male**	**Female**	**Overall**
B. auritus	$W=0.0188TL^{2.9063}$ (r = 0.96, P >0.05) N=132	$W=0.0167x^{TL2.951}$ (r= 0.96, P >0.05) N=281	$W=0.0171TL^{2.9428}$ (r = 0.96, P >0.05) N=413
P. bellottii	$W=0.0209TL^{2.8889}$ (r = 0.96, P >0.05) N=176	$W=0.0283TL^{2.7967}$ (r = 0.95, P < 0.05) F=114	$W=0.019TL^{2.9102}$ (r = 0.95, P >0.05) N=290
G. decadactylus	$W=0.0126TL^{2.9523}$ (r= 0.98, P >0.05) N=200	$W=0.0121TL^{2.9915}$ (r = 0.98, P >0.05) F=110	$W=0.0101TL^{3.0313}$ (r = 0.98, P >0.05) N=338
P. senegalensis	$W=0.0053TL3^{3.1347}$ (r = 0.94, P >0.05) N=203	$W=0.0096TL^{2.9666}$ (r = 0.96, P >0.05) F=176	$W=0.0075TL^{3.0376}$ (r = 0.95, P >0.05) N=379

9.3 Growth

A total of 15 length-frequency samples (representing 15 months of sampling) were collected for *B*. auritus, G.decadactylus and P. senegalensis respectively, while 10 samples (representing 10 months of sampling) length-frequency were collected for *P*. bellottii. The 10 months of sampling for *P*. bellottii was as result of later inclusion of the species in the studies as explained earlier. The run of ELEFAN program in FiSAT produced monthly length-frequency distribution of the species (Figure 10, Figure 11, Figure 12 and Figure 13) fitted with the von Bertalanffy growth curves.

The estimated asymptotic length (L_∞) were 25.73 cm (TL) 46.50 cm (TL), 47.78 cm (TL) and 95.0 cm (TL) for *B*. auritus, P. bellotti , *G. decadactylus, P. senegalensis* respectively. The estimated growth rates (K) of the species were 0.68, 0.51, 0.47 and 0.33y-1 for B. auritus , P. bellotti , G. decadactylus, P. senegalensis respectively. The estimated growth performance index (Φ) were 2.650 for B. auritus, 2.659 for P. bellottii, 3.031 for G. decadactylus and 3.470 for P. senegalensis. Longevity was also estimated at 4.41, 5.90, 6.38 and 9.10year B. auritus, P. bellotti , G. decadactylus, P. senegalensis respectively.

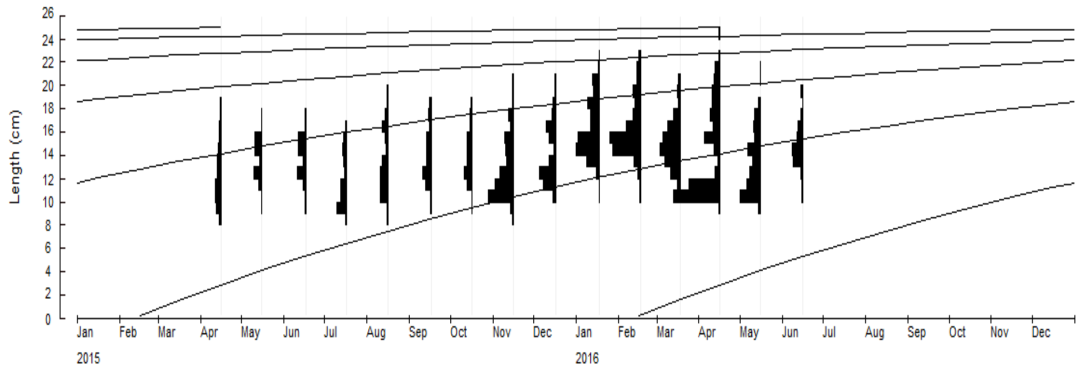

Figure 14 Monthly - length frequency distribution of Brachydeuterus auritus fitted with growth curves from ELEFAN suite of FiSAT II Routine.

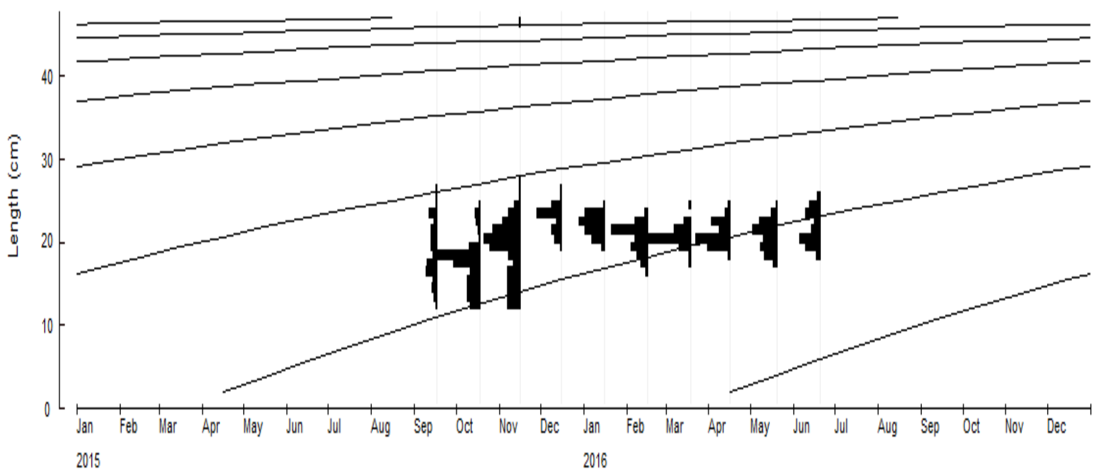

Figure 15 Monthly - length frequency distribution of Pagellus bellottii fitted with growth curves from ELEFAN suite of FiSAT II Routine.

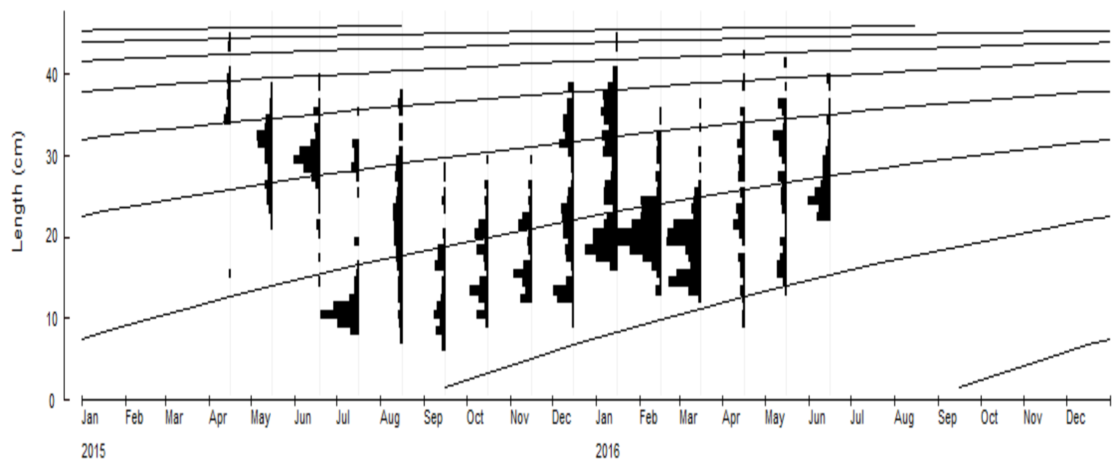

Figure 16 Monthly - length frequency distribution of Galeoides decadactylus fitted with growth curves from ELEFAN suite of FiSAT II Routine.

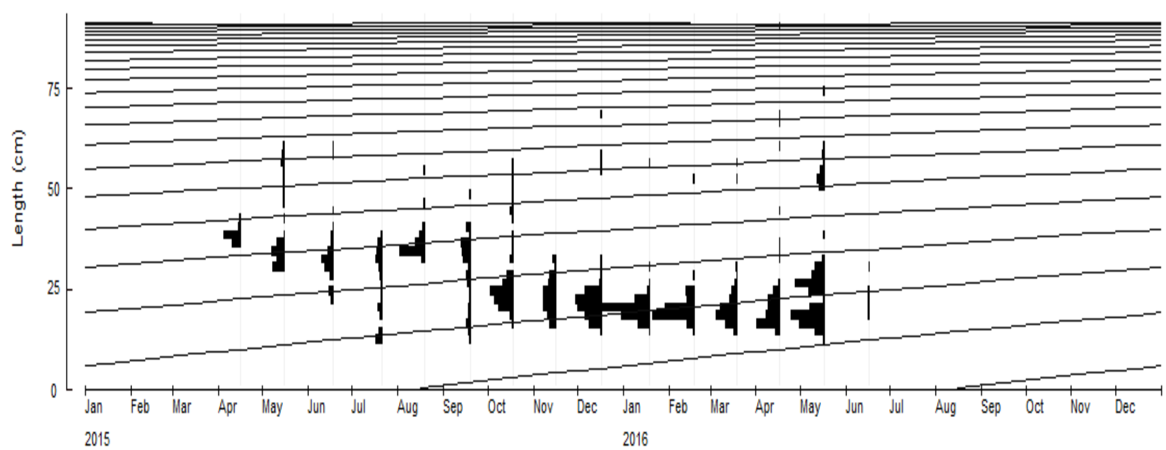

Figure 17 Monthly - length frequency distribution of Pseudotolithus senegalensis fitted with growth curves from ELEFAN suite of FiSAT II Routine.

9.4 Mortality Rates

The total mortality (Z) coefficients estimated from the length-converted catch curves were 2.82 for *B.* auritus, (Figure.14), 4.79 for *P.* bellottii, (Figure 15), 2.09 for *G.* decadactylus (Figure 16), and 1.55 for *P.* senegalensis (Figure 17).

Natural mortalities (M) were estimated using Pauly's empirical formula with an annual mean temperature of 26.5°. The natural mortality estimates for the species were 1.41 for *B.* auritus, 1.11 for *P.* bellottii, 0.93 for *G.* decadactylus and 0.61 for *P.* senegalensis.

The estimates for fishing mortality (Z-M) were 2.82, 4.79, 2.09 and 2.16 for *B.* auritus*, P.* bellottii, *G.* decadactylus and *P.* senegalensis respectively.

The mortality rates estimated for the four species indicated that fishing mortality contributed more to the total mortality of the populations examined except *B.* auritus where instantaneous natural mortality is the same as the rate of fishing pressure exerted on the fishery.

9.5 Exploitation Ratio

The exploitation ratio (E = F/Z) of the populations were estimated at 0.50 for *B*. auritus, 0.77 for *P*. bellottii, 0.55 for *G*. decadactylus and 0.72 for *P*. senegalensis. The E value of *B*. auritus indicated an optimally exploited fishery. The E values for the rest of the populations were all above the optimal exploitation level of 0.5 which indicates that the three stocks, *P*. bellottii, *G*. decadactylus and *P*. senegalensis are all overexploited.

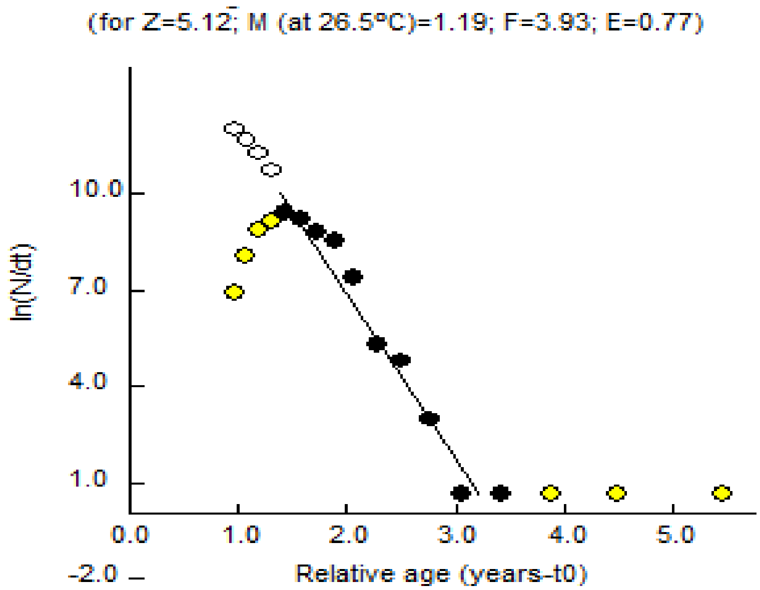

Figure 18 Length converted catch curve for Brachydeuterus auritus

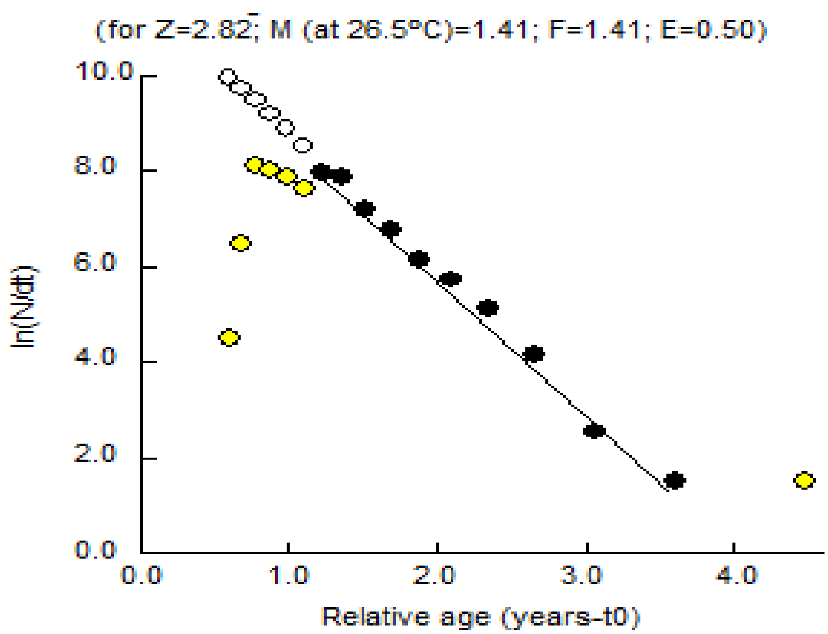

Figure 19 Length converted catch curve of Pagellus bellottii

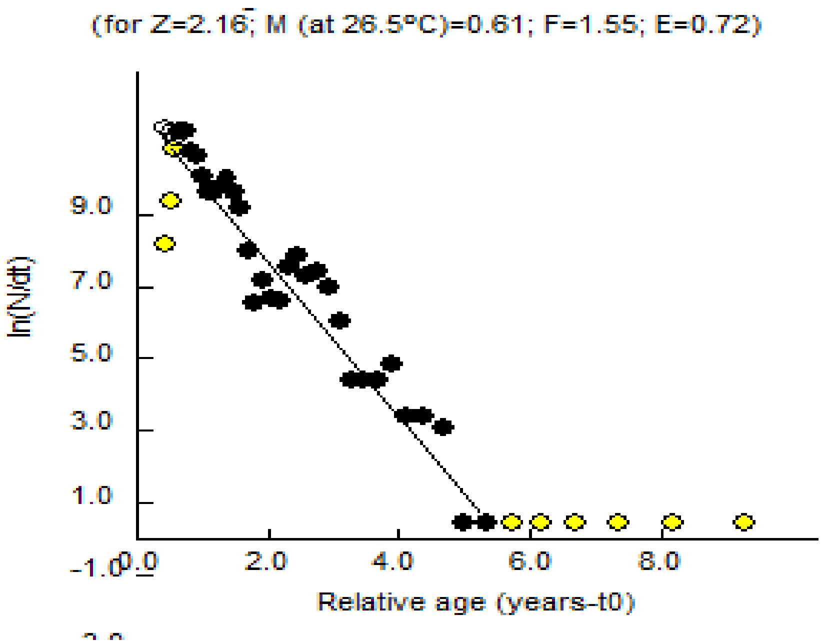

Figure 20 Length converted catch curve of Galeoides decadactylus

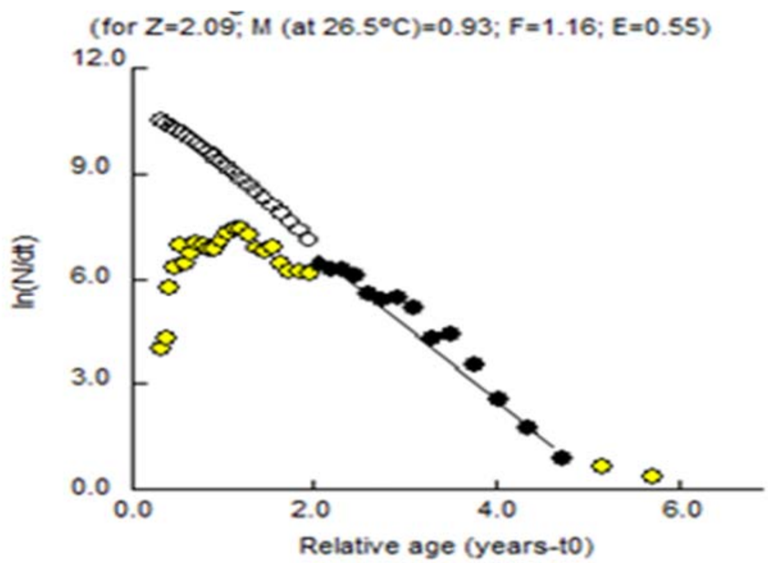

Figure 21 Length converted catch curve of P. senegalensis

Figures 18,19, 20, and 21 show the recruitment pattern of *B.* auritus, *P*. bellottii, *G*. dedactylus and *P*. senegalensis respectively. The recruitment patterns indicated year round recruitment for all the four species.

9.6 Recruitment

Table 3 Summary of Growth, mortality and exploitation ratios of the four demersals

Species	L_∞ (TL)	K (y^{-1})	t_o (year)	t_{max}(year)	Φ	F	M	Z	E
B. auritus	25.73	0.68	0	4.41	2.65	1.41	1.41	2.82	0.5
P. bellottii	46.5	0.51	0	5.9	2.659	3.93	1.19	5.12	0.77
G. decadactylus	47.78	0.47	0	6.38	3.031	1.16	1.16	2.09	0.55
P. senegalensis	95.0	0.33	0.0001	9.1	3.47	1.55	1.55	2.16	0.72

The recruitment pattern of *B.* auritus and *P*. senegalensis indicate a major and a minor recruitment with two peaks. The major recruitment for *B.* auritus appeared to occur between January and August peaking in May and the minor recruitment also appear to occur between September and December with a peak in October (Figure.22). Major recruitment for *P.* senegalensis appears to occur between January and June with a peak in May, the minor recruitment however occurs between August and December peaking in September (Figure. 25.).

The recruitment pattern of *P*. bellottii and *G*. decadactylus showed one peak. Recruitment pattern for *P*. bellottii indicates that recruitment occurs more between March and August with a peak in April (Figure 23) while that of *G*. decadactylus also shows much recruitment activity occurring from February to May with a peak in April. (Figure 24)

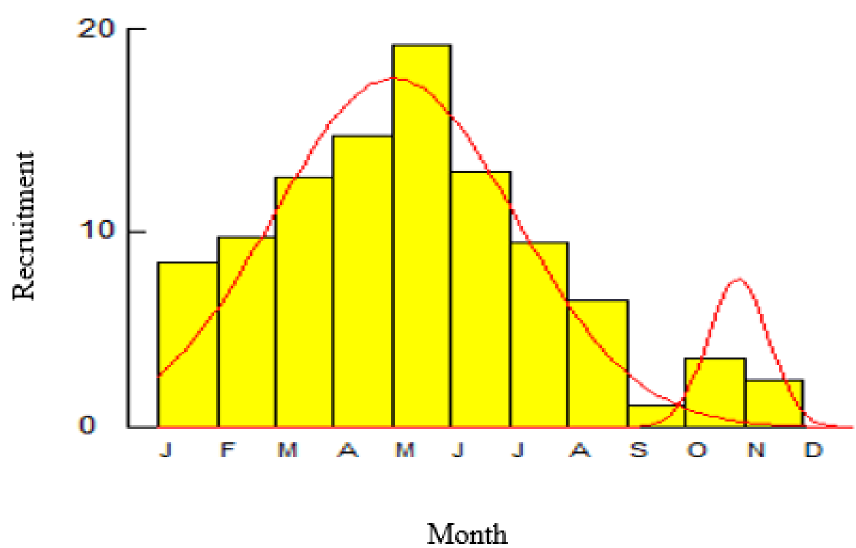

Figure 22 Recruitment pattern of Brachydeuterus auritus

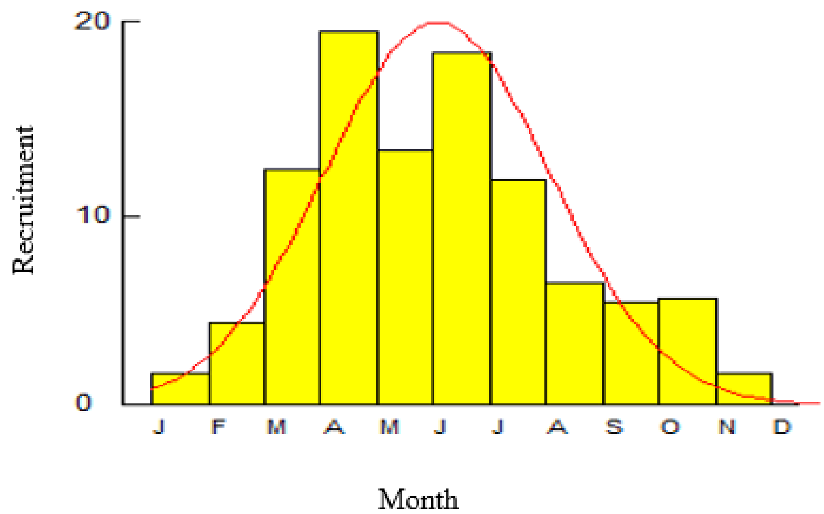

Figure 23 Recruitment pattern of Pagellus bellottii

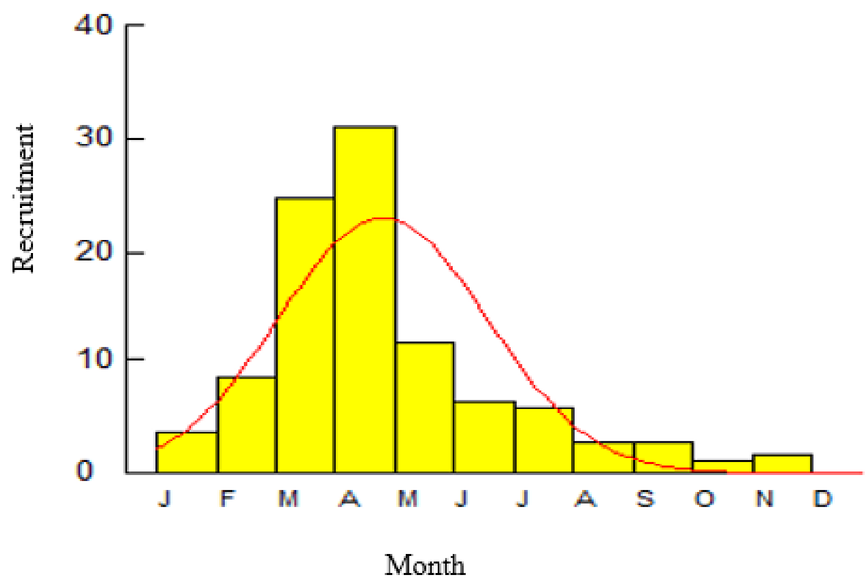

Figure 24 Recruitment pattern of Galeoides decadactylus

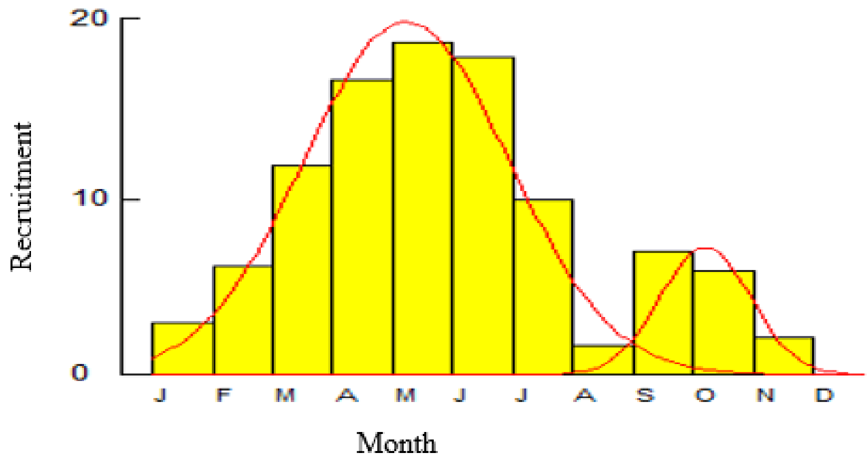

Figure 25 Recruitment patterns of Pseudotolithus senegalensis

SECTION 10: YIELD AND BIOMASS PER RECRUIT

The yield per recruit and biomass per recruit were determined as a function of L_c/L_∞ and M/K. the knife edge selection option of the Beverton and Holt yield per recruit model was used in the analysis. The input parameters for L_c/L_∞ and M/K are presented in Table 4.

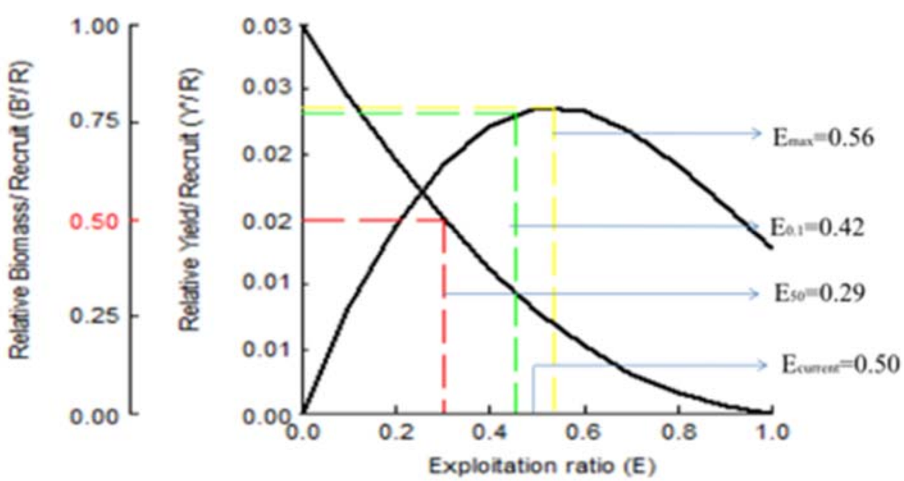

Figure 26 Yield per recruit and biomass per recruit curves of B. auritus

Figure 26 presents the yield per recruit and biomass per recruit of *B. auritus*. The optimum exploitation rate (E_{max}) which produces maximum yield, given length at first capture 8.5 cm, was 0.56 whereas the exploitation level at which the marginal increase in yield per recruit is 10% ($E_{0.1}$) was 0.42. The exploitation level, which corresponds to 50% of relative biomass per recruit of the unexploited stock (E_{50}), was 0.29 (Figure.26). The yield per recruit analysis of the species indicate that the current exploitation level ($E_{current}$ = 0.5) is below the exploitation level that gives optimal yield.

Table 4 Lc/L∞ and M/K input parameters for yield per recruit analysis

Species	**L_c/L_∞**	**M/K**
Brachydeuterus auritus	0.3	2.1
Pagellus bellottii	0.3	2.2
Galeoides decadatylus	0.1	2
Pseudotolithus senegalensis	0.1	1.8

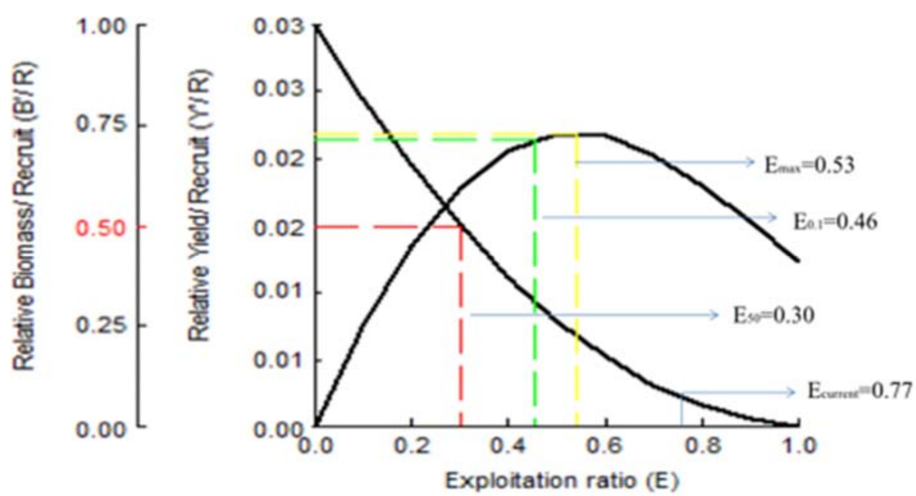

Figure 27 Yield per recruit and biomass per recruit curves for P. bellottii

Figure 27 presents the yield per recruit and biomass per recruit of *P. bellottii.* The optimum exploitation rate (E_{max}) which produces maximum yield, given length at first capture 12.5 cm was 0.53 whereas the exploitation level at which the marginal increase in yield per recruit is 10% ($E_{0.1}$) was 0.46. The exploitation level, which corresponds to 50% of relative biomass per recruit of the unexploited stock (E_{50}), was 0.30 (Figure 27). The yield per recruit analysis of the species indicate that the current exploitation level ($E_{current}$ = 0.77) is higher than exploitation level that gives optimal yield.

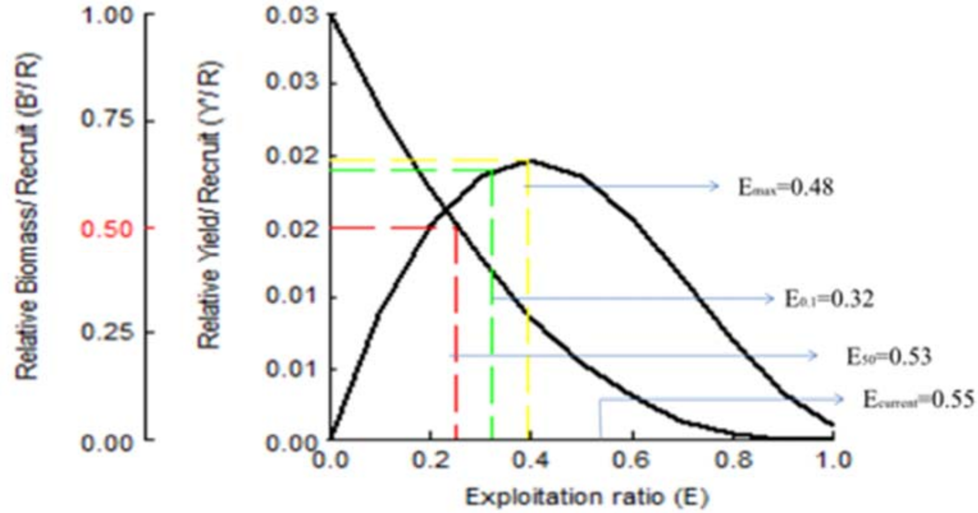

Figure 28 Yield per recruit and biomass per recruit curves for Galeoides decadactylus

Figure 28 presents the yield per recruit and biomass per recruit of *P. bellottii.* The optimum exploitation rate (E_{max}) which produces maximum yield, given length at first capture 11.5 cm was 0.48 whereas the exploitation level at which the marginal increase in yield per recruit is 10% ($E_{0.1}$) was 0.32. The exploitation level, which corresponds to 50% of relative biomass per recruit of the unexploited stock (E_{50}), was 0.53 (Figure 28). The yield per recruit analysis of *G. decadatylus* also indicate that the current exploitation level ($E_{current}$ = 0.55) is higher than exploitation level which gives optimal yield.

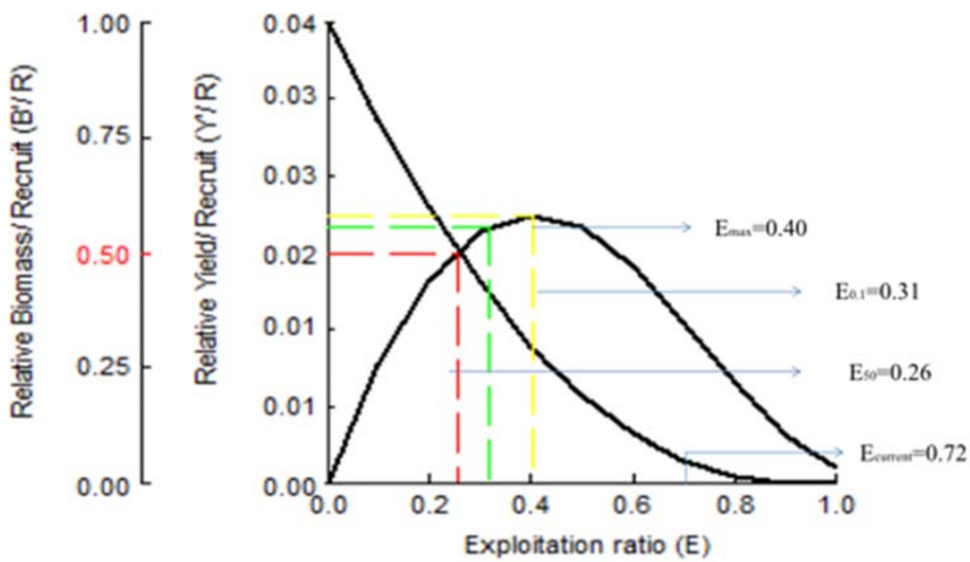

Figure 29 Yield per recruit and biomass per recruit curves for P. senegalensis

Figure 29 presents the yield per recruit and biomass per recruit of *P. senegalensis.* The optimum exploitation rate (E_{max}) which produces maximum yield, given length at first capture 12.5 cm was 0.40 whereas the exploitation level at which the marginal increase in yield per recruit is 10% ($E_{0.1}$) was 0.31. The exploitation level, which corresponds to 50% of relative biomass per recruit of the unexploited stock (E_{50}), was 0.26 (Figure 29). The yield per recruit analysis of *P. senegalensis* also indicate that the current exploitation level ($E_{current}$ = 0.72) is higher than exploitation level which gives optimal yield.

SECTION 11: SCATCH AND EFFORT STATISTICS

11.1 Variations in Catch, Effort and CPUE of Demersal (Fin Fish) Fishery

Twenty-five years' time series data of catch from FAO, and effort from FSSD analyzed. Generally, there were fluctuations in total demersal catch and effort over the two and half decades. The total demersal catch appears to be fluctuating around mean catch of 35000 tons.

However, total catch of the demersal fishery of Ghana is generally experiencing a downward trend while effort on the fishery showed an increasing trend (Figure 30). The fishery recorded decrease in catch from 38822 tons in 1990 to 22459 tons in 2003. Effort around that period was however, stable, 50 vessels. Constant increase in total demersal catch with a corresponding continuous rise in effort was observed from 2004 with 44751 tons to a peak of 66033 tons in 2008. Total catch dropped to 39381 in 2009 with slight decrees in effort. Generally, the fishery experienced steadily decrease in catch with gradual increasing effort from 2009 to 2011. A gradual rise in catch was recorded from 2013 to 2015 with decreasing effort (Figure 31).

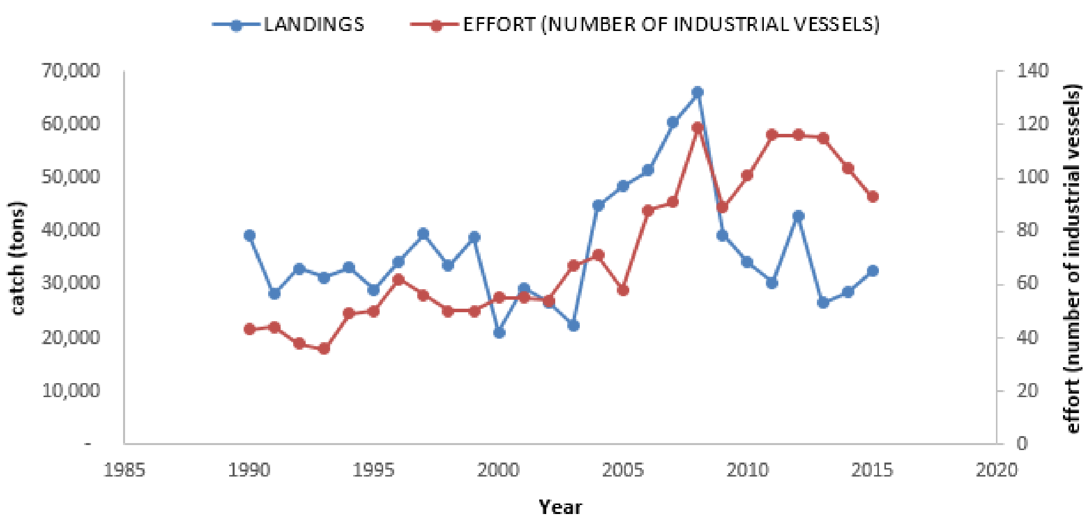

Figure 30 Total catch and effort trends of demersals (fin fish) in Ghana

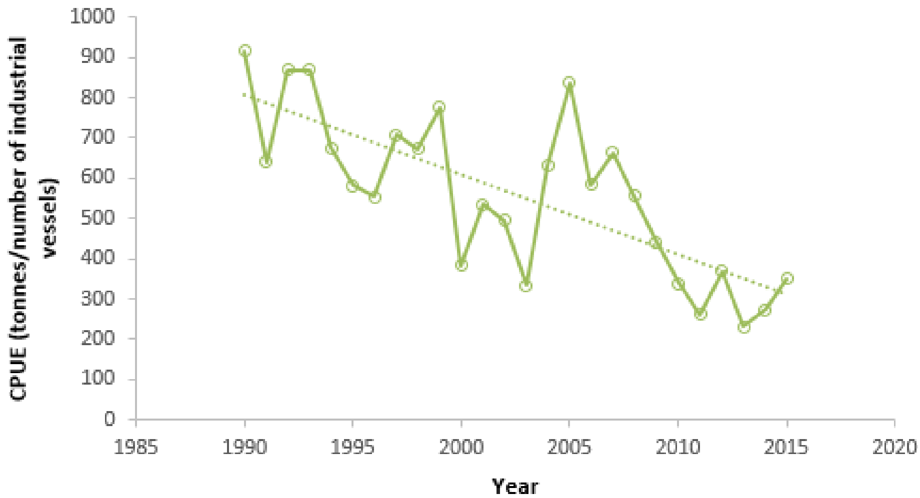

Figure 31 Variations in catch per unit effort (CPUE) of demersal fishery in Ghana

Variations in CPUE of the demersal fishery followed a similar trend as that of total annual catch for the period. CPUE generally showed a downward trend within the twenty-five year period. CPUE correspondingly increased in increasing catch and decreasing effort, and vice versa.

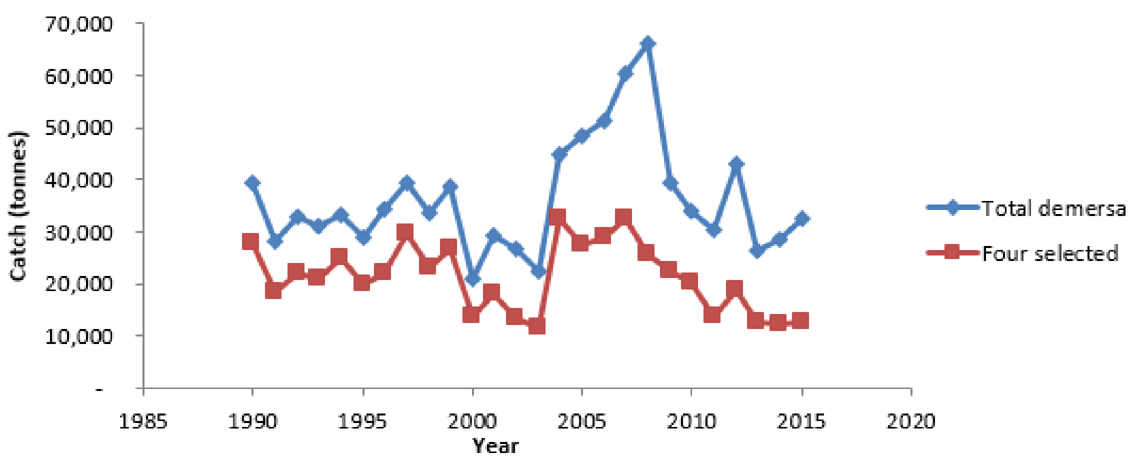

Figure 32 Total catch of all demersals (fin fish) and the four selected demersals

Variations in total catch of the four selected demersal species followed a similar trend as that of the overall demersal catch. Generally, total catch of the four demersals appears to be decreasing over the period. The four selected demersal species appear to have a heavy tow on the total demersal stocks in that periods where the total catch of the species increased, total demersal catch also increased and vice versa (Figure 32).

11.2 Variation in the Catch, Effort and Catch per Unit Effort (CPUE) of the Four Selected Demersal Fishery

Generally, the total annual catches of all the species fluctuated considerably with a general downward trend.

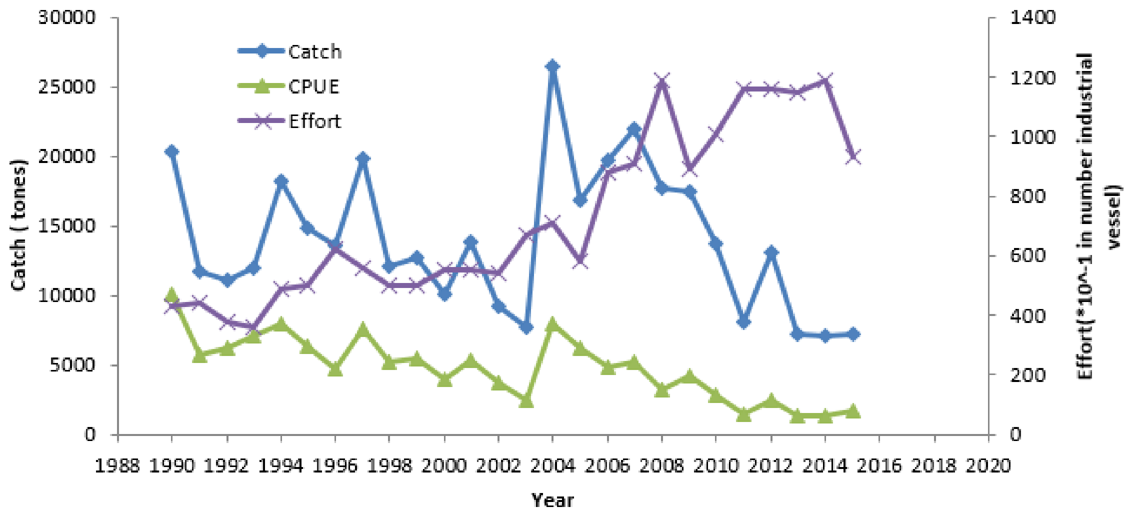

Figure 33 Total catch, effort and CPUE trends B. auritus in Ghana (form 1990-2015)

Figure 33 shows trends in annual catch, effort and CPUE of *B. auritus* over 25-year period. Total catch and CPUE fluctuated over the period. Generally, total catch of the species increased with increasing effort from 1990 to 2007 while catches declined with steady rise in effort between 2008 and 2015. The total annual catch of the *B. auritus* fishery peaked in 2004 with 26456 tonnes with 71 industrial vessels. There was continuous increase in effort from 2005 to 2014 with decreasing annual catch and correspondent decrease in CPUE.

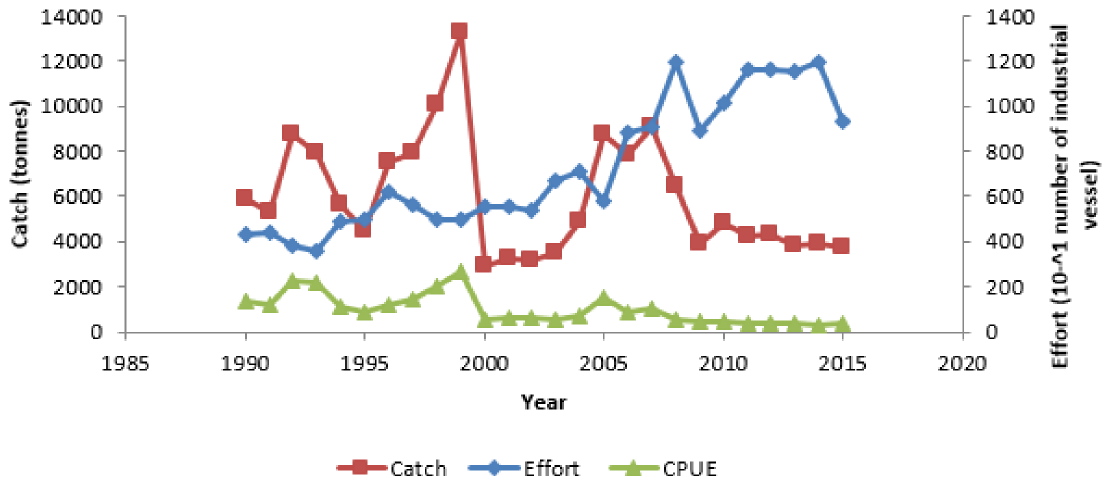

Figure 34 Total catch, effort and CPUE trends of P. bellottii in Ghana

The *P. bellottii* fishery has recorded alternate increase and decrease in total annual catches over the 25-year period. The CPUE also followed similar trends as that of the catch. Effort for the fishery however, generally increased from over the period (Figure 34). Annual catch of the species peaked 1999 with 13265 tonnes having a corresponding effort of 50 industrial vessels. The CPUE also peaked in the same year. The fishery experienced a sharp decline in the catch and CPUE in 2000.

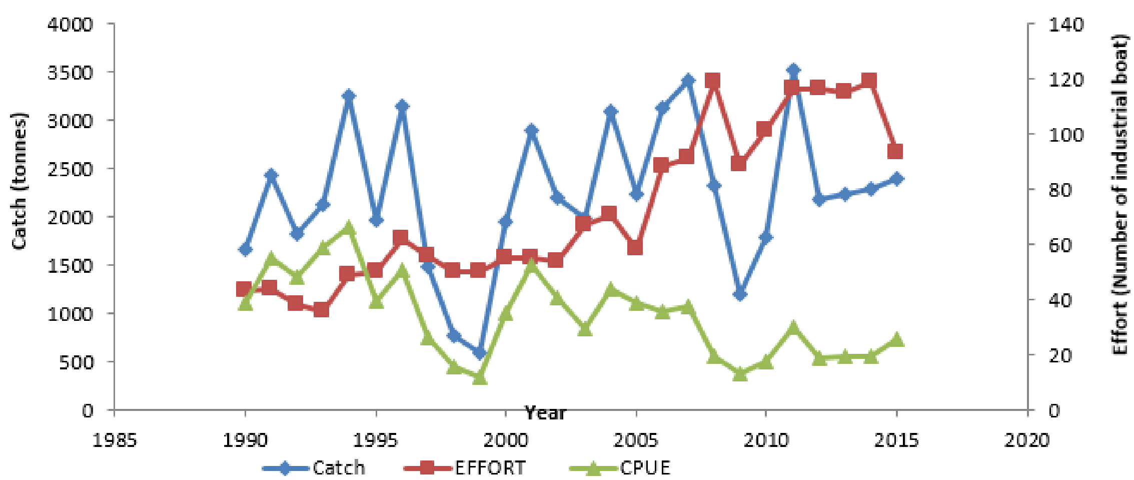

Figure 35 Total catch, effort and CPUE trends of G.decadactylus in Ghana

Galeoides decadactylus also showed an alternate rise and fall in the catches and its corresponding CPUE. The fisheries experienced a sharp decline with a corresponding decline in CPUE 1999.The highest catch for the 25 was however, recorded in 2011 (Figure 35).

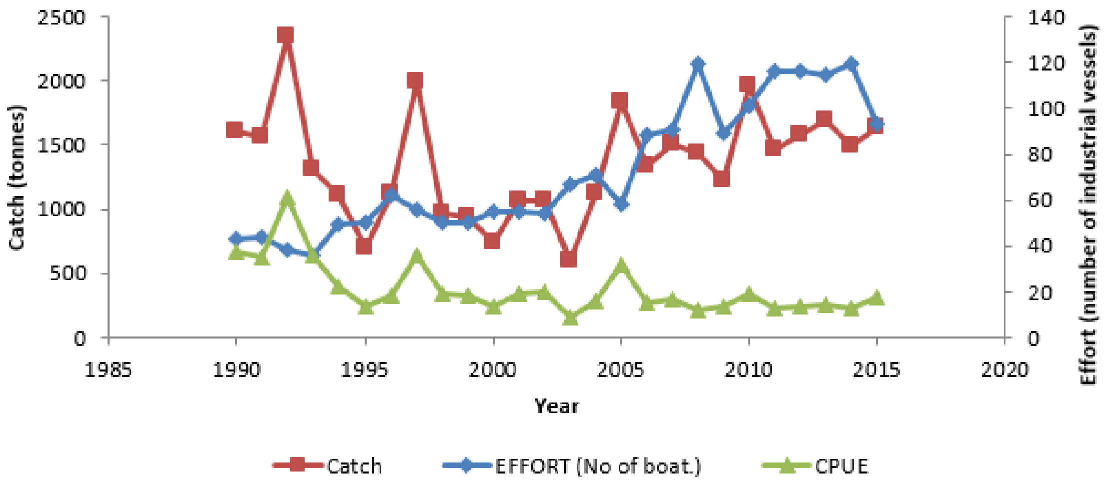

Figure 36 Total catch, effort and CPUE trends P. senegalensis in Ghana

P. senegalensis also showed an irregular alternate increase and decrease in catches and the corresponding CPUE over the period. The highest catch and CPUE were recorded in 1992 with 2340 tonnes and 61.6 respectively. The lowest catch was also observed in 2003 with 593 tonnes. Total annual catch for the species appears to fluctuate around an average catch of 1500 tonnes. (Figure 36…?..)

11.3 Maximum Sustainable Yield

The Schaefer's production model was used to estimate the maximum sustainable yield of the four populations of fish species and their corresponding level of fishing effort. The 25-year time series catch and effort data was used in the estimation of MSY and F_{MSY} for the fisheries. Figures 37, 38, 39 and 40 show the production curves for *B. auritus*, *P. bellottii*, *G. decadactylus* and *P. senegalensis* respectively. (Figure 41…?…)

The computed MSY of *B. auritus* was approximately 16094 tonnes and the corresponding effort (number of industrial vessel) was approximately 78 vessels (Figure 37). The MSY of *P. bellottii* was also around 6891 tonnes and the corresponding effort was 71 vessels (Figure 38). The MSY computed for *G. decadactylus* was approximately 2568 tonnes and the related effort was around 93 vessels (Figure 39). The MSY and F_{MSY} estimates for P. senegalensis were also 1583 tonnes and 97 vessels respectively.

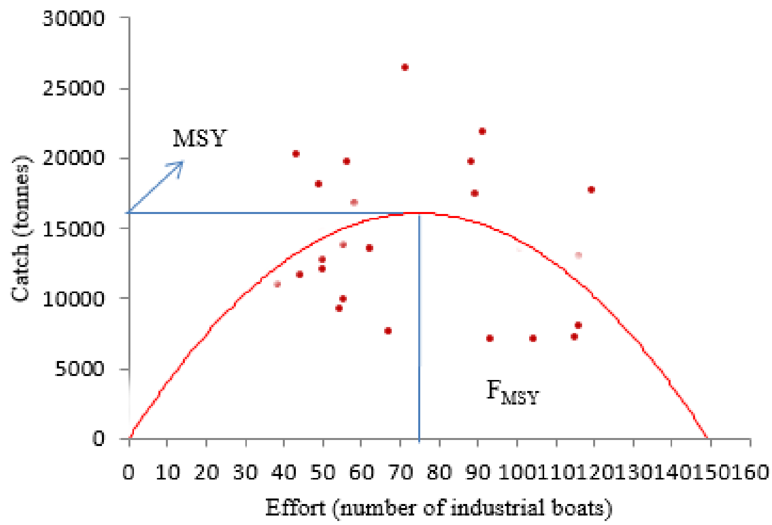

Figure 37 Maximum sustainable yield and its corresponding effort for B. auritus based on Schaefer's model

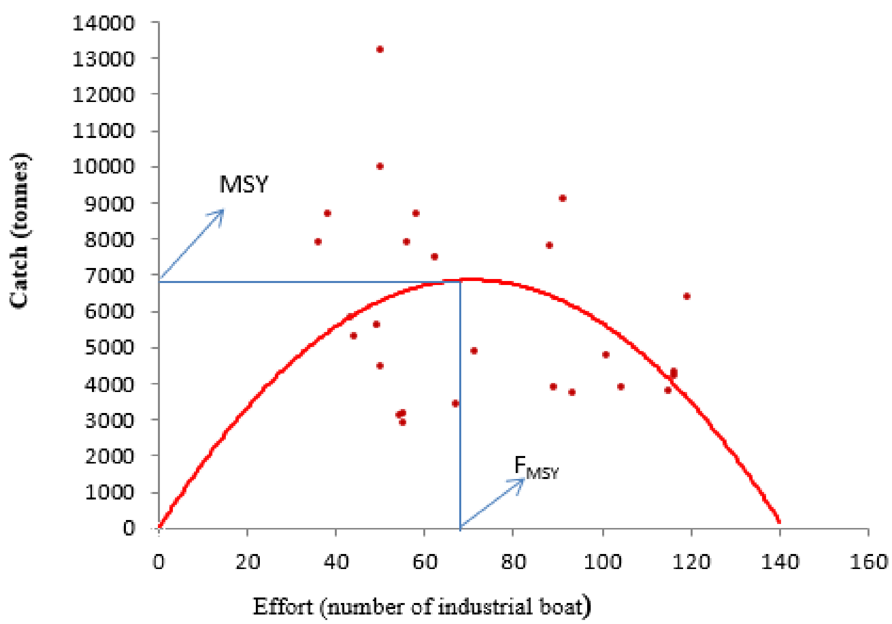

Figure 38 Maximum sustainable yield and its corresponding effort for P. bellottii based on Schaefer's model

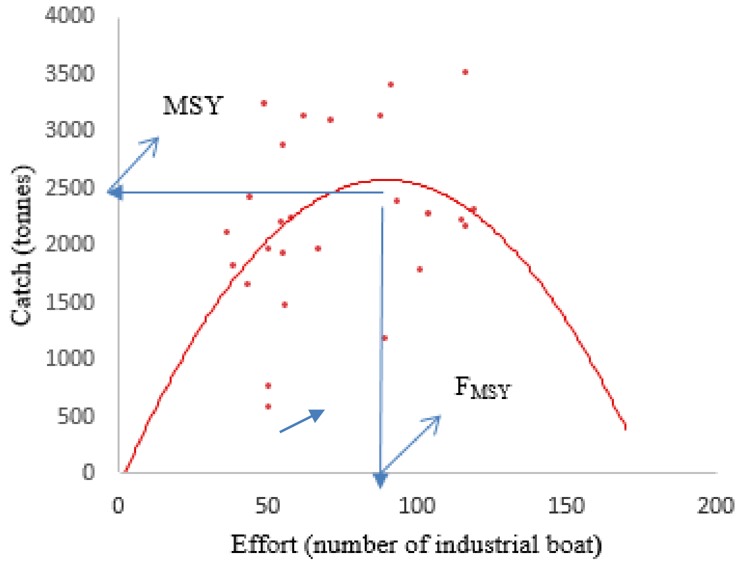

Figure 39 Maximum sustainable yield and its corresponding effort for G. decadactylus based on Schaefer's model

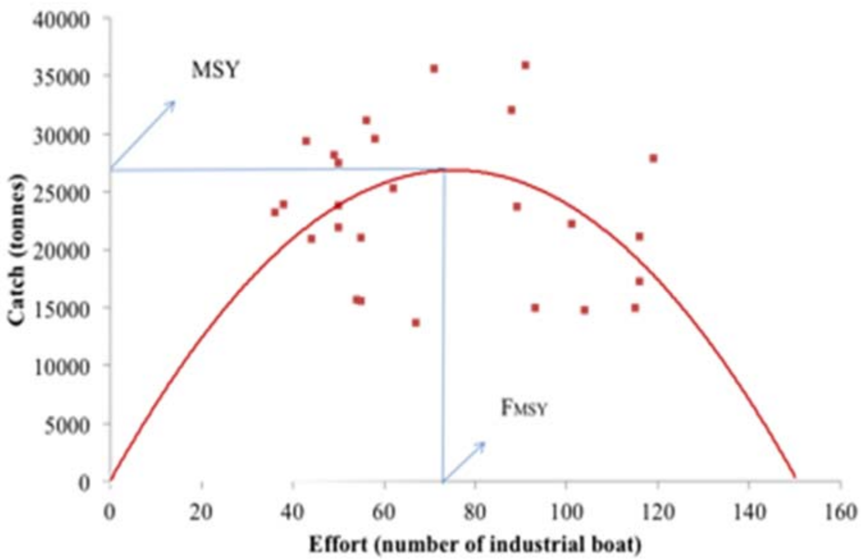

Figure 40 Maximum sustainable yield and its corresponding effort for P. senegalensis based on Schaefer's model

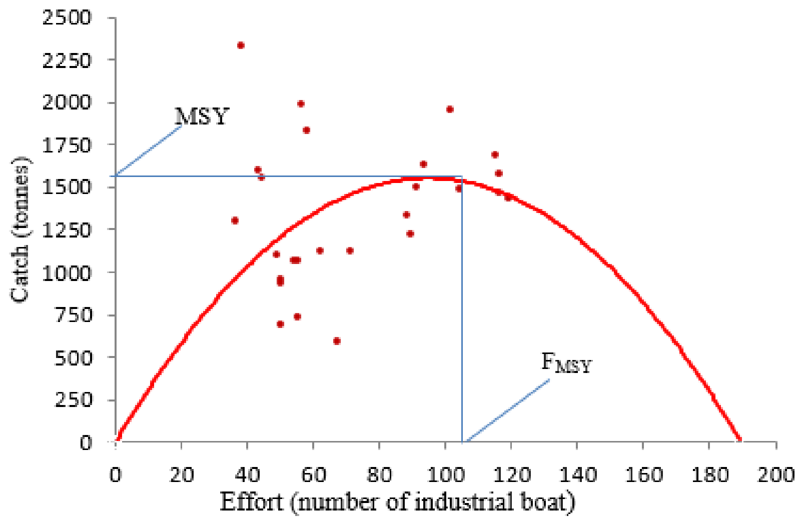

Figure 41 Maximum sustainable yield and its corresponding effort for the four demersals based on Schaefer's model

SECTION 12: REPRODUCTIVE BIOLOGY

12.1 Sex ratio

Table 5 presents the sex ratio of the four species under consideration. There was significant difference (P<0.05) between the number of males and females for all the four populations. *B. auritus* was predominately females while *Pseudotolithus senegalensis, Galeoides decadactylus and Pagellus bellottii* populations were male dominated.

Table 5 Sex ratios of selected demersal species

SPECIES	RATIO	P VALUES
Brachydeuterus auritus	1:2	P<0.05
Pseudotolithus senegalensis	1.7:1	P<0.05
Galeoidis decadactylus	2:1	P<0.05
Pagellus bellottii	1.6:1	P<0.05

12.2 Sex ratio at size

A confirmatory analysis was performed to determine the sex ratios at the various size groups of the species revealed the length at which the two hermaphroditic species, *G. decadactylus* and *P. bellottii* change from one sex to the other. In *G. decadactylus,* males dominated size classes below 31.5cm. A sharp decline in the number of males was observed from 31.5cm length class and above. This indicates that at 31.5cm, most of the males in the population change sex to females (Figure 44) *P. bellottii* also appeared to have most individuals change sex at a length of 31.5cm. (Figure 43)

B. auritus population had more females than males at all length classes (Figure 42). Generally, males dominated all the size classes of *P. senegalensis* except the lengths from 44 cm to 51 cm which had more females than males (Figure 45).

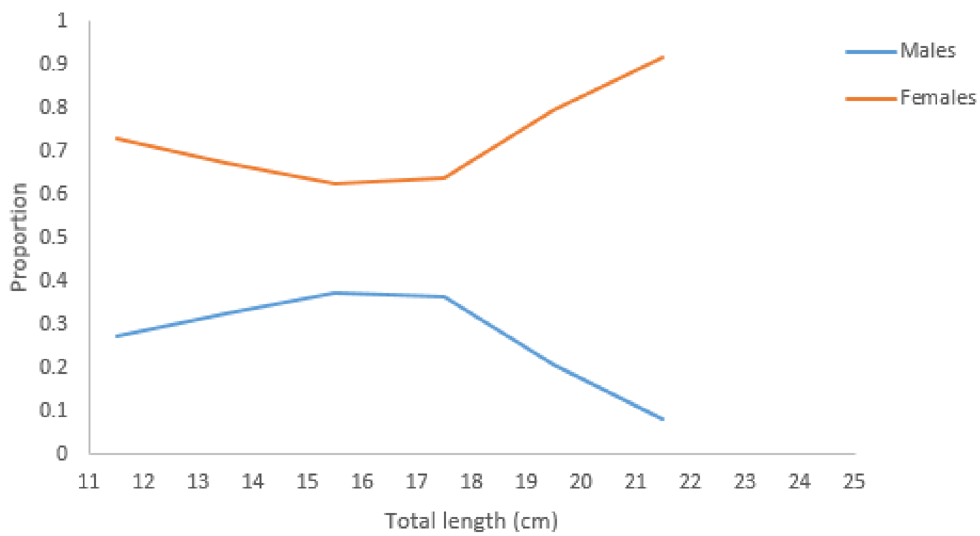

Figure 42 Sex ratios at size of B. auritus

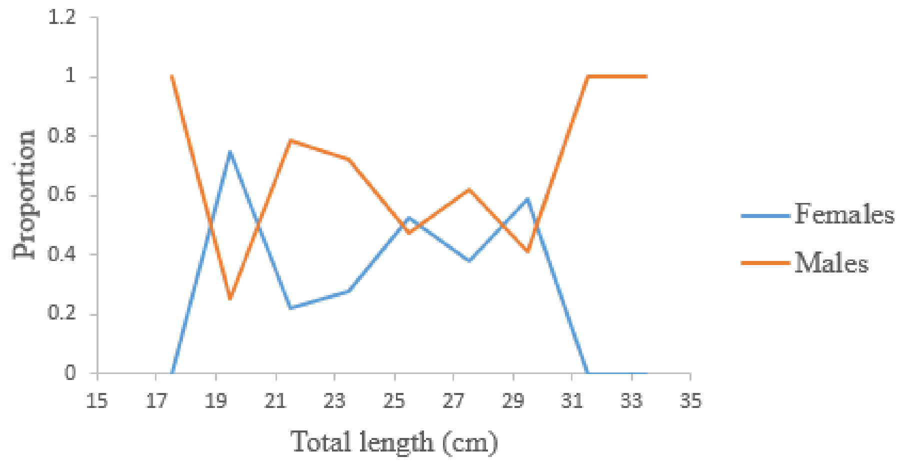

Figure 43 Sex ratio at size of P. bellottii

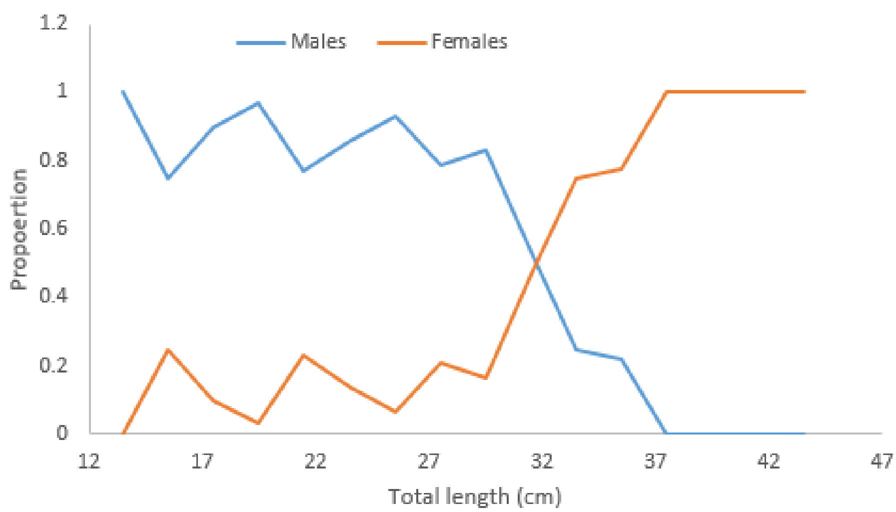

Figure 44 Sex ratio at size of G. decadactylus

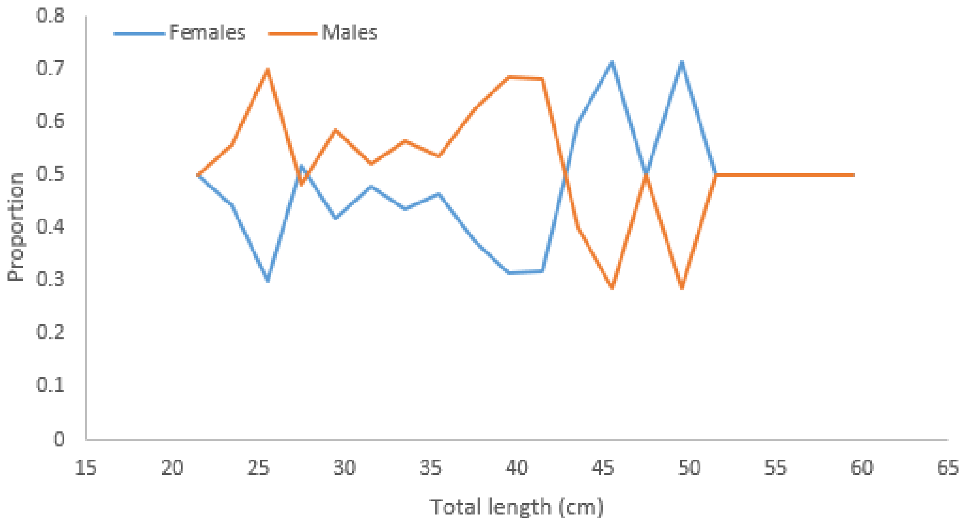

Figure 45 Sex ratio at size of P. senegalensis

12.3 Mean Length at maturity

The orgive method gave an indication of the mean length at which each of the four species mature. Figures 46 to 49 give information on the mean at maturity of *B. auritus*, *P. bellottii*, *G. decadactylus* and *P. senegalensis* respectively. All mean lengths were estimated with total length. In *B. auritus* and *P. senegalensis* mean length at maturity differed from males and females while mean lengths were same for both sexes in *G. dacadactylus* and *P. bellottii*.

Mean length for males was about 16.8cm and that of females was about 17.5 cm in *B. auritus* population (Figure 46). Mean length for males and females in *P. senegalensis* population were 35.5 cm and 40.0 cm (Figure 49). Mean length for males and females of *G. decadactylus* was 27.5 cm (Figure 48) and that of *P. bellottii* was 27 cm (Figure 47).

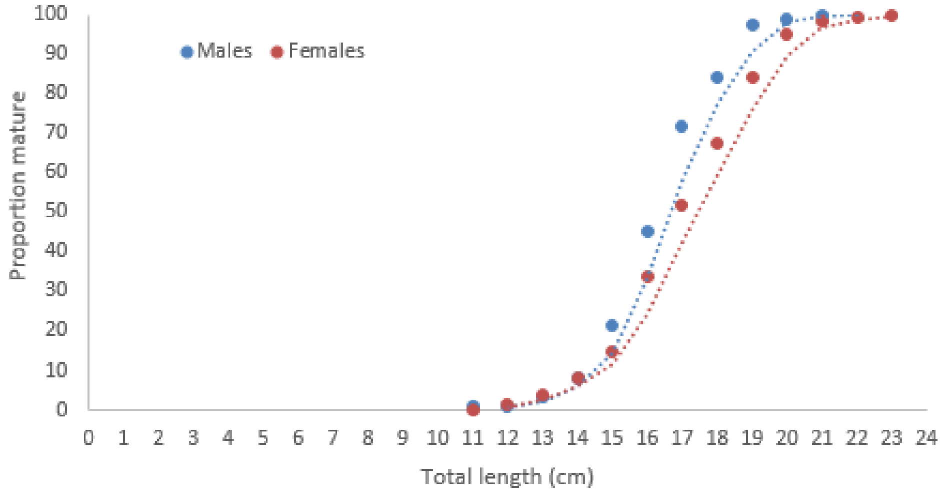

Figure 46 Mean length at maturity of B. auritus

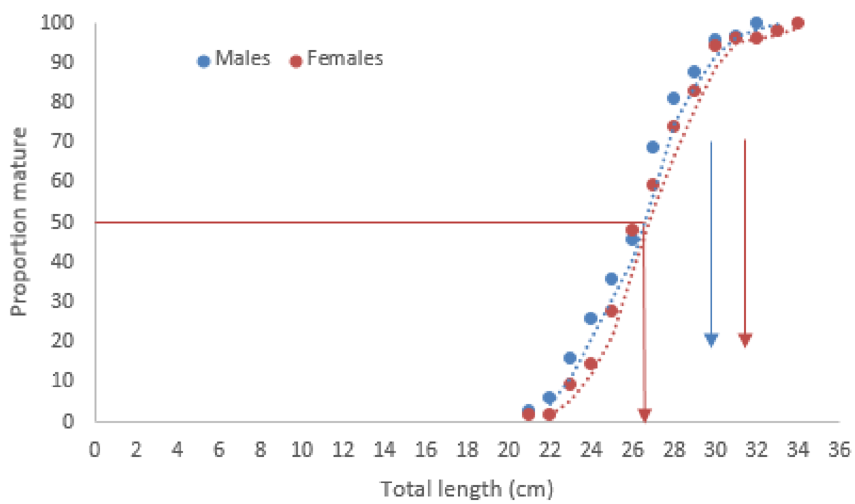

Figure 47 Mean length at maturity of P. bellottii

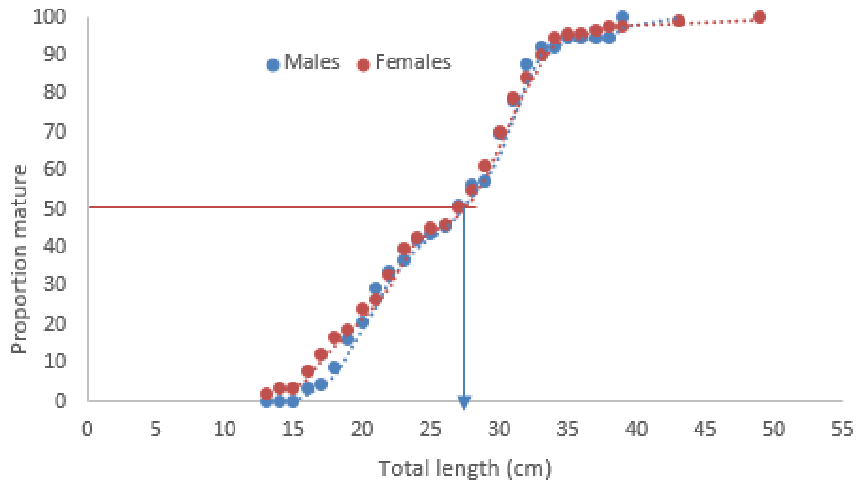

Figure 48 Mean length at maturity of G. decadactylus

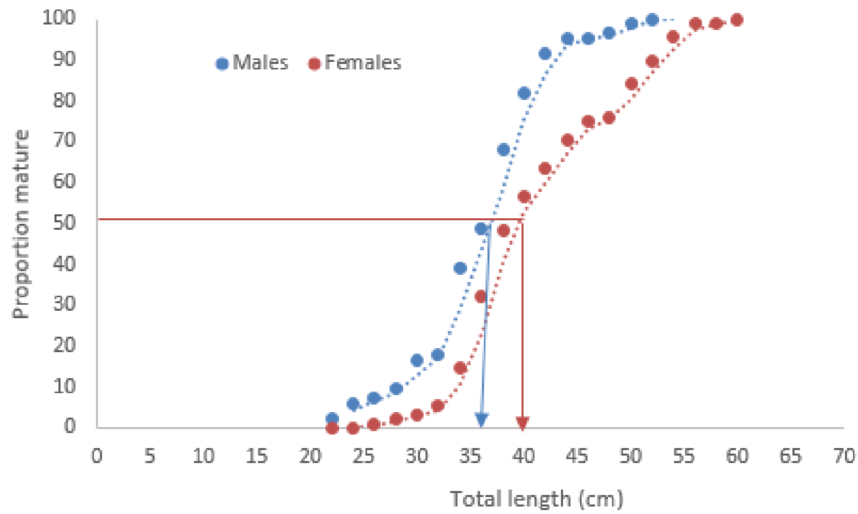

Figure 49 Mean length at maturity of P. senegalensis

12.3 Spawning Season

Monthly percentage frequency of spawning individuals of the respective species was determined to ascertain the spawning periods of the species. Figures 50 to 53 displays the spawning periods of B. auritus, P. bellottii, G. decadactylus and P. senegalensis respectively. B. auritus appears to spawn throughout the year with intense breeding activities occurring between January to June (Figure 50). There was no sample for reproductive study in May 2016 for B. *auritus* because fish Mummies only allowed fish measurements and not buying of fish species that very month.

P. bellotii also appears to spawn mainly between April and June though some breeding activities was observed in January, September and December (Figure 51). *G. decadactylus* also appears to have two spawning peaks, January and May. Minor spawning activity were in some other months (Figure 52). The study could not elicit the spawning peaks of *P. senegalensis* because monthly samples for reproductive studies were not enough to serve as a representation of the population. However, the analysis gave an indication that the species spawn all year round, the peak of the spawning season could not be determined (Figure 53).

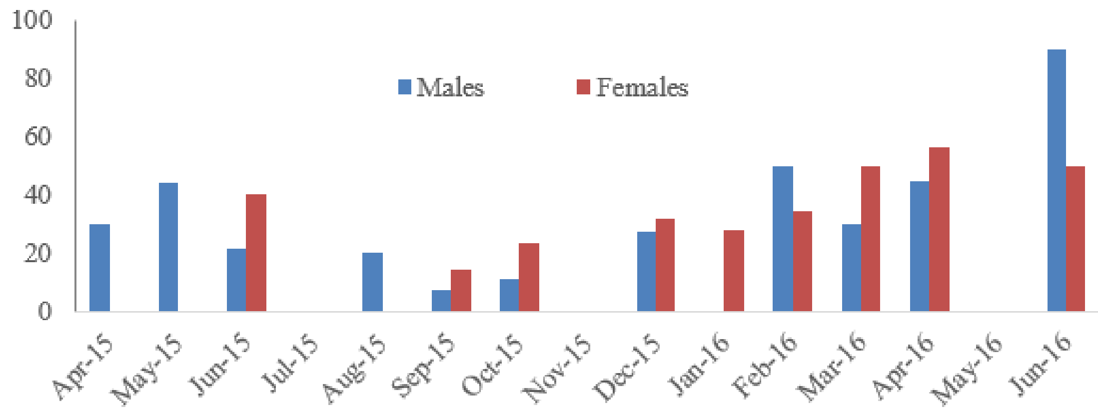

Figure 50 Percentage frequency of spawning individuals of Brachydeutertus

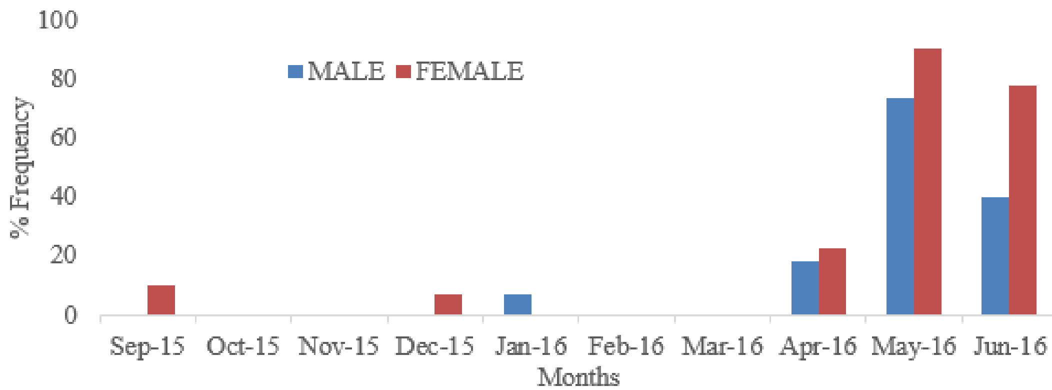

Figure 51 Percentage frequency of spawning individuals of Pagellus bellottii

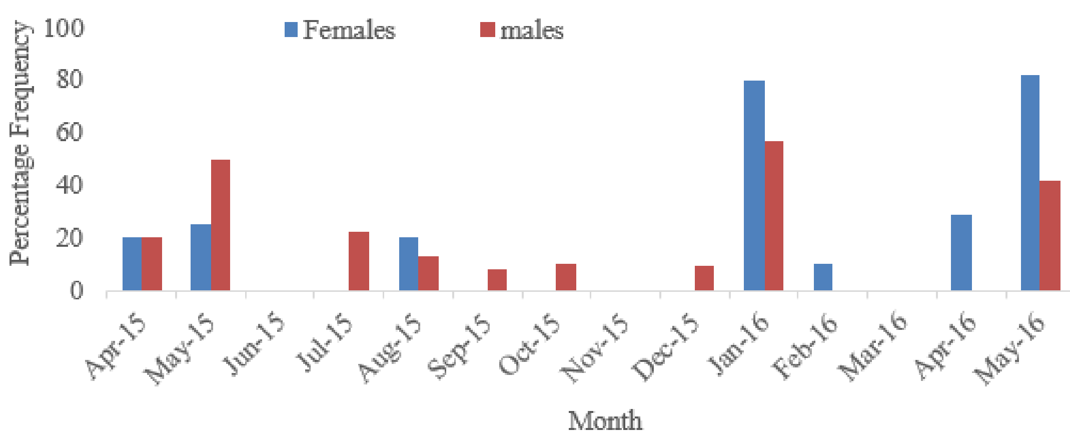

Figure 52 Percentage frequency of spawning individuals of Galeoides decadactylus

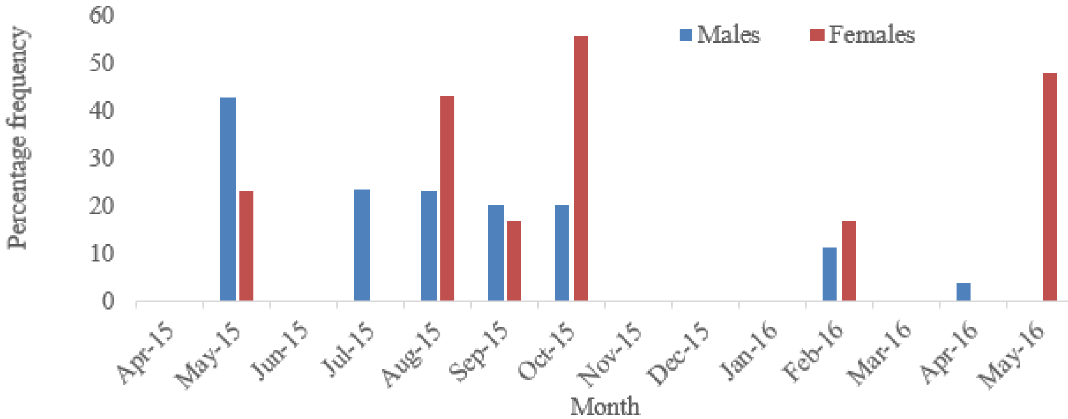

Figure 53 Percentage frequency of spawning individuals of Pseudotolithus senegalensis

SECTION 13: CHARACTERIZATION OF GEARS USED IN THE DEMERSAL FISHERIES OF GHANA

Table 6 presents a description on the fishing gears used by fishers to catch demersals. The gears include trawl net, bottom gill net, hook and line and the beach seine. The table describes the type of materials used in making the nets, size of canoes, engine capacity etc. and the species caught with these gears.

Table 6 Description of Fishing Gear Used in the Western and Central Region

Gear Name	Local Name	General Description	Species Caught
Trawl	Tweewui	They are used to target demersals fishes. They employ 5-15 crewmen depending on the size of the vessels. About 2- 3 fishing nets are used per fishing trip. Trawlers normally make about 2 trips per week. The mesh size of the nets used ranges between 1-2 inches and 3-5 inches. The size the net used is about 10-30 yards. There are about 5-10 floats and 10-50 leads on each net used. The vessel uses an outboard motor of an engine capacity of 30-150Hp. They use premix fuel during their trips but depend on petrol when there is a shortage of premix fuel. They spend about GH¢100- GH¢ 1000. They earn about 2 times the amout spend during their trip or more depending on the season. They earn more during the major fishing season. During fishing, they normally fish at a depth of about 10-60 fathoms and spend about 3hours per trawl. They fish in Sekondi, Axim, Ankobra, Shama, Komenda, Ada etc. waters depending on the season.	All demersal fishes
Bottom set gill net	Tenga	The length of this net is 10 yards and can be joined together with a depth of 2-3 yards. The material used is monofilament. It has mesh sizes of 1½, 1¼, $3^1/_2$ and 4inches. This gear is operated by 1-5 crew members. These nets are used to catch both demersal and pelagic species. It is made from polyethylene material which could be about 200-yard-long and 1.5 yards wide. They can also be joined to get any	All demersals

Gear Name	Local Name	General Description	Species Caught
		required length or dept. It is operated from small and medium-sized vessels. They set off at about 3.00 a.m. and land at 2.00 p.m. the same day. This gear is set for about 3-4 hours before it is hauled. They are most often used in the minor season. There are two types of canoes used by the fishermen. The motorized canoes and the non-motorized ones. The motorized type of canoe is approximately 30m long and 2m wide made from a single dug out log. The preferred wood is Wawa. Above the dugout, the hull is planked. Outboard motors of 40 HP are used. The non- motorized canoes use paddles. They are dug out logs of about 6-12 yards in length and about 2 yards in width	
Hook and Line	Asosow	It targets big demersal fishes as well as large pelagic. They employ 5-15 crewmen. They use hooks with numbers ranging from 1- 20 inscribe on them. They signified the different sizes of the hooks. The lines used are also of different sizes with numbers 8, 10, 12, 14, 16, 20 inscribed on them. They are made of nylon and about 50-200 yards. They normally use motorized canoes These are mostly used by artisanal fishermen who use the hook and line. Wawa is usually used in constructing. They usually spend between 6-8 days on an expedition. They leave anytime they wish and fish throughout the week. They also use ice blocks to preserve their catch because of the number of days spent on an expedition. They use sardines as bait to catch the specific species they go in for. They use anchors with 10mm anchor ropes to stabilize the canoe whilst they fish. The canoe uses outboard motors of 40 HP. They also use premix fuel.	All demersal

Gear Name	**Local Name**	**General Description**	**Species Caught**
Beach Seine	Tweewui	They employ 1-5 crew members. The average distance from the shoreline to where the net is set is about 1 to 2 km. The net has a mesh size of about 2-4inches. The size of beach-seine nets varies from 480 m long (excluding ropes) by 8 m deep to 1 640 m long by 22m deep. The net is mainly operated in the areas of concentration of the young. It requires 30 to 50 men to haul a small net and 50 to 100 men for a big net. A canoe is required to go offshore to cast the net. The net may be left in the sea for about a day before it is hauled.	All demersals

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