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Trends and effects of Gears on the catches of Tuna landed in Ghana

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ABSTRACT

The trends and effects of gears on catches of tuna landed in Ghana by the artisanal, semi-industrial and industrial sectors were analysed over a ten-year period (2001 to 2010). Greater catches were made by the industrial sectors of about 698,754 metric tons out of 846,223 metric tons and skipjack tuna *Katsuwonus pelamis* dominated the catches of tuna. Of all the gears used in exploiting tuna in the Ghanaian coastal waters, the purse seine gear used in the industrial sector made the highest catches of tuna of about 374,218 metric tons. Analysis of variance was used to ascertain whether there was significant difference in the quantity of tuna caught using the different gears; for *Thunnus albacares* P-value (3.25E-13) < significant level (0.05), for *Thunnus obesus* P-value (0.001437) < significant level (0.05), for *Katsuwonus pelamis* P-value (1.04E-15) < significant level (0.05) for *Auxis thazard* P-value (2.41E-06) < significant level (0.05) and for *Euthynnus alleteratus* P-value (8.14E-07) < significant level (0.05). It was observed that fishing in the Ghanaian waters is having a large impact on the biomass level; and the current level of exploitation of about 80,000 metric tons of tuna averagely per annum appears not to be sustainable in the long term, unless the high recent reports of recruitment is maintained. The purse seine gear employed in the industrial sector was the only gear that showed relative increase in the percentage growth rate in output of all the tuna species in the ten-year period. These were 18%, 17%, 16%, 11% and 6% for *Thunnus obesus, Euthynnus alleteratus, Auxis thazard, and Katsuwonus pelamis* respectively. This could be attributed among others to the fact that the purse seiners fish around fish aggregating devices (FADs) and also use relatively more sophisticated equipment. It is recommended that detailed tuna species stock assessment should be undertaken to enable adoption of improved and adaptive management approaches.

Introduction

In Ghana, marine fisheries have been the most important aspect of the fishing industry in terms of local fish production, delivering more than 80% of total fish supply. The marine fishing industry in Ghana with a coastline of 550 km, stretching from Aflao in the East to Half Assini in the West has three sectors, namely Artisanal (small-scale), Semi-industrial (inshore) and Industrial sectors (Amador *et al*., 2006).

In the artisanal sector, various fishing gears are employed and the fishing craft used is the dugout canoe. The canoes operate from 302 landing sites located in 186 fishing villages and usually produce about 60% of the total fish production in Ghana (Akyempon *et al.*, 2014). The semi-industrial sector comprises mainly locally built, wooden-hulled vessels measuring between 8 and 37m long. The sector operates using bottom trawl nets or purse seine nets depending on the season. The inshore vessels operate from 7 landing sites and produce about 5% of the total fish production in Ghana. The industrial sector comprises mainly large-steel hulled foreign-built trawlers, tuna bait-boats and tuna purse seiners. The Industrial vessels operate only from 2 landing sites where there are suitable berthing facilities and produce about 20% of the total fish production in Ghana. The species exploited by the various sectors are both pelagic and the demersal species. Among the large pelagic species being caught and landed by the various sectors, is Tuna.

Tuna is a collective term for saltwater finfish that belong to the Tribe Thunnini, a sub-grouping of the Mackerel family (Scombridae). Thunnini comprises fifteen species across five genera which are *Allothunnus*: slender tunas, *Auxis*: frigate tunas, *Euthynnus*: little tunas, *Katsuwonus*: skipjack tunas and *Thunnus*: albacores, true tunas, the sizes of which vary greatly (World Tuna Trade, 2013). Tuna is a highly migratory species and its seasonal migration patterns appear to vary, depending on age class and fish size. Their circulatory and respiratory systems are unique among fish, enabling them to maintain a body temperature higher than the surrounding water. Tuna, which is an active agile predator has a sleek, streamlined body and is among the fastest-swimming pelagic fish, capable of speeds of up to 75 kilometre per hour or 45 miles per hour (World Tuna Trade, 2013). Tuna torpedo-shaped bodies streamline their movement through water and their special swimming muscles enable them to cruise the ocean with great efficiencies found in warm seas (World Wildlife Fund, WWF, 2014). Tuna are remarkable and impressive wild animals and they swim incredible distances during migration. These extraordinary marine animals are also integral to the diet of millions of humans and are one of the most commercially valuable fish (WWF, 2014).

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The Tuna fishery is one of the most important marine fisheries in terms of volume and value of landing. In Ghana, commercial tuna fishery started in 1962 (Kwadjosse, 2009). In the Tuna fishery there are various management measures imposed on regional scales, particularly in areas where tuna fishery bodies have been operational for a long time like the International Commission for the Conservation of Atlantic Tuna (ICCAT). These measures include size limits, fishing effort restraints, catch limits, seasonal and geographical closures and restrictions on the use of Fishing Aggregating Devices (FADs) (Miyake *et al.*, 2010). However, in tuna fisheries the adaptation and the implementation of management measures have become difficult in recent years due to global excess fishing capacity. According to Regional Fisheries Management Organisation (RFMO) tuna stocks are approaching or exceeding their full exploitation level; Yield per recruit (Y/R) is reducing due to increasing juvenile catches, competition among gear types has been accentuated and global fishing capacity has risen (Miyake *et al.*, 2010).

In Ghana, the fishing gears which are commonly used in exploiting tuna are; "Poli/Watsa", Purse seine, Pole and line, Drift gillnets, Longline and Trolling (Doyi, 1984).

Tuna is an important commercial fish, an important source of income and employment for many coastal countries. For some of the coastal countries, the tuna resources within their 200 nautical mile Exclusive Economic Zones (EEZs) represent their only significant renewable resource and their best opportunity for economic development (Secretariat of the Pacific Community, SPC, 2010).

Tuna is an excellent source of heart-healthy niacin, free radical-scavenging selenium and muscle-building protein. Tuna is also a very good source of energy, omega -3 fatty acids, bone-healthy phosphorus and magnesium, and heart-healthy potassium.

According to the International Seafood Sustainability Foundation, (ISSF, 2012)-Status of the world fisheries tuna report, the fishing pressure on tuna has increased greatly on the global scale indicating an overexploitation. Hence, it is essential that mechanisms be implemented to maintain the degree of exploitation at levels that will ensure that the populations of tunas are maintained at desired levels of abundance. These have necessitated the need to review the trends and impacts of the fishing gears on the tuna catches.

Materials and Methods

Study Area

The coast of Ghana has been divided into three possible geopolitical zones using the length of the coastline: Eastern, Central and Western coasts. The Volta and Greater Accra regions constitute the eastern coast considering the short coastline of both regions, Central region for the central coast and the Western region constitute the western coast and also has the longest coastline. This study covered the entire coasts. The artisanal sector has 302 landing sites/beaches, comprising 49 in Volta region, 59 in Greater Accra region, 98 in Central region and 96 in Western region (Akyempon *et al.*, 2014).

The semi-industrial sector has seven landing beaches (Tema, Apam, Elmina, Mumford, Sekondi, Takoradi and Axim); Tema in the Greater Accra region, Apam, Elmina and Mumford in the Central region and Sekondi, Takoradi and Axim in the Western region (Figure 3.1).

The industrial sector has only two landing sites (Tema and Takoradi); Tema in the Greater Accra region and Takoradi in the Western region.

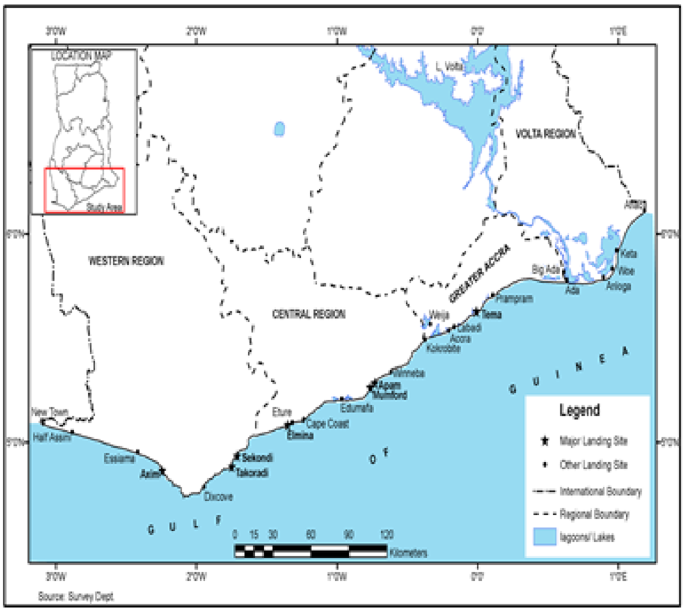

Figure 1: A coastal map of Ghana, showing the major and other landing sites

Data collection

This study covers the four coastal regions (Volta, Greater Accra, Central and Western) and the population of the study consists of all the landing sites of the three sectors; the artisanal, semi-industrial and the industrial.

In collecting the catch data from the artisanal sector, only 50 landing sites were targeted out of about 302 landing sites. Sampling was done randomly and in three tiers (number of vessels, number of days and number of landing sites). Sampling was done fortnightly to obtain the catch data. In collecting the catch data from the semi-industrial sector, all the landing sites were targeted due to the small sample size and sampling was done randomly and in two tiers (catch by units and number of days). Sampling was done fortnightly to obtain the catch. In collecting the catch data from the industrial sector, the total landings by the various fleets obtained from catch returns of the captain's log book were used in this study. The catch returns were submitted by the fishing companies on quarterly basis to the Fisheries Scientific Survey Division (FSSD), Tema of the Fisheries Commission. There are about 13 purse seiners and 15 bait boats.

Statistical Analysis

Desktop analysis was done using ArtFish Software (FIGIS, 2007) for processing the data from the artisanal and semi-industrial sectors and AVDTH Software developed by Le Chauve in the year 2001 (Bannerman *et al*, 2009) for processing the data from the industrial sector (FSSD).

In order to show the annual series of total catches of tuna made by the Artisanal, Semi-industrial and Industrial sectors, bar and line graphs were used. The trend of tuna catch rate was established using line graphs. Analysis of variance (ANOVA) of the SPSS package which is a parametric test was used to ascertain whether there was significant difference in the quantity of tuna caught using the different gears.

The growth rate model was used to determine the growth of fish production over the ten-year period. The line graph was employed to trace the general direction of production over the period under study. The equation was written as:

$$\text{Ln}(Y) = W + \beta t \qquad \text{(Solow and Swan, 1956)}$$

Where, Y is the dependent variable which represents the quantity of fish produced.

β is the growth rate of production over the period t (exogenous variable), is the period (time) of producing the fish. W represents a constant amount (term).

Results

The tunas considered were Yellowfin *Thunnus albacares*, Bigeye *Thunnus obesus*, Skipjack *katsuwonus pelamis* and two others; Frigate *Auxis thazard* and Atlantic Little Tuna *Euthynnus alleteratus*.

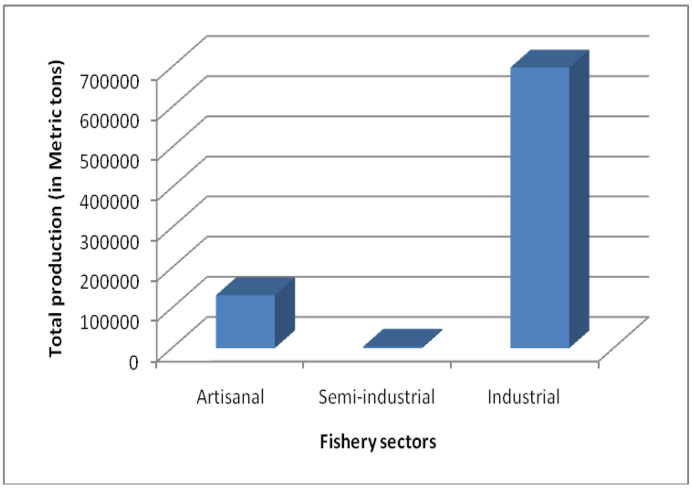

Figure 2: Total production of tuna from 2001 to 2010 from all sectors

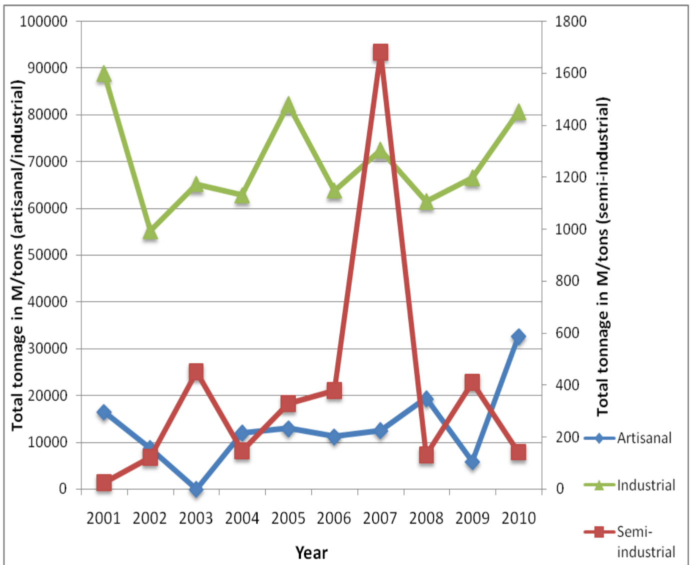

Figure 3: The trend in productivity by the three fishery sectors from 2001 to 2010

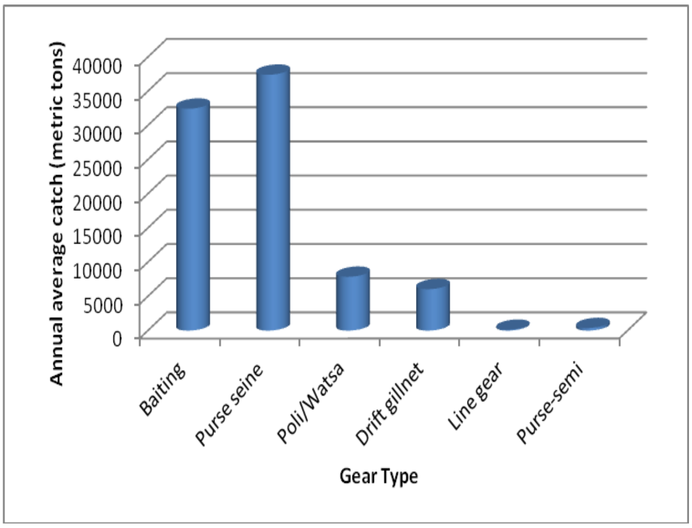

Figure 4: Annual Average Catch per gear type

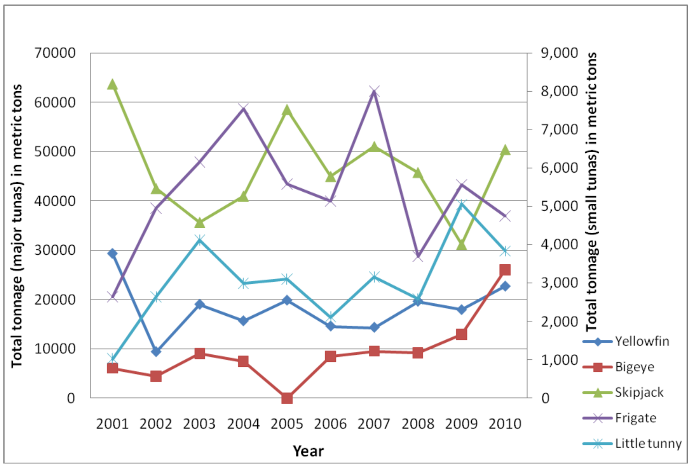

Figure 5: The trend of tuna catches landed in Ghana from 2001 to 2010

Discussions

The six gear groups analysed differed widely in their catch composition and there were also considerable temporal variations and fluctuations within some of these groups. In terms of weight of tuna caught, the purse seine gear used in the industrial sector was the most important gear with an annual average catch of about 37,422 metric tons (Figure 4) followed by the pole and line gear also used in the industrial sector with an annual average tuna catch of about 32,456 metric tons (Figure 4) . "Poli/Watsa" gear was the third with an annual average tuna catch of about 7,873 metric tons (Figure 4), drift gill net followed next with an annual average of tuna catch of about 6,060 metric tons (Figure 4). The fifth gear was the purse seine gear used in the semi-industrial sector with an annual average tuna catch of about 378 metric tons (Figure 4) while the line gear used in the artisanal sector recorded the lowest tuna catch of about 122 metric tons annual average (Figure 4).

It was observed that there was a trend in annual catches of tuna from 2001 to 2010. In the artisanal sector, total tonnage of tuna produced in year 2001 was 16,474 metric tons, it reduced to 8,729 metric tons in year 2002 and stable in year 2003 with about 8,750 metric tons. In year 2004, total tonnage rose to 12,012 metric tons, further increased to 12,975 metric tons in year 2005 but reduced to 11,230 metric tons in year 2006. In the year 2007, total tonnage increased again to 12,514 metric tons but all these years values recorded were lower than what was realized in year 2001 till year 2008 which recorded 19,358 metric tons. In year 2009, total tonnage reduced to 5,866 metric tons but increased significant to about 32,635 metric tons in year 2010 (Figure 3).

In the semi-industrial sector, total tonnage of tuna produced in year 2001 was 24 metric tons, increased to 120 metric tons in year 2002, further increased to 450 metric tons in year 2003. Year 2004 recorded a reduction to about 146 metric tons but total tonnage increased to 327 metric tons in year 2005, experienced a slight increase to 378 metric tons in year 2006. Year 2007 recorded a significant improvement to about 1,680 metric tons but reduced to 129 metric tons in year 2008, increased again in year 2009. Year 2010 experienced a reduction (Figure 3).

In the industrial sector, total tonnage of tuna produced in year 2001 was 88,806 metric tons, reduced to 55,146 metric tons in year 2002, increased to 65,153 metric tons in year 2003 but reduced to 62,741 metric tons in year 2004. In the year 2005, total tonnage increased again to 82,226 metric tons but reduced to 63,771 metric tons in year 2006 increased to 72,336 metric tons in year 2007.

Table 1: The growth of tuna production in Ghana from 2001 to 2010

Gear/Tuna type	Co-efficient	Growth rates (%)	R Square	Adjusted R square
Artisanal sector				
Poli (Y)	0.258773	25.87732	0.078996	-0.0361
Poli (B)	-0.13094	-13.0944	0.033964	-0.0868
Poli (S)	0.015191	1.519077	0.000334	-0.1246
Poli (F)	-0.00019	-0.01862	1.18e-06	-0.125
Poli (L)	-0.36926	-36.9263	0.235549	0.13999
Drift (Y)	-0.03081	-3.0809	0.00784	-0.11619
Drift (B)	-0.10518	-10.518	0.04877	-0.07013
Drift (S)	0.120189	12.0189	0.09868	-0.01398
Drift (F)	-0.0063	-0.6301	0.00030	-0.12466
Drift (L)	-0.08949	-8.9491	0.15967	0.05463
Line (Y)	0.32961	32.9610	0.26295	0.17082
Line (B)	-0.00904	-0.9036	0.00058	-0.1244
Line (S)	0.17449	17.4492	0.03628	-0.0842
Line (F)	0.15650	15.6496	0.06367	-0.0534
Line (L)	0.04991	4.99049	0.00796	-0.1161
Semi-industrial sector				
Purse(Y)	-0.02213	-2.2132	0.00168	-0.12311
Purse(B)	0.076379	7.63788	0.02584	-0.09593
Purse(S)	-0.11934	-11.934	0.02509	-0.09677
Purse(F)	0.183082	18.3082	0.24699	0.152858
Purse(L)	0.265527	26.5527	0.21489	0.116748
Industrial sector				
Bait (Y)	-0.08926	-8.92606	0.641485	0.59667
Bait (B)	0.166611	16.66109	0.44236	0.195682
Bait (S)	-0.10798	-10.7982	0.84291	0.710498
Bait (F)	0.02435	2.435005	0.005683	-0.11861
Bait (L)	-0.00921	-0.92055	0.000467	-0.12447
Purse(Y)	0.1066	10.6622	0.20830	0.10933
Pulse(B)	0.1796	17.95871	0.49808	0.43534
Pulse (S)	0.0560	5.599641	0.19979	0.09977
Pulse (F)	0.1630	16.30462	0.39875	0.32359
Pulse(L)	0.1695	16.946	0.41333	0.33999

Year 2008 experienced a reduction to about 61,452 metric tons, increased to 66,469 metric tons in year 2009 and further increased to 80,653 metric tons. These trends could be attributed to increased competition between small-scale fisheries and large-scale fisheries due to overfishing. The trends could also be attributed to underestimation of tuna catches and then influx of fishers and tuna vessels (Figure 3).

According to the results (Figure 3), from year 2002 onwards, total tuna catches annually started and continuously declined till year 2010 which experienced significant improvement. This implies that, annual values in terms of landings from 2002 to 2009 were far lower than values obtained in 2001 and 2010.

That is, in year 2001 total tonnage was about 105,305 metric tons, reduced in year 2002 and 2003 to about 63,996 metric tons and 65,602 metric tons respectively. In year 2006, 2008 and 2009, total tonnages were 75, 379 metric tons, 80,940 metric and 72,744 metric tons respectively; all these tonnages were lower than tonnages in year 2001 and year 2010 where year 2010 was 113,429 metric tons. This can be partly explained by the fact that stocks in the Atlantic Ocean were reported to have reached their full exploitation status during this period (FAO, 2010a). This suggests that fishing was lower than the carrying capacity.

Concerning the artisanal, semi-industrial and industrial sectors it was observed that, the semi-industrial sector virtually recorded a very low figure of about 3,803 metric tons in terms of total landings of tuna (Figure 1). This could be due to the fact that the semi-industrial operators normally switch from purse seine to trawling during the thermocline period and trawling harvest mainly demersal species. During the upwelling period, they switch back to purse seine, hence influencing their total catches annually, unlike the artisanal and industrial sectors that are able to fish throughout the year. Another reason can be attributed to the fact that the number of semi-industrial vessels that go for fishing within a year are not as many as those artisanal crafts that go for fishing within the year. There may also be bias in estimating catches, such as period vessels landed at the various beaches for numerators to take their sampling; the type of gear used, time of the day fished and season to fish, all these influence the catches.

The results (Figure 5) indicated that, the skipjack tuna, *Katsuwonus pelamis*, dominated the catch with significant values of about 465,205 metric tons representing 56% from 2001 to 2010, this could be attributed to the fact that the underlying population is likely to be healthy, making the *Katsuwonus pelamis* population more available (Harley *et al*., 2010). The yellowfin tuna, *Thunnus albacares*, which was the next dominant species, with about 182,612 metric tons representing 22% which was far lower than that of the *Katsuwonus pelamis* from 2001 to 2010. In the previous or earlier year yellowfin tuna, *Thunnus albacares* was the dominant species among all the tuna species exploited in the Atlantic Ocean or the Ghanaian waters. It could be suggested that the *Thunnus albacares* stock in the Ghanaian water is probably not overfished but the stock is likely to be nearing full exploitation and current levels of fish mortality are likely to move the *Thunnus albacares* stock to an over-fished state. Bigeye tuna, *Thunnus obesus* was the least among the major targeted tunas with about 101,533 metric tons representing 12%.

Frigate tuna *Auxis thazard* was the next species after *Thunnus obesus* in terms of dominance and then Atlantic little tuna *Euthynnus alleteratus* with values of about 54,072 metric tons representing 6% and 30,671 metric tons representing 4% respectively. One of the reasons could be attributed to the fact that fishing in the Ghanaian waters is having a large impact on the biomass level.

The current level of exploitation appears not to be sustainable in the long term, unless the high recent recruitment is maintained. Another reason could be associated with species misidentification. Real difficulties in identifying juvenile yellowfin and bigeye tunas and even adults do exist, because these two species look very similar in their juvenile stages and sometimes adults and they are captured together from the same schools. Therefore, fishers generally reported them together as “yellowfin”, hence under-reporting of bigeye tuna, *Thunnus obesus*. Species misidentification is also associated with frigate, *Auxis thazard* and Atlantic little tunas, *Euthynnus alleteratus*, because fishers normally reported them as one species with the name “soda”, this even include the Industrial vessels, making it affect the actual representation or estimation of *Auxis thazard* and *Euthynnus alleteratus* and also values recorded by *Auxis thazard* and *Euthynnus alleteratus* may be too low due to the fact that, they are the minor target species, so some may have been discarded and under-reported.

It was observed that only the purse seine employed in the industrial sector achieved a significant growth rate in output annually in the exploitation of all the tuna species from 2001 to 2010. In the exploitation of yellowfin tuna *Thunnus albacares* with a purse seine gear, 11% growth rate in output annually was achieved, that of bigeye tuna *Thunnus obesus* was 18%, skipjack tuna *Katsuwonus pelamis* was 6%, frigate tuna *Auxis thazard* 16% and Atlantic little tuna *Euthynnus alleteratus* was 17% (Table 1).

The pole and line employed in the industrial sector achieved a positive growth rate in output annually in the exploitation of only bigeye, *Thunnus obesus* and frigate tuna, *Auxis thazard*. The growth rate for bigeye, *Thunnus obesus* was 0.2%, frigate tuna, *Auxis thazard* was 0.02% and that of yellowfin tuna *Thunnus albacares* skipjack tuna *Katsuwonus pelamis* and Atlantic little tuna *Euthynnus alleteratus* was -0.1%, -0.1% and -0.01% respectively (Table 1).

The purse seine used in the semi-industrial showed a positive growth rate in output annually in the exploitation of only bigeye, *Thunnus obesus*, frigate, *Auxis thazard* and little tunny, *Euthynnus alleteratus*. The growth rate for bigeye, *Thunnus obesus* was 8%, frigate, *Auxis thazard* was 18% and Little tunny, *Euthynnus alleteratus* was 27% and that of yellowfin tuna *Thunnus albacares* and skipjack tuna *Katsuwonus pelamis* was -2% and -12% respectively (Table 1).

In the artisanal sector, the line gear experienced a positive growth rate in output annually in the exploitation of all the targeted tunas except the bigeye tuna, *Thunnus obesus*. The growth rate for yellowfin tuna *Thunnus albacares* skipjack tuna, *Katsuwonus pelamis*, frigate, *Auxis thazard* and little tunny, *Euthynnus alleteratus* were 33%, 17%, 16% and 5% with that of bigeye tuna *Thunnus obesus* being -1%. Drift gill net showed a positive growth in output annually in the exploitation of only the skipjack *Katsuwonus pelamis* from 2001 to 2010. The growth rate of skipjack *Katsuwonus pelamis* was 12%, that of yellowfin *Thunnus albacares*, bigeye tuna *Thunnus obesus*, frigate *Auxis thazard* and little tunny *Euthynnus alleteratus* were -3%, -11%, 0.6% and -9% respectively. The “poli/watsa” also experienced a positive growth rate in output annually in the exploitation of only yellowfin, *Thunnus albacares* and skipjack tuna, *Katsuwonus pelamis*. The growth rate of yellowfin, *Thunnus albacares* was 26%, skipjack tuna, *Katsuwonus pelamis* was 2% and that of bigeye tuna, *Thunnus obesus*, frigate, *Auxis thazard* and little tunny, *Euthynnus alleteratus* were -13%, -0.01 and -37% respectively.

These variations in growth rates suggest that the artisanal and semi-industrial sectors fish on free school whilst the industrial sector fish around fish aggregating device (FAD) and again use more sophisticated equipment like sonars, radio buoys, echo sounder, fish finder, etc. and it is very difficult fishing on free school than on FADs. This is because objects that are floating in the ocean are important in tuna fishing. For reasons still unknown to science, almost anything floating in the ocean tends to attract tuna and several other types of fish, sometimes in very large quantities (Gillett, 2004). FADs, even though they attract a lot of tunas, they are usually associated with small tunas and the purse seiners exploit all together hence affecting or depleting the tuna stock. Also FADs drift at the mercy of the current, and as they drift, they move along with the tunas, affecting population of tunas in a particular location. Poli/watsa and drift gill net also drift and they drift whilst harvesting and moving along with the tunas, hence affecting the population of tunas in a particular location.

Conclusion

Five tuna species were recorded from the three marine fishery sectors (artisanal, semi-industrial and industrial) in Ghana. The industrial sector producing the highest tuna catches and the semi-industrial producing the lowest could be attributed to the fact that the semi-industrial operators normally switch from purse seine to trawling during the thermocline period and switch back during the upwelling period, unlike the industrial vessels that are able to fish throughout the year.

Katsuwonus pelamis dominance could be attributed to the fact that the underlying population of which is likely to be healthy, making the *Katsuwonus pelamis* population more available. The purse seiner being the most efficient gear throughout the ten-year period, in terms of exploitation of the tunas could be attributed to the fact that the purse seiner fish on FADs, and use an improved form of technology, and they fish all year round; they do not depend on the density-independent factors like weather, thermocline and upwelling.

Finally, while tuna fisheries’ efficiencies are being reduced by many new elements like sonar, net size, GPS and age of vessel, the market is becoming increasingly, dynamic, resulting in higher competition among the fisheries, species, industries and even between tuna products such as *sashimi* and fresh and canned tuna.

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