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Assessment of fishing effort, catch per unit effort and fish production of the tropical coastal lagoon of grand-lahou (Côte-d'Ivoire, West Africa)

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Abstract

Catch composition, fishing effort and gears production were investigated in the coastal lagoon of Grand-Lahou from November 2013 to October 2014. Samplings were carried out by mean of artisanal fisheries once a month in three stations. *Ethmalosa fimbriata* was the top dominant specie in catches with 56% followed by *Elops lacerta* (12%), *Liza falcipinnis* (11%) and *Chrysichthys nigrodigitatus* (11%). In Tadio station, important fishing effort value was recorded with small mesh size gill nets (37 trip/day) whereas in Agoudam and Passagri stations highest values of fishing efforts were recorded with medium mesh size gill nets and cast nets respectively. Highest CPUE were recorded with small mesh size gill nets (24.98 kg/trip) in Tadio station whereas low CPUE were recorded with large mesh size gill nets (1.74 kg/day) in Agoudam station. Highest production was recorded in Tadio station (265.921) tons with small mesh size gill nets (226.617) tons. The total production of sampling stations was estimated to 386,842 tons.

Keywords: catch composition, gears fishing effort, fish production, grand-lahou lagoon, Côte d'Ivoire

1. Introduction

Coastal lagoons are generally more productive than over aquatic ecosystems in terms of fisheries yield, fish productivity average with 100 kg/ha/year^[1]. However, they don't have a uniformly high yield^[2]. In Côte d'Ivoire, lagoons fishing activities are concentrated on four lagoons (Ebrie, Aby, Grand-Lahou and Fresco)^[3]. An overexploited state of fisheries in Côte d'Ivoire was reported by^[3] for Aby and Ebrie lagoons and raised the question of the management of the fisheries. The intensity of fishing gears mesh size and catches per unit effort are good indicators of the status of exploitation level^[4]. Fish is the most important source of protein in the country, contributing approximately 70 percent of the animal protein intake and about 15 percent of the total protein consumption^[5]. Statistics on fish production from the lagoons are often expressed together with shrimp or with coastal marine fisheries^[6]. For this reason, no or less separate information is available on lagoons fish production^[6] fishing effort, gears catches per unit effort of the lagoon particularly in Grand-Lahou lagoon. The aim of the study was to increase knowledge about gears fishing effort, catch per unit effort of the gears and analyze their monthly variations in Grand-Lahou lagoon.

2. Material and Methods

2.1 Study area

Located between 5° 08'-5° 03'N and 4° 51'-5° 25'W, Grand-Lahou lagoon (Côte d'Ivoire, West Africa) is an elongated open coastal water body. A channel connects the lagoon to the Atlantic Ocean in the eastern part, whereas in the north it receives freshwater discharged from three connecting rivers (Bandama, Boubo and Gô)^[7]. This aquatic system is a lagoon complex composed of four lagoons (Figure 1) which are from east to west, Tagba (57 km²), Mackey (28 km²), Tadio (90 km²) and Niouzoumou (15 km²)^[7]. The climate, characterized by 4 seasons. A long dry season from December to March, a long rainy season from April to July, a short dry season in August and September and a short rainy season in October and November^[8]. Grand-Lahou lagoon is considered as an important fishing area with three main fishing sectors (Tadio, Agoudam and Passagri)^[9]. Fishery is artisanal with several fishing gears such as various gill net mesh sizes, hooks, and cast nets^[9].

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2.2 Data collection

Data collected from November 2013 to October 2014 involved two major research activities. i) survey designed to obtain information on the gears characteristics and ii) survey designed to obtain information on landings. Concerning the first step, from November 2013 to October 2014, each month per station, information such as type of gears used, number of gears and size of mesh for gill nets were recorded. The second step concerned survey of daily catches during four days per month per station and per gear type. Total catch of each fisherman and per gear type was weighted. Fish species composition, weight and / or number of individuals per specie were noted. Species were identified according to [10-11]. For each landing, all the catch or 30 individuals when the catch exceeded 10 kg chosen randomly were weighted to the nearest gram and. Independently daily statistics production was recorded during 15 days per month and per station.

2.3 Data analysis

Gears considered in this study are gill nets of small size (10 mm to 35 mm knock to knock); medium size (40 mm to 60mm); large size (65- 90mm); cast nets, hooks and fixed

fisheries. Fishing effort considered in the present study was the fishing trip per day for all the gears. The fishing effort by gear type was then evaluated per month and per station. The total monthly catches per unit effort (CPUE) were estimated using a model equation derived from the one developed by [12] modified by [13] and [14].

$$CPUE_i = Y_{gi} / f_{gi}$$

With CPUE_i catches per unit effort during the month i
 Y_{gi} = total daily catches per gear during the month i
 f_{gi} = mean daily effort per gear during the month I
 the monthly total catches per station per gear was also estimated: C(t)_i = CPUE_{gi} x f_{gi} x h
 With C (t)_i the monthly total catches in the month i, CPUE_{gi} = weight of fish caught (kg) per unit effort per gear in the month i.
 f_{gi} = the month average fishing effort per gear in the month i and h the number of fishing days during the month i.
 The annual total catches were estimated by adding up each monthly catches of all gears
 C_a = Σ C_{amg} with c_a annual catches; C_{amg} monthly catches per gear

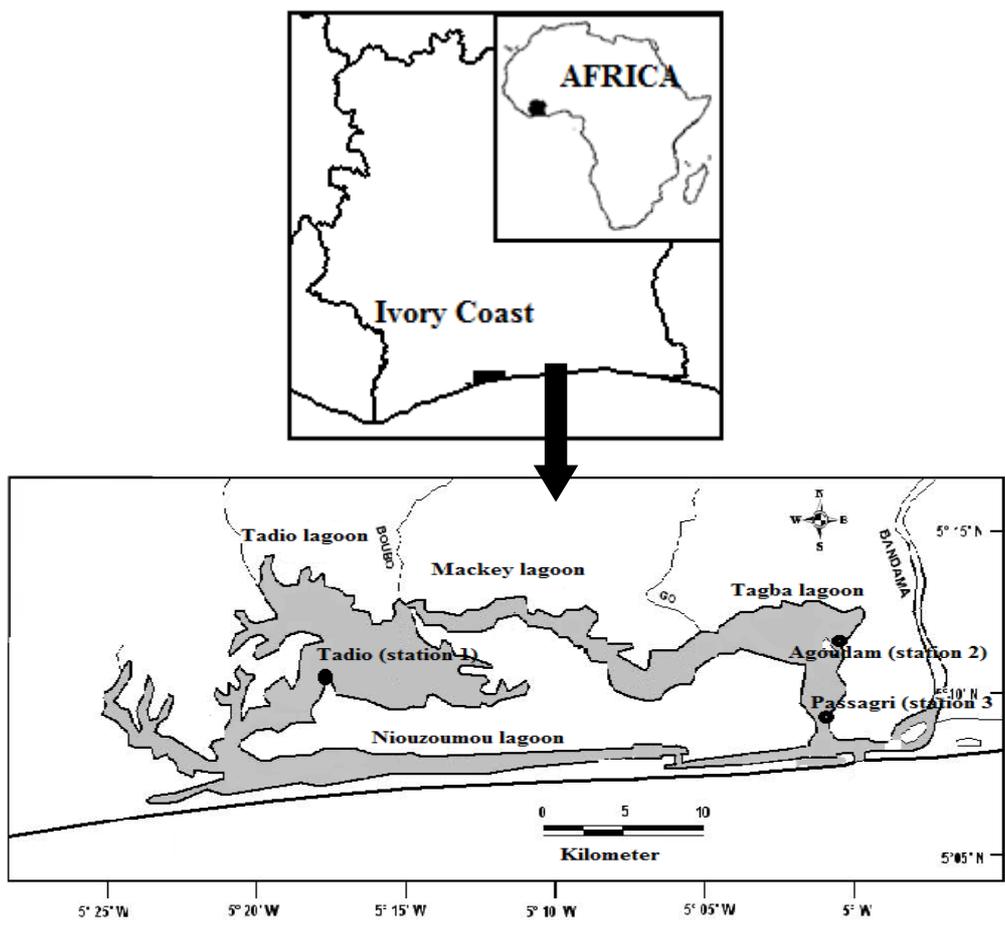


Fig 1: Map of grand-lahou lagoon showing sampling stations.

2.4 Statistical analysis

The CPUE data followed a normal distribution and thus parametric analysis of variance (ANOVA) was used to compare CPUE among station for the gears.

3. Results

3.1 Catches composition in Grand-Lahou lagoon

A total of 47 species belonging to 25 families and 36 genera (Table I) were found in the catches during the surveys. The

families with the largest number of species were Mugilidae with 6 species followed by the Cichlidae and Carangidae with 5 species. *Ethmalosa fimbriata*, *Elops lacerta*, *Chrysichthys nigrodigitatus*, *Liza falcipinnis* and *Tilapia guineensis* were the essential species in the catches. *Ethmalosa fimbriata* was the top dominant specie in catches with 56% followed by *Elops lacerta* (12%), *Liza falcipinnis* with (11%) and *Chrysichthys nigrodigitatus* (11%). Five species *Trachinotus teraia*, *Arius latiscutatus*, *Eucinostomus melanopterus* *Tilapia*

guineensis and *Pomadasys jubelini* were less represented in catches (5%) (Figure 2A)

3.2 Catches composition per station

At Tadio station (Figure 2B), the dominant specie by weight was *Ethmalosa fimbriata* with 68% of total catches followed by *Elops lacerta* with 13% *Chrysichthys nigrodigitatus*, *Liza falcipinnis* (5%). At this station, *Pomadasys jubelini*, and *Tilapia guineensis* were the less representative species in the catches with 1%.

At the Agoudam station (Figure 2C), *Chrysichthys nigrodigitatus* and *Liza falcipinnis* were the two top dominant

species in the catches with 28% and 26 % respectively. The two species were followed by *Tilapia guineensis* (13%), *Ethmalosa fimbriata* (12%), *Pomadasys jubelini* with 9%. *Arius latiscutatus*, *Trachinotus teraia*, and *Eucinostomus melanopterus* were represented by less than 1% in the catches. At Passagri station (Figure 2D), the dominant specie in the catches was *L. falcipinnis* (34%) followed by *C. nigrodigitatus* (24%) *Tilapia guineensis* (13%), *Ethmalosa fimbriata* and *Elops lacerta* (12%). *Eucinostomus melanopterus*, *Arius latiscutatus* and *Trachinotus teraia* were the less representative species in the catches with 1%

Table I: Catches composition inventory in Grand-Lahou lagoon from november 2013 to october 2014 (+: présence ; -: absence ; St1= Tadio; St2 = Agoudam; St3 = Passagri).

Familles /Espèces	Code	St 1	St 2	St 3		
Dasyatidae						
<i>Dasyatis margarita</i> (Günther, 1870)	Dma	+	+	+		
Elopidae						
<i>Elops lacerta</i> Valenciennes, 1846	Ela	+	+	+		
Clupeidae						
<i>Ethmalosa fimbriata</i> (Bowdich, 1825)	Efi	+	+	+		
<i>Pellonula leonensis</i> (Boulenger, 1916)	Ple	+	+			
Oteoglossidae						
<i>Heterotis niloticus</i> (Cuvier, 1829)	Hni	+	+	+		
Hepsetidae						
<i>Hepsetus odoe</i> (Bloch, 1794)	Hod		+	+		
Claroteidae						
<i>Chrysichthys maurus</i> (Valenciennes, 1839)	Cma	+	+	+		
<i>Chrysichthys nigrodigitatus</i> (Lacépède, 1803)	Cni	Ec	+	+	+	
Schilbeidae						
<i>Schilbe mandibularis</i> (Günther, 1871)	Sma	+	+	+		
Clariidae						
<i>Clarias gariepinus</i> (Burchell, 1832)	Cga	+	+	+		
<i>Heterobranchus longifilis</i> (Valenciennes, 1840)	Hlo	+	+	+		
Mochokidae						
<i>Synodontis schall</i> (Bloch & Schneider, 1801)	Sch	+	+	+		
Ariidae						
<i>Arius latiscutatus</i> (Boulenger, 1911)	Ala	+				
Hemiramphidae						
<i>Hemiramphus balao</i> (Lesueur, 1825)	Hba	+				
<i>Hyporhamphus picarti</i> (Valenciennes, 1846)	Hpi	+				
Channidae						
<i>Parachanna obscura</i> (Günther, 1861)	Pob		+	+		
Serranidae						
<i>Epinephelus aenus</i> (Geoffroy Saint Hilaire, 1817)	Eae		+	+		
Carangidae						
<i>Caranx hippos</i> (Linnaeus, 1766)	Chi	+	+	+		
<i>Decapterus rhonchus</i> (Geoffroy Hilaire, 1817)	Dro	+	+	+		
<i>Senele dorsalis</i> (Gill, 1863)	Sdo		+	+		
<i>Trachinotus teraia</i> (Cuvier, 1832)	Tte	+	+	+		
<i>Trachinotus ovatus</i> (Linnaeus, 1758)	Tov	+	+			

Table I (suite): Catches composition inventory in Grand-Lahou lagoon from november 2013 to october 2014 (+: présence ; -: absence ; St1= Tadio; St2 = Agoudam; St3 = Passagri).

Familles/ espèces	Codes	St1	St2	St3	Sssoo
Lutjanidae					
<i>Lutjanus dentatus</i> (Deménil, 1858)	Lde	+	+	+	
<i>Lutjanus goreensis</i> (Valenciennes, 1830)	Lgo	+	+	+	
Gerreidae					
<i>Eucinostomus melanopterus</i> (Bleeker, 1863)	Eme	+	+	+	
Haemulidae					
<i>Pomadasys jubelini</i> (Cuvier, 1830)	Pju	+	+	+	
<i>Pomadasys peroteti</i> (Cuvier, 1830)	Ppe	+	+	+	
Sciannidae					
<i>Pseudotholithus elongatus</i> (Bowdich, 1825)	Pel		+	+	

Monodactylidae					
<i>Monodactylus sebae</i> (Cuvier, 1831)	Mse		+	+	+
Cichlidae					
<i>Hemichromis bimaculatus</i> Gill, 1862	Hbi			+	+
<i>Hemichromis fasciatus</i> Peters, 1852	Hfa				+
<i>Sarotherodon melanotheron</i> Ruppel, 1852	Sme			+	+
<i>Tilapia guineensis</i> (Bleeker in Günther, 1862)	Tgu		+	+	+
<i>Tilapia mariae</i> Boulenger, 1899	Tma		+	+	+
<i>Tylochromis jentengi</i> (Boulenger, 1915)	Tje			+	+
Mugilidae					
<i>Liza demeruli</i> (Steindachner, 1870)	Lde			+	+
<i>Liza falcipinnis</i> (Valencienne, 1835)	Lfa		+	+	+
<i>Liza grandisquamis</i> (Valencienne, 1836)	Lgr			+	+
<i>Mugil bananensis</i> (Pellegrin, 1927)	Mba		+	+	+
<i>Mugil cephalus</i> Linnaeus, 1758	Mce		+	+	+
<i>Mugil curema</i> (Valencienne, 1836)	Mcu			+	+
Sphyraenidae					
<i>Sphyraena afra</i> Peters, 1844	Saf		+	+	+
<i>Sphyraena guachancho</i> Cuvier, 1829	Sgu		+	+	+
Polynemidae					
<i>Galeodes decadactylus</i> (Bloch, 1795)	Gde		+		
<i>Polydactylus quadrifilis</i> (Cuvier, 1829)	Pqu		+	+	+
Gobiidae					
<i>Gobioides africanus</i> (Giltay, 1935)	Gaf		+		
Cynoglossidae					
<i>cynoglossus senegalensis</i> kaup, 1858	Cse		+	+	+

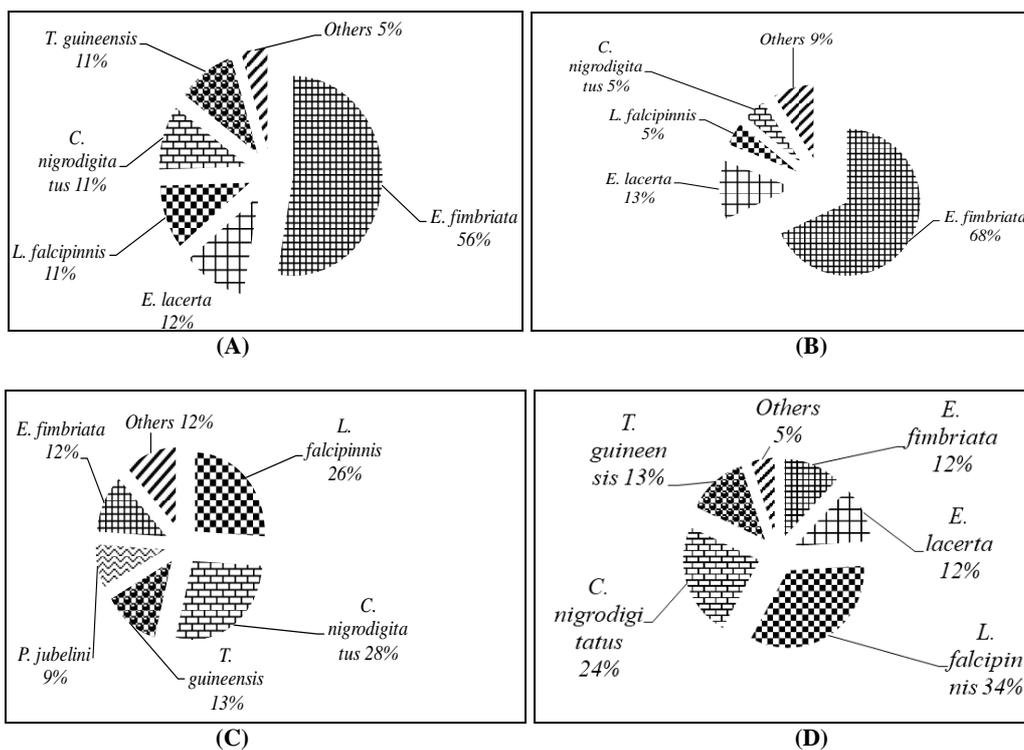


Fig 2: Ponderal proportions of dominant fish species caught in the lagoon (A), Tadio station (B), Agoudam station (C) and Passagri station (D) (Grand-Lahou) lagoon between November 2013 and October 2014

3.3 Fishing effort in Grand-Lahou lagoon

The spatio-temporal fishing effort variations for small size gill nets were mentioned in (figure 3A). For this gear, the highest value (38 trip/day) was recorded in Tadio station whereas the lowest value (1 trip /day) was recorded in Passagri and Agoudam stations. Monthly variations of fishing effort in Tadio station showed that from November to April the fishing effort decreased and from April to Jun the fishing effort increased. For gill nets of medium mesh size (Figure 3B) the highest value (30 trip /day) was recorded in the Agoudam station whereas lowest values of fishing effort (0 trip/ day)

was recorded Tadio and Passagri station. Monthly variations showed that fishing effort varied from 8 to 30 trips/day, decreased from November to January and increased from April to Jun with 30 trip per day for this month. Fishing effort of gill nets of large size (Figure 3C) was higher in Tadio station and lower in Agoudam and Passagri stations. Cast net fishing effort was illustrated in (figure 3D) and its variations showed that high and low values of this gear were recorded in the Tadio station 16 tip /day and 0 trip/ day. The temporal variations revealed that the high value of fishing effort of cast nets was obtained in February whereas in

Agoudam and Passagri stations the highest values were obtained in November (9 trip/day and 8trip/day) respectively. For hooks, important spatio-temporal variations of fishing effort (figure 3E) with similar trends were observed in the

three stations. Fishing effort of fixed fisheries (figure 3F) was higher in Agoudam station than Passagri station 5 trips/day against 4 trips/day.

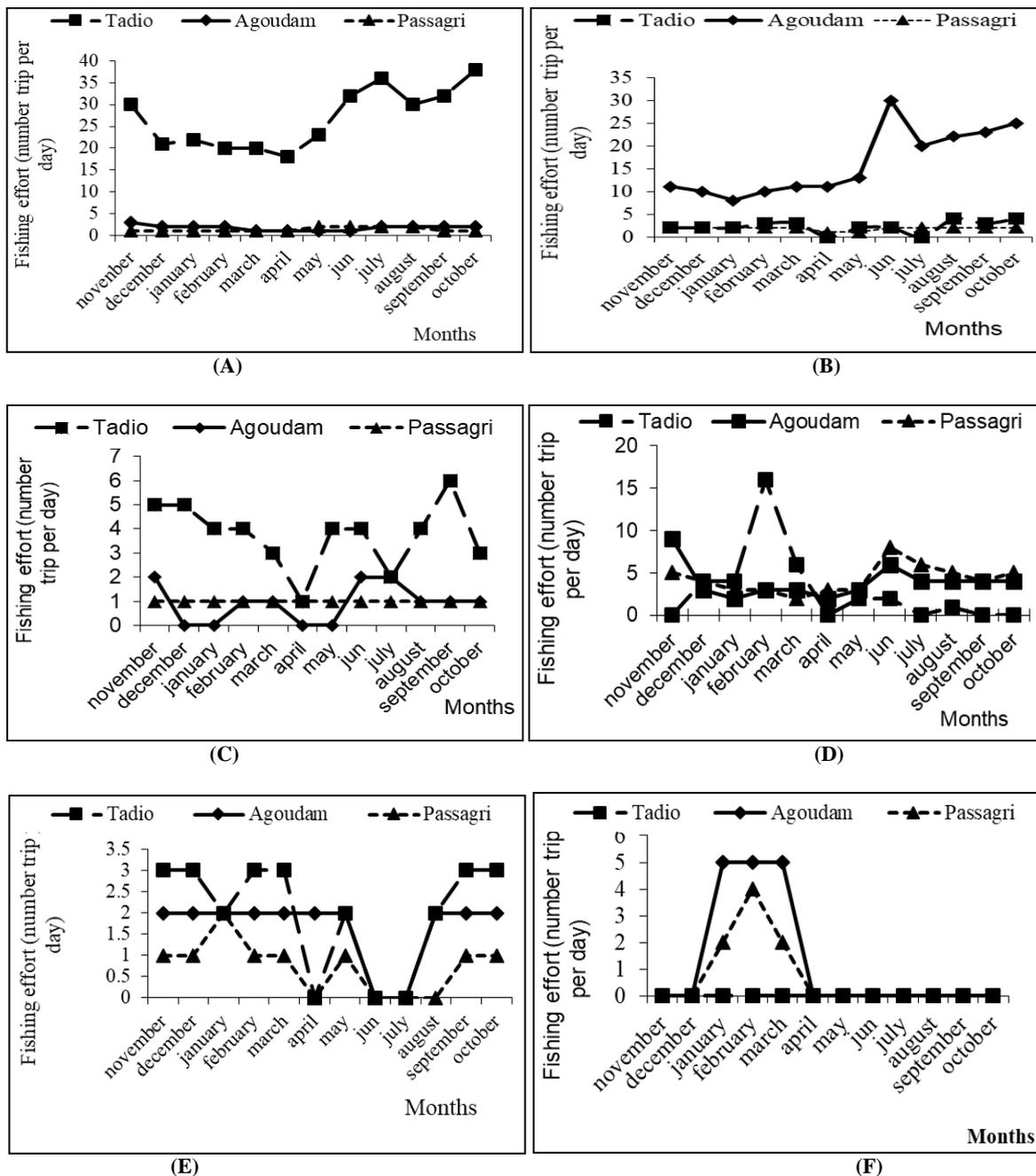


Fig 3: Fishing effort of gears small mesh size gills nets (A) medium mesh size gill nets (B), large mesh size gill nets (C), cast nets (D), Hooks (E), fixed fisheries (F) in Grand-Lahou lagoon between november 2013 and october 2014.

3.4 Catches per unit effort (CPUE) per gear and sampling station production

3.4.1 Spatial variations of CPUE of fishing gears in Grand-Lahou lagoon

Catches per unit effort (CPUE) per gear were illustrated in tables II in the three sampling stations. With small mesh size gill nets (Table II), the highest mean value of CPUE 24.98 ± 3.5 kg/trip/day was recorded at Tadio station whereas the lowest value was obtained in Agoudam station. There was a significant difference of CPUE between stations ($F= 72.34$; $p= 0.001$). The total production of the gear was 265.91 tons. With medium mesh size gill nets (table II), the highest mean value of 12.82 ± 1.2 kg/trip was recorded in Agoudam station

and the lowest value (2.71 ± 0.3) was recorded in Tadio station. A significant difference was observed between those stations ($F= 74.71$; $p = 0.000000$). The total production of this gear was 72.286 tons. With large mesh size gill nets the highest CPUE (16.5 ± 1.5) was observed in Tadio station whereas the lowest CPUE (1.74 ± 0.8) was obtained in Agoudam station. There was a significant difference between stations ($F= 134.78$; $p= 0.000000$). The total production of the gear was 20.714 tons. For cast nets, the CPUE highest values (11.67 ± 2.1 , 11.64 ± 2.1) were recorded in Agoudam and Passagri stations respectively. There was a significant difference between stations ($F= 3.507$; $p= 0.049$). The production of the gear was 42.148 tons. With hooks, the

highest value of CPUE (11.5 ± 1.2) was observed in Tadio station and the lowest value (5.81 ± 0.4) was recorded in Passagri station. There was no significant difference between stations ($F = 2.139$; $p = 0.134$). The total production of the gear was estimated to 15.124 tons. The production of the others gears was estimated to 9.95 tons. Fish production of the three sampled stations was estimated to 386.854 tons.

3.4.2 Seasonal variations of CPUE of gears in Grand-Lahou lagoon

CPUE seasonally variations were mentioned for the stations in (Table III). In Tadio station the highest values of CPUE were recorded in the long rainy season with small size mesh (26.92 kg/trip against 19.88 kg/trip) whereas the others gears showed highest CPUE during the long dry season. In Agoudam station (B) we recorded highest CPUE during the long rainy season (11.12 kg/ trip) with gill nets of medium mesh size. With cast nets, hooks and fixed fisheries CPUE were higher during the long dry season. In Passagri station, CPUE of cats nets, hooks, fixed fisheries were higher during the long dry season whereas small size gill nets showed highest CPUE during the long rainy season.

Table II: Spatial variations of CPUE of gears in Grand-Lahou lagoon during the surveys period from november 2013 to october 2014

GEARS	CPUE kg/trip			p
	TADIO	AGOUDAM	PASSAGRI	
FMPM	24.98 ± 3.5	3.05 ± 0.5	3.32 ± 0.08	***
FMMM	2.71 ± 0.3	12.82 ± 1.3	3.19 ± 1.2	***
FMGM	16.5 ± 1.5	1.74 ± 0.8	3.02 ± 0.7	***
EPERV	6.08 ± 0.3	11.67 ± 2.1	11.64 ± 2.1	**
PALAN	11.5 ± 1.2	9.05 ± 0.8	5.81 ± 0.4	nsd

FMPM: Small mesh size gill nets; FMMM: medium mesh size gill nets; FMGM: large mesh size gill nets; EPER: cast nets; PALA: Hooks. *** significant at 0.0000; ** significant at 0.001; nsd no significant difference

Table III: Seasonal variations of CPUE of fishing gears. GSS: long dry season; GSP: Long rainy season. FMPM: Small mesh size gill nets; FMMM: medium mesh size gill nets; FMGM: large mesh size gill nets; EPER: cast nets; PALA: Hooks; PEFIX: fixed fisheries. Tadio station (A), Agoudam station (B), Passagri station (C).

Station		FMPM	FMMM	FMGM	EPER	Autres	Total
		Station 1	GSS	19,28	13,03	18,78	14,62
	GSP	26,92	1,47	14,25	2,25	2,5	47,39
Station 2	GSS	3,27	10,62	1,1	12,50	30,98	58,47
	GSP	2,85	11,12	1,65	10,05	3,52	29,16
Station 3	GSS	2,9	3,05	1,92	11,22	20,27	39,36
	GSP	3,65	2,69	3,77	7,70	2,55	20,36

4. Discussion

Concerning the small mesh size gill nets catches composition, our results were similar to those of several authors in West African lagoons [15]. However, our results were different to those of [7] in Grand-Lahou lagoon where the catches of those gears were dominated by *Chrysichthys nigrodigitatus*. Fish fisheries activities were held in Grand-Lahou lagoon with several gears notably gill nets (small, medium and large size), hooks, cast nets and fixed fisheries. Highest fishing efforts were recorded with small, medium mesh size gill nets, cast nets in Tadio, Agoudam and Passagri stations respectively. In passagri station, the gear type used agreed with [9] who reported in this station that cat nets were the top dominant gears. Gears used in Agoudam and Passagri stations have limited catches capacities whereas in a Tadio station, fish

exploitation was based on the use of professional fishing techniques with gears of very important catch capability such as small and middle mesh gill nets. The wide use of gill nets in Grand-Lahou lagoon, could be explained by its versatility, low cost and ease of operation. Fishing is often undertaken in small artisanal scale and most widely used fishing gear in coastal and brackish waters are gill net [16-17]. Our finding was in agreement with that of [18] in the sector V of Ebrie lagoon. Small mesh sizes gill nets were the most abundant gear used in lagoons and estuaries [19].

CPUE trends could be explained by the fact that CPUE spatial variations were caused by conditions such as water current, transparency and fishing pressure. CPUE spatial variations are due to gears efficiency in the stations and other aspects such as lagoon water deep [20]. Besides, in the three sampling stations CPUE differences could be explained by the well upkeep of fishing equipment notably gears, canoes and professional experience of Tadio's fishermen. Catches per unit effort CPUE are good indicators of exploitation of Aquatics waters [20]. Majority CPUE for the present study were more important during the long dry season than the long rainy season. According to [20-21] low CPUE during the rainy season were explained by the fishes scattering in the water column for feeding or spawning thus the dilution of fishes in the mass of water makes them less vulnerable to the fishing gears which induce a decline in CPUE during this period. However, during the long dry season with water recession, fish individuals are concentrated in a weak volume of water. Fishes become more vulnerable to fishing gears and CPUE increased [20-21].

Fish production of 386.854 tons in the present study was higher than 306 tons mentioned by [7] in the study area. The lowest production recorded in Grand-Lahou lagoon could be attributed to the non-use of seines in the lagoon and the lack of professionalism of many fish farmers.

5. Conclusion

The results reported in this study represent the first information about fishing efforts, CPUE and production of the gears used in Grand-Lahou lagoon. The study showed the highest fishing effort and production were recorded with small mesh size gill nets. Tadio station also presents the highest production with 265.842 tons whereas the three sampling stations production was estimated at 386.854 tons. There is an urgent need to devolve fisheries management to the local level of this lagoon of Grand-Lahou in order to compel fishers to take greater responsibility for the sustainability and conservation of fisheries resources.

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