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Ichthyological composition of fishing gear types from marine artisanal fishery of grand-lahou (Ivory Coast)

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DOI: https://doi.org/10.22271/23940522.2022.v9.i5a.931

Abstract
In Côte d'Ivoire, fishing in Grand-Lahou locality provides 20% of national artisanal catches. From August 2016 to February 2017, fishing units and the ichthyological composition of their fishing gears were characterised on Lahou-Kpanda site. One unit using the beach seine, eleven the purse seines and seven the gillnets were involved. Twenty-two fish species have been identified. Twenty-one of them were caught by purse seines, eleven by the beach seine and six by gillnets. Purse seines and the beach seine preferentially catch Clupeidae, 80.95% and 88.12% respectively. According to species, *Sardinella maderensis* (55.76%) and *Ethmalosa fimbriata* (13.73%) dominate purse seines catches and *Sardinella maderensis* (37.68%), *Ethmalosa fimbriata* (28.16%) and *Sardinella aurita* (20.12%) those of the beach seine. The gillnets catch more Sciaenidae (59.10%), Sphyraenidae (16.20%) and Cynoglossidae (15.39%) with *Pseudotolithus typus* (30.14%) as well as *Pseudotolithus elongatus*, *Sphyraena afra* and *Cynoglossus canariensis* as dominant species.

Keywords: Marine artisanal fishing, fishing gears, fish species, grand-lahou, Côte d'Ivoire

Introduction
In Côte d'Ivoire, marine artisanal fishing is practised along the coastline of 550 kilometres within 2 nautical miles of the continental shelf (FAO, 2008) [12]. One hundred and five landing sites have been identified over there. However, only three of them, including the site of Grand-Lahou, have a minimum of equipment such as landing quay, electricity, ice halls or cold stores (Konan, 2015) [15].

With regard to artisanal fishing, Grand-Lahou provides 20% of national catches. These captures come from lagoon fishing, but particularly from marine fishing practiced mainly by Ghanaian fishermen (MIRAH/BAP, 2014) [17]. While there are some data available on lagoon fishing activity, the data reported for marine fishing is limited. In fact, in marine area, previous studies refer to the work of Anoh (2007) [2] on the dynamics of the occupation of the Ivorian coastline for fishing and aquaculture purposes and to that of Domingo (1980) [10] on the evolution of artisanal fisheries in Côte d'Ivoire in the 1980s. Écoutin *et al*. (1993) [11] produced general information on marine fishing, Golé Bi *et al*. (2005) [13] focused on the socio-economic aspect of artisanal fisheries in Côte d'Ivoire and Koffie-Bikpo (2010) [14] on the maritime fishing piracy. It is therefore obvious that studies relating the impact of fishing gears on exploited resources are rare. In fisheries sciences, sustainable fish stock management, with the purpose of obtaining the best economic benefits, must be based on scientific knowledge. Lack of control generally encourage fishermen to use illegal fishing gears or methods. This situation inevitably leads to fish stock overexploitation.

This study was undertaken at the Lahou-Kpanda site in Grand-Lahou. The fishing environment there has changed in recent years. Indeed, like the whole of the country's coastline, this place is suffering from coastal erosion. It is even one of the five hot spots identified on the Ivorian coast (Djagoua *et al*., 2016) [8]. So, the objective is to diagnose the new fishing environment by characterising fishing units in this fishery and the ichthyological composition of catches.

Materials and methods
Study area
This study was conducted at Lahou-Kpanda site in Grand-Lahou (Figure 1). Grand-Lahou

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coastline is located between latitudes 5°12'N and 5°9'N and longitudes 4°56W and 5°70W (Djagoua *et al*., 2016) [8]. Fishermen exclusively practise their activity on the continental shelf. Depending on fishing gears types they use,

they can exploit areas close to the coast and up to 12 to 20 miles at the edge of the continental shelf and at average depths of -120 meters (Koffie-Bikpo, 2010) [14].
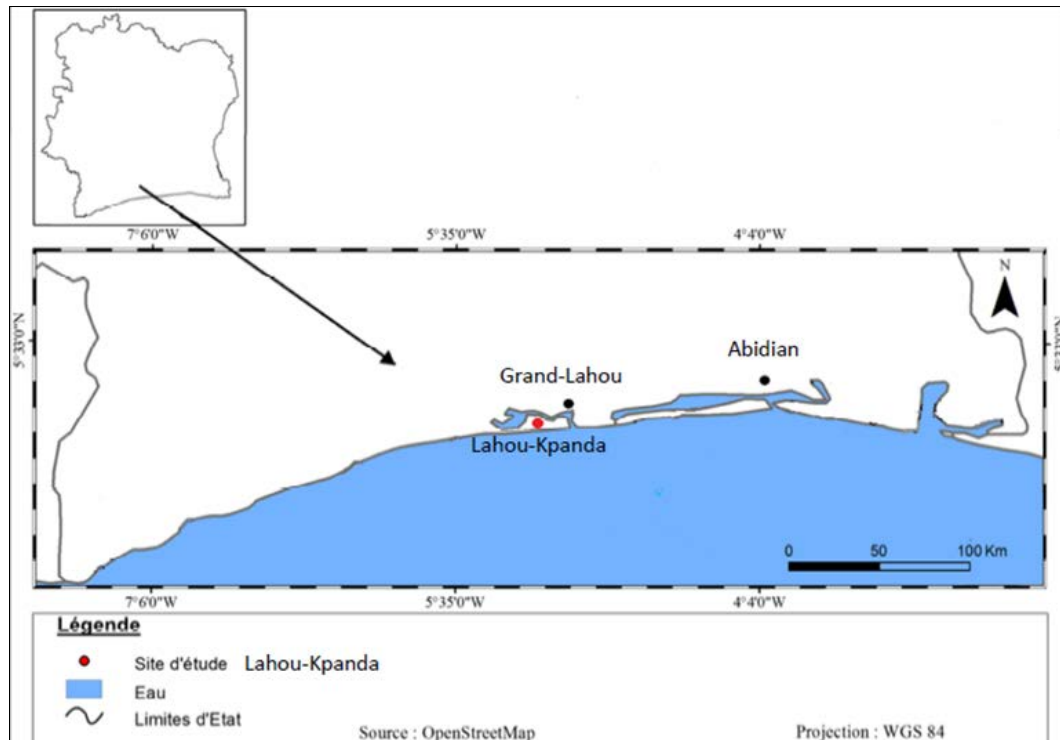

Fig 1: Geographical location of Lahou-Kpanda site in Grand-Lahou

Sampling period
In Côte d'Ivoire, in relation to marine artisanal fishing, the low season lasts eight months and the high season only four months (Koffie-Bikpo, 2010) [14]. At the Lahou-Kpanda site in Grand-Lahou, according to fishermen, fishing trips are highly practised from July to March. Time of fishing units' outings ranged from evening (16:00-18:00) to the following morning (08:00-10:00). Saturdays and Sundays are fishermen's rest days. For this study, sampling was conducted from August 2016 to February 2017. Data were collected once or twice a week.

Identification of fishing units and fishing gears
A survey have been conducted to identify fishing units present on the study site. Each unit corresponds to a team of fishermen using the same boat. In each unit, fishing gears were recorded. On each of them, total length was measured at the level of the head rope, height from attachment point of the side rope on the head rope to attachment point on the foot rope and mesh size corresponding to bar length measured with a calliper. These measurements were carried out when fishing gears were spread out on the beach to dry.

Analysis of catch composition
Representative samples were taken at random from each fishing unit's catches for analysis. Fish were identified *in situ*. Identification guides used were those of Ouattara *et al.* (2016) [8] and Seret and Opic (2011) [9]. Then, on each fish, fork length in centimetre was measured with an ichthyometer for specimens smaller than 70 cm and with a 3 meters long band for larger ones to the nearest centimetre. Finally, each fish

was also weighed to the nearest gram using an electronic scale with a capacity of 7 kg for the smaller and another one with a capacity of 20 kg for the larger ones.

Results
Inventory of fishing units
Thirty-nine (39) fishing units have been identified at the Lahou-Kpanda site in Grand-Lahou. However, only nineteen (19) of them agreed to collaborate in this work. Each of these nineteen (19) sampled units used a Ghanaian boat type. The smallest crew had eight (8) fishermen against twenty-three (23) for the largest. There were eighteen (18) motorised units, eleven (11) of which used purse seines and seven (7) used gillnets. Only one (01) non-motorised fishing unit uses beach seines.

Characteristics of fishing nets
Purse seines surveyed have total lengths between 300 m and 1,200 m, heights of 4 m to 22 m and mesh sizes between 12 mm and 25 mm. Analysis of Table I shows that fishermen have great preference for large purse seines made with nets with mesh sizes of 20 mm or less (91.53%), lengths over 500 m (91.53%) and heights over 10 m (89.83%). As for gillnets, their lengths vary from 50 m to 500 m, height and mesh sizes from 3 m to 12 m and from 25 mm to 40 mm respectively. However, 83.33% of fishermen prefer gillnets with lengths over 100 m (75.00%), height over 5 m (75.00%) and mesh sizes over 35 mm. Finally, the only beach seine used on the site is made of 10 mm mesh. It has a length of 1660 m and a height of 5 m.

Table 1: Characteristics of fishing gear types surveyed

Fishing gears	Characteristics		Number	Percentages (%)
Purse seines	Total length	≤ 500 m	5	8,47
		> 500 m	54	91,53
		Total	59	100,00
	height	≤ 5 m	2	3,39
		6 - 10 m	4	6,78
		> 10 m	53	89,83
		Total	59	100,00
	Mesh size	≤ 20 mm	54	91,53
		> 20 mm	5	8,47
		Total	59	100,00
Gillnets	Totale length	≤ 100 m	3	25,00
		> 100 m	9	75,00
		Total	12	100,00
	height	≤ 5 m	3	25,00
		> 5 m	9	75,00
		Total	12	100,00
	Mesh size	≤ 35 mm	2	16,67
		>35 mm	10	83,33
		Total	12	100,00

Catch composition

A total of 22 species belonging to 4 orders and 9 families were identified during the 24 sampling campaigns (Table II). Perciformes and Mugiliformes have the most species, respectively 10 and 6. At the family level, Mugilidae had 6 species, followed by the Clupeidae, Carangidae and Sciaenidae, each represented by 3 species. In addition, 21 of the 22 species identified were caught by purse seine. Gillnet and beach seine caught respectively 6 and 11 species.

Table 2: Fish species caught by fishing gear type; * = presence

Ordres	Families	Species	Gillnet	Purse seine	Beach seine
Clupeiformes	Clupeidae	*Ethmalosa fimbriata*		*	*
		Sardinella aurita		*	*
		Sardinella maderensis		*	*
	Pristigasteridae	*Ilisha africana*		*	*
Mugiliformes	Mugilidae	*Liza dumerili*		*	*
		Liza falcipinnis		*	*
		Liza grandisquamis		*	*
		Mugil bananensis		*	*
		Mugil cephalus	*	*	*
		Mugil curema		*	*
Perciformes	Carangidae	*Trachurus trecae*		*	
		Caranx hippos		*	
		Chloroscombrus chrysurus		*	*
	Haemulidae	*Pomadasys perotti*		*	
	Polynemidae	*Galeoides decadactylus*		*	
		Polydactylus quadrifilis		*	
	Sciaenidae	*Pseudotolithus elongatus*	*		
		Pseudotolithus senegalensis	*	*	
		Pseudotolithus typus	*	*	
	Sphyraenidae	*Sphyraena afra*	*	*	
Pleuronectiformes	Cynoglossidae	*Cynoglossus canariensis*	*	*	
		Cynoglossus senegalensis		*	

Species relative abundances by fishing gear type
Purse seine catches

In total, 3,541 fish specimens have been analysed with a remarkable abundance of Clupeidae (80.95%). Each of the other seven families have percentage lower than 5%, except for the Carangidae (Figure 2). At species level, *Sardinella maderensis* represents for more than half of the total catches (55.76%) followed by *Ethmalosa fimbriata* (13.73%), both constituting almost 70% of the catches (Figure 3). The other species appear weekly in the catches with percentage lower than 2% each except for *Sardinella aurita* (6.53%), *Pomadasys perotti* (4.95%), *Ilisha africana* (4.91%), *Polydactylus quadrifilis* (3.20%) and *Trachurus trecae* (2.88%).
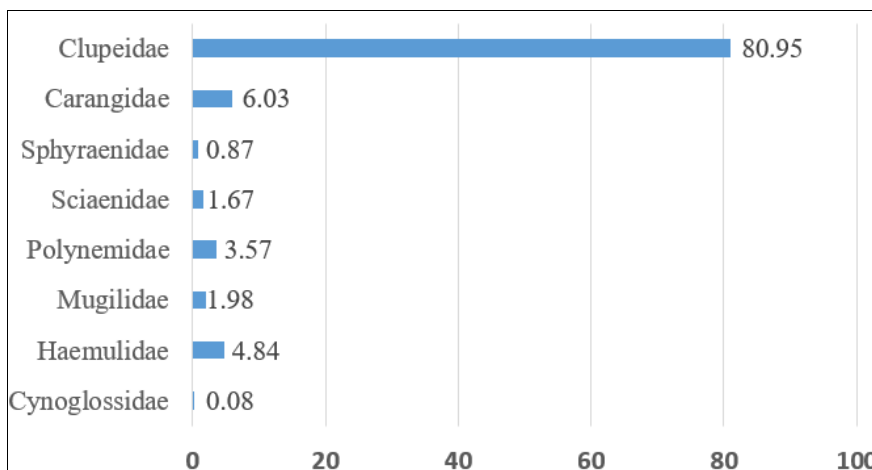
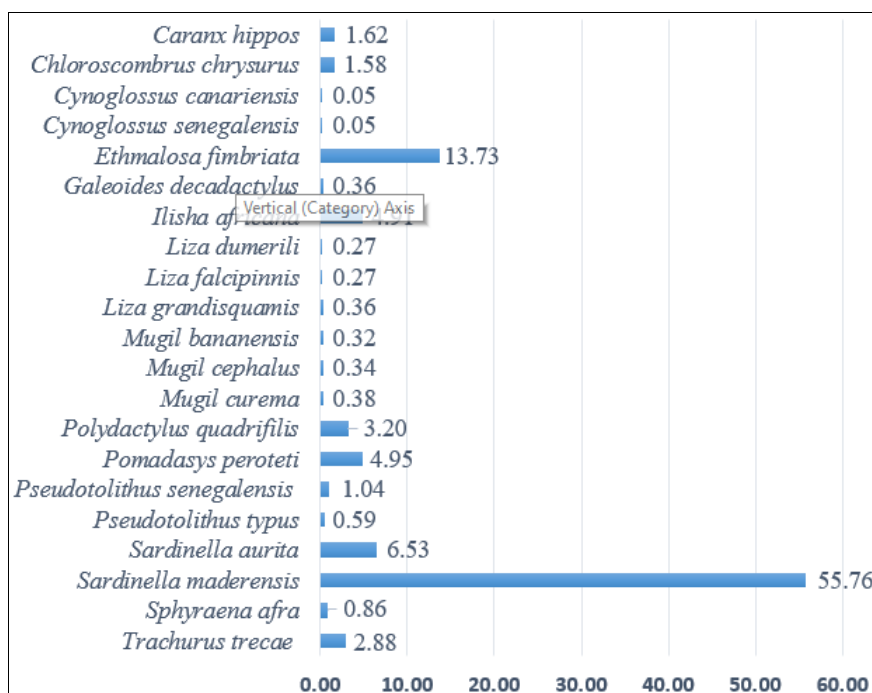**Fig 2:** Relative abundances of fish families caught by purse seine

Fig 3: Relative abundances of fish species caught by purse seine

Gillnet catches

Out of a total of 1.446 specimens sampled, Sciaenidae are dominant (59.10%), followed by Sphyraenidae (16.21%) and Cynoglossidae (15.38%). Mugilidae, on the other hand, are the least represented (Figure 4). As for species, six have been caught by this gear. *Pseudotolithus typus* (30.13%) is the most abundant, followed by *Pseudotolithus elongatus*, *Sphyraena afra* and *Cynoglossus canariensis*, whose individual proportions vary between 15% and 17%. The least represented are *Mugil* cephalus and *Pseudotolithus senegalensis* (Figure 5).
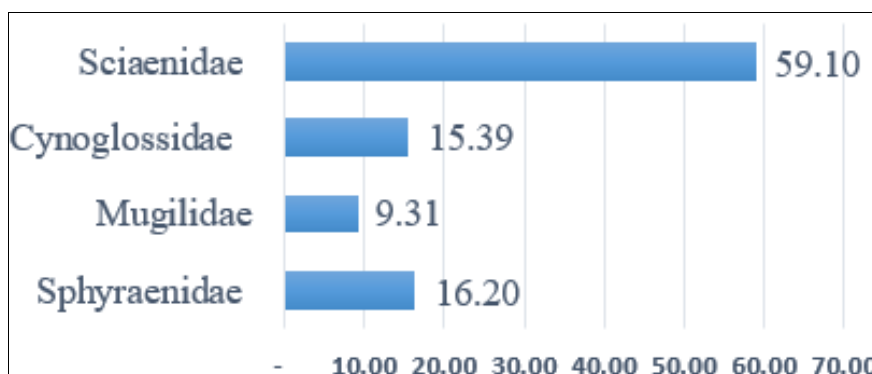

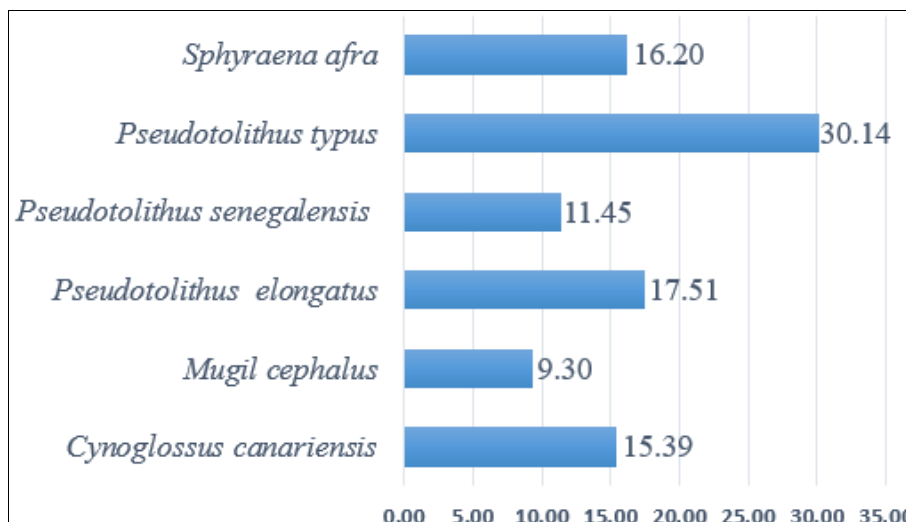**Fig 4:** Relative abundances of fish families caught by gillnets

Fig 5: Relative abundances of fish species caught by gillnets

Beach seine catches
Fish families caught by beach seine are the least diverse with only three representatives. Clupeidae (88.12%) constitute the large majority of the 1,803 specimens sampled (Figure 6).

According to species, eleven ones have been identified in captures. *Sardinella maderensis*, *Ethmalosa fimbriata* and *Sardinella aurita* are the most represented in proportions of 37.68%, 28.16% and 20.12% respectively (Figure 7).
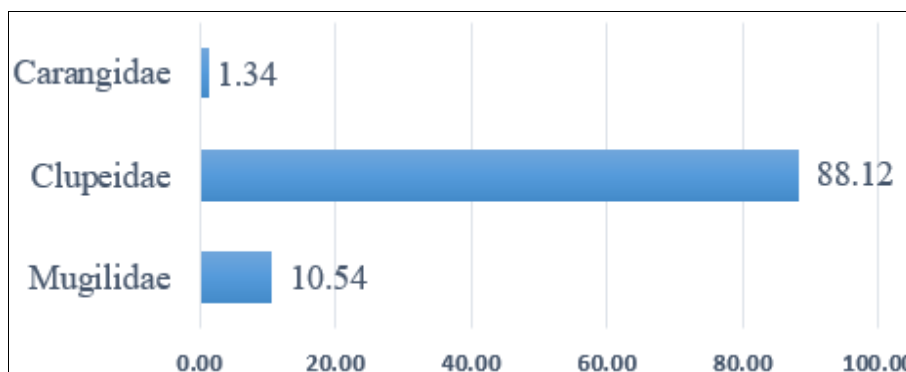

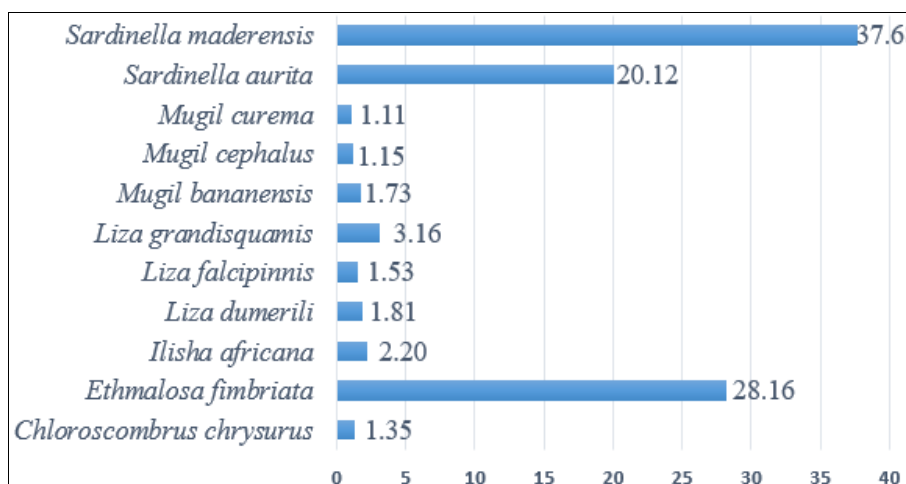**Fig 6:** Relative abundances of fish families caught by beach seine

Fig 7: Relative abundances of fish species caught by beach seine

Length and weight of specimens in fishing gears catches
Smallest specimens of 10 cm fork length were caught by beach seine and purse seine, whereas the largest ones were caught by the purse seine. Also, 45.46% of beach seine catches and 28.57% of purse seine catches were made up of specimens with a fork length lower than 20 cm. These small fish have not been caught by gillnet. In contrast, large

specimens with fork length higher than 50 cm constitute half of gillnets catches and only 09.52% of purse seine captures. No specimen of this length were caught by beach seine. As for specimens with fork lengths between 20 and 50 cm, they are caught in proportions of 54.54%, 50.00% and 61.90%, respectively by beach seine, gillnet and purse seine (Table 3).

Table 3: Mean length and mean weight of specimens caught by fishing gears types with extreme values highlighted (Mini, minimum; Maxi, maximum; SD, standard deviation)

		Beach Seine			Gillnet			Purse Seine		
		Mini	Maxi	Mean ± SD	Mini	Maxi	Mean ± SD	Mini	Maxi	Mean ± SD
Caranx hippos	Length							31,4	73,2	38,9
	Weight							403,5	1200	452,9
Chloroscombrus chrysurus	Length	10,8	23,9	18,8				10,3	38,1	22,8
	Weight	30,4	85,5	52,5				25,9	125,2	67,3
Cynoglossus canariensis	Length				22,1	53,3	47,1	22,6	40,5	32,2
	Weight				28,7	187,5	110,3	40,1	142,6	95,4
Cynoglossus senegalensis	Length							25,7	43,2	31,3
	Weight							45,7	106,2	89,7
Ethmalosa fimbriata	Length	11,4	26,1	15,8				12,4	34,8	25,5
	Weight	48,4	98,6	66,5				61,5	253,6	164,3
Galeoides decadactylus	Length							14,6	23,8	20,5
	Weight							111,4	340,2	205,7
Ilisha africana	Length	12,2	20,4	15,9				13,6	19,3	16,2
	Weight	32,9	120,2	86,5				43,3	116,2	90,8
Liza dumerili	Length	20,8	52,4	25,8				15,9	27,3	17,4
	Weight	63,9	1200	154,8				87,8	147,4	81,5
Liza falcipinnis	Length	18,4	51,2	27,6				22,7	29,2	25,9
	Weight	58,4	1300	181,6				142,3	207,2	155,7
Liza grandisquamis	Length	13,8	48,9	28,3				12,2	37,6	31,5
	Weight	47,7	1200	167,5				42,6	689,7	435,3
Mugil bananensis	Length	20,1	61.9	29,1				26,5	70,2	28,2
	Weight	260,4	1300	307,6				338,7	1600	316,1
Mugil cephalus	Length	22,4	41,5	30,5	30,5	61,7	52,5	31,3	43,2	35,1
	Weight	104,7	1200	348,2	331,6	1600	1452,6	342,5	1200	371,2
Mugil curema	Length	20,7	38,9	31,2				19,7	25,3	23,8
	Weight	261,5	1100	801,7				192,3	430,5	315,6
Polydactylus quadrifilis	Length							63,2	117,9	98,9
	Weight							1400	10300	9122,3
Pomadasys perotti	Length							22,6	28,7	26,8
	Weight							180,4	251,3	240,4
Pseudotolithus elongatus	Length				23,3	48,8	42,5			
	Weight				148,2	1200	1161,3			
Pseudotolithus senegalensis	Length				24,5	53,9	48,7	25,4	41,8	32,5
	Weight				163,6	1400	925,5	187,9	542,3	240,4
Pseudotolithus typus	Length				33,8	65,4	60,3	33,9	52,5	47,7
	Weight				395,7	1500	1315,4	325,6	1200	925,3
Sardinella aurita	Length	16,5	25,3	16,5				16,4	22,8	19,3
	Weight	27,8	275,4	59,7				54,8	191,2	85,5
Sardinella maderensis	Length	15,1	23,2	19,3				14,6	25,4	22,5
	Weight	48,5	104,7	67,4				44,4	128,7	92,2
Sphyraena afra	Length				50,9	120,3	115,4	37,9	101,8	57,6
	Weight				1300	6300	5802,7	424,3	3100	1904,7
Trachurus trecae	Length							14,6	27,3	19,7
	Weight							81,5	125,4	96,8

Discussion

Three fishing gear types are used by marine artisanal fishermen working at the Lahou-Kpanda site in Grand-Lahou. These are gillnet, beach seine and purse seine. These fishing gears have been listed by Anoh (2007) [2] along the entire Ivorian coastline. This author also mentions longline, the latter being particularly suitable in fisheries with uneven and rocky sites where the other fishing gears are less effective (Chavance, 1999) [4]. Only one beach seine is currently used in Lahou-Kpanda, compared to nine reported in 2010 (MIRAH/SP, 2010) [16]. According to fishermen, this fishing gear has a low yield, hence their great preference for purse seine and secondarily for gillnet. Indeed, purse seines are the most elaborate artisanal fishing gears and the most similar to industrial ones (Deme *et al*., 2012) [6]. This could justify their choice to obtain maximum catches. Also, these gears are more efficient for catching *Sardinella*, unlike gillnets and beach seines (Bousso, 1994) [3]. Fishermen note that they only use gillnets when the yields of other fishing gears are less important.

Ichthyological composition of each fishing gear type reveals that 21 of the 22 species listed were caught by purse seine. Gillnet and beach seine caught 6 and 11 species respectively. The reduction in the areas of use of the beach seine, which is limited to sites close to the shore, unlike the purse seine, could explain the high species richness of the latter fishing gear. The low number of species caught by gillnets could be related to their occasional use. Catches of purse seine and beach seine are dominated by Clupeidae, 80.95% and 88.12% respectively. Also, *Sardinella maderensis* constitutes more than half of the species caught by purse seines (55.76%) and secondly *Ethmalosa fimbriata* (13.73%). Such observations have also been reported in the artisanal maritime fishery in Senegal by Deme and Kébé (1993) [5]. These authors state that

purse seines catch mainly small pelagic species such as *Sardinella*, *Ethmalosa*, small tuna and associated species. Also In beach seine catches, dominant species are *Sardinella maderensis* (37.68%), *Ethmalosa fimbriata* (28.16%) and *Sardinella aurita* (20.12%). It should be noted that the Ivorian coastline is under the influence of periodic up welling which favour the development of plankton. Two upwelling seasons are observed. The short season is noted in January and February and the long upwelling season from mid-May to September (Djakouré, 2010) [9]. These two upwelling seasons extend over a large part of our sampling period. They are therefore favourable to the development of fish populations, among which *Sardinella* are dominant. In any case, the main categories of ichthyological resources in the Côte d'Ivoire Exclusive Economic Zone are mainly small pelagic with a particular abundance of *Sardinella*, followed by demersal fish and tuna. Anchovies, horse mackerel and other clupeids and carangids are of secondary importance (Shep *et al*., 2016) [21]. As for gillnets, they mainly caught Sciaenidae (59.10%) with *Pseudotolithus typus* (30.13%) as the dominant species, followed by *Pseudotolithus elongatus*, *Sphyraena afra* and *Cynoglossus canariensis*, whose individual proportions vary between 15% and 17%. These fishing gears are used more outside the periods of abundance of small pelagic (ACPFISH II, 2013) [1].

Conclusion

Fishing is still practised on the Lahou-Kpanda site in Grand-Lahou despite erosion advance along the Ivorian coast. Fishermen mainly use purse seine, secondarily gillnet and rarely beach seine. However, purse seine and beach seine caught more species. These two gears mainly catch Clupeidae with particular abundance of *Sardinella maderensis* and *Ethmalosa fimbriata* in addition to *Sardinella aurita* for the beach seine. As for gillnet, it caught more Sciaenidae and *Pseudotolithus typus*. Finally, smallest specimens were caught by beach seine and the largest ones by gillnet.

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