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Characterization of shrimp fishery in the Bandama River, Côte d'Ivoire

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Abstract

The study was conducted to assess the yields and analyze the profitability of small-scale shrimp fishery in Bandama River, Côte d'Ivoire. A total number of 142 shrimp fishers were recorded. Fishermen used 142 non-motorized canoe with two types of artisanal trap gear known locally as "Papolo" and "N'zrè". The mean annual fishing effort calculated for all three stations sampled is 47 fishermen per day. Shrimp appeared year-round, however high catches are observed in the rainy seasons (April-July and October-November). Annual landings stood at 41.62 tons. The shrimp species identified included *Macrobrachium vollenhovenii* (81.13 % by weight), *M. macrobrachion* (18.79 %), *M. felicinum* (0.05 %), and *Atya gabonensis* (0.03 %). A total amount of \$121,114.2 was estimated while average price was \$2.91 kg^{-1}. Net profits, economic and financial performance of the shrimp fisher were satisfactory. The net profit varied from \$1387.79 to \$1887.88. The mean gross revenue for the entire stations was \$1953.58. The level of profitability and the profit margin are more than 10 %. The benefit cost ratio (BCR) was greater than 1 in the three stations. Monthly income per fisher was highest opposed to guaranteed minimum wages and guaranteed minimum agricultural wage. These high prices encourage regular and active *Macrobrachium* fishing in Bandama River. Shrimp fishing should therefore be monitored during the rainy months for a sustainable use. There was also the urgent need for effective management of shrimp fisheries in the River Bandama, to improve on the living standard of the people.

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Introduction

Freshwater shrimps are distributed over globe's regions. More than one hundred species are known and among them a quarter in America and three quarters in Asian and African waters (Holthius, 1980). Several shrimp species of genus *Macrobrachium* inhabit fresh and brackish water of West Africa (Monod, 1966; Holthuis, 1980). According to Gooré Bi *et al.* (2007), only two of the 7-10 shrimp species inhabiting rivers of Côte d'Ivoire are exploited by fishing activities: *Macrobrachium vollenhovenii* (Herklots, 1851) and *Macrobrachium macrobrachion* (Herklots, 1857). *Macrobrachium* species are relished by indigenous consumers due to their large size, nutrient value and pleasant taste. They are commercially important prawn species common in West African waters and sustaining viable artisanal fisheries in some rivers and estuaries within the region. Shrimp fishery sector provide direct and secondary employment (Marioghae, 1990; Deekae and Idoniboye-Obu, 1995; Okogwu *et al.*, 2010). Shrimps are considered in Côte d'Ivoire a valuable fishing resource and their market prices are appreciably higher than those of fishes. In fact, depending on season and location, a kilogram of shrimps is usually sold at $2.91 - $9.09, whereas fish price ranges between $0.54 and $1.27 per kilogram (Gooré Bi *et al.*, 2007).

In spite of this appreciable contribution to Côte d'Ivoire economy, fresh water shrimps have not been taken into account for a long time in fishery statistics of this country, since available statistics are essentially based on marine shrimp catches. Through lack of fishery statistics, contribution of freshwater prawns' fishery to national economy is unknown (Kebe and Tallec, 2006). Today, owing to significance offered by shrimp's exploitation, there is necessity to acquire data on shrimp fishery network in fresh water. Information on the ecology and biology of freshwater prawn are available. In contrast, fisheries characteristics and socioeconomic studies are scanty (Gooré Bi *et al.,* 2007).

The first study on shrimps fisheries characteristics and its socioeconomic analysis in Côte d'Ivoire was made in Bia River by Gooré Bi *et al.* (2001). The shrimps *Macrobrachium macrobrobrachion* and *M. vollenhovenii* are exploited in River Bandama in large quantities but there are no reports on stock assessment in this area.

This study is a preliminary on shrimp stock assessment in Bandama River. The main objectives of this study are to bridge the gap in knowledge by providing information on shrimps fishing effort, species composition, seasonal and spatial variation of catches and economic analysis of the fishing operation to the fishermen.

Materials and methods

Study area

The study area is located downstream hydroelectric dams, between latitudes 6°00'- 6°20' N and longitudes 4°90'- 5°00' W. The study area is located in an equatorial transition zone with two rainy seasons separated by a short dry period from August to September and a more pronounced dry season from December to March. The River body in the study area is characterized by two high water level periods, June-July and October-November. Conversely, lowest water level periods are December to March (Heldin, 1971). The hydrological variation of the River in this study area depends on opening and closing of the hydroelectric dam.

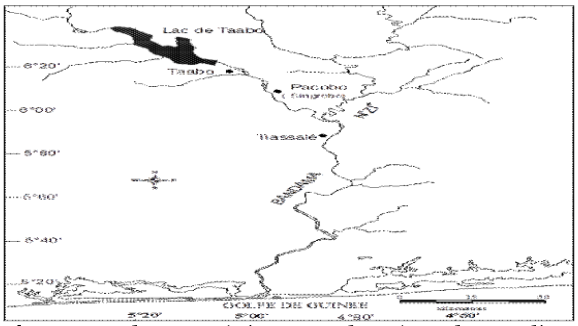

Fig. 1. Study area (River Bandama) and sampling stations (●).

The survey of artisanal shrimp fishing was held in three main stations. They constitute the main shrimp fishing sectors on the river Bandama. These three stations include seven landing places easily accessible at any season. Furthermore, in these landing places, shrimps are sold locally making easier access to catches (Fig. 1). Station 1 includes the villages N'dènou, Ahouati and Sokrobo; Station 2 regroups Singrobo and Tiassalé villages; Station 3 includes the villages Tiassalékro, Broukro and M'brimbo.

Data collection

Data collection from January to December 2009 involved two major survey instruments: i) fishery survey designed to obtain information on the gear characteristics, catch composition and landings; and, ii) an economic survey aimed at identifying cost and earning data on the artisanal fisheries. For fishery survey, samples were collected from the two gear exploiting the fishery (the two fishing gear were only used in station 3), to examine the species composition in percent by weight. Batches are chosen randomly, made up of whole or catch fractions (when the catch exceeded 10 kg). Catches were analyzed and shrimp species were identified according to Monod (1966), Gooré Bi *et al.* (2007). Each sample was a subsample from a total catch of known weight. Besides, material and size of fishing gear were reported. Secondly, catches from artisanal fishermen were taken daily at the landing stations and number of fishermen indicated. For each fisherman, total catch per trip was recorded at the station using a 25 kg spring balance to the nearest 0.5 kg. For economic analysis, the first stage was the selection of 30 respondents from each station. Secondly, basic information was obtained by direct information and questioning. The number of fishing gear and cost, type of bait and cost, cost of a canoe, repair and maintenance cost were obtained by direct observation and questioning. These estimates were confirmed by direct questioning of the inhabitants of the community. Furthermore, prices of shrimps were periodically recorded across seasons to detect any difference. This price was used as basis for economic analysis. Fishers used cassava and oil palm fruit as bait in gear 1. For gear 2, bait is rice and maize bran's. Bran is cooked and divided up.

Data analysis

Catches

The unit of analysis was the fishing trip which corresponds to the activity of each fisherman in one day (fishermen go fishing only once each day). The fishing effort was considered as the daily fishing trip and expressed in number of fishermen landing day. The catch Per Unit of effort (CPUE) is widely used as a relative abundance index in several fisheries all over the world (Tah *et al.* 2009; Mendonça *et al.*, 2010). Therefore, the CPUE was chosen as an indicator of the status of shrimp fisheries of the Bandama River. The CPUE was estimated every month per landing station, as follows:

$$CPUE_i = W_i/T_i$$

Where $CPUE_i$ is the weight of shrimps caught (kg) per fishing trip in the month i, Wi is the total weight (kg) of daily catches landed by fishermen in the month i; T_i corresponds to the number of daily fishing trip in the month i.

The monthly total catches per station i was estimated following Tah *et al.* (2009):

$$C(t)_i = CPUE_i \times F_i \times D$$

Where $C(t)_i$ is the monthly total catches in the station i; $CPUE_i$ is the weight of shrimps caught (kg) per fishing trip in the month i; Fi is the monthly average number of fishermen landing catches in station i. D correspond to the number of fishing days during the month i.

The total annual catch was determined in all stations where sampling was carried out adding up each station catches. Data from subsamples were used to extrapolate monthly CPUE of each species, by relating subsample to total catches. For statistical analysis, standard deviation values and one-way ANOVA were carried out to test any difference in catches between gears (Papolo and N'zrès), then to compare means CPUE among sampling sites.

Economic and financial performance

An average number of gear per fisherman and cost per canoe was estimated. For bait including freight charges, a fisher used a bag of 100 kg of rice and maize bran, lasting four days. The ratio of operating days in the year by four days gives the number of bags used in the year by a fisher. Cost of bait in the year is equal to the number of bags multiplied by the bag price (freight charges add to purchase price). Cost of repair and maintenance was estimated by the average number of maintenance in a year.

Calculation of economic and financial performance

Profitability analysis deals with the fishing effort, catch, prices, costs and revenues. Agbeja and Falaye (2007), Adeogun *et al.* (2011) identified three cost categories in fishing enterprises. (1) variable costs (costs that tend to be directly related to production), (2) fixed costs (these include insurance, property taxes, license fees and lease payments), which as Norton (1968) showed, do not vary with output and (3) interest cost on owned capital invested in the fishing assets can also be included as part of fixed costs (Panayotou, 1985). Interest cost was considered zero due to none of the small-scale fishing canoe used bank credit. Depreciation, which is the part of the costs of the fixed assets consumed during a given period, was calculated using the straight line method. The net income (NI) expresses the absolute income of the fisher. It was computed as the difference between revenue and the cost of production using the expression:

$NI_t = TR_t – TC_t$

Where, TC_t is the sum of fixed and variable costs which represent total costs of a fisher at time t.

$TC = FC + TVC_t$

Where, FC is the fixed costs per fisher which consists of the cost of investment associated with canoe and gears. TVC_t is the variable costs component. TR_t denotes total revenue

Total revenue of a fisher can be calculated as:

$TR = CPUE \times T \times P$

CPUE = general annual catch per unit effort per fisher estimated from average CPUE of each sampling stations, T is the fishing trip in the year corresponding to operating day in the year, P is the average price of shrimp.

Subsequently, Average income per fisher per annum was obtained from net income.

$MNI = NI_t / n$

Where, MNI is the monthly net income per fisher, NI_t is net income per fisher per annum and n is the number of months in one year.

Various ratios were computed to ascertain the extent of the profitability of shrimp enterprise namely:

- Profit Margin (%) = NI/TR. Closely related indicator of economic performance, which expresses the net profit as a percentage of the total revenue. A ratio of more than 10% can be considered as good (Tietze *et al.*, 2005).

- Profitability (N) = NI/TC. The financial performance was measured by profitability. A level of 10% is generally considered to be a good result. The net profit expressed as a percentage of the invested capital, indicates the profitability of the investment in relation to other alternative investments (Tietze *et al.*, 2005).

- Operating Expense Ratio (%) = TVC/TR
- Benefit Cost Ratio (BCR) = TR/TC

If the benefit cost ratio is greater than 1 (> 1) the project is profitable and if it is exactly 1, it means a project that breaks even, i.e., neither making profit nor loss. When the ratio is less than 1 (< 1), the project is operating at a loss.

Standard deviation and the analysis of variance (ANOVA) were used to verify the significant differences in economic returns among the investigated stations, complemented by the Tuckey test to indicate in which year or with which gear occurred the most significance differences. A degree of significance (α) of 5 % was used.

Results

Gears characteristics

Shrimp fishing activity is held by two kinds of people: traditional Bozo fishermen coming from Mali and the indigenous inhabitants.

The fishery is exploited by two types of artisanal trap gear. The first known locally as "Papolo" (gear 1) is covered by a multifilament net of various mesh sizes ranging from 20-28 mm, a length of 43-72 cm and a mouth opening of 13-25 cm in diameter. The second trap known locally as "N'zrè" (gear 2) made from textile strip of palm associated with the creepers, comprising a cylindrical part (35 cm) with an average diameter of 15 cm opening and a cone (15 cm).

They generally have a length between 5 and 8 m and are made with wooden boards or cut into the wood. The lifetime is a function of the building material. The average life of a canoe crafted in wood board is between 4 and 6, 8 and 10 years for those carved in wood.

Evaluation of the catch

A total of 142 fishermen have been counted in the three sampling stations. Yields of 41.62 tons performed by 1012 fishing trips were registered at the three sampling stations from trap catches: 40.39 tons for gear 2 (811 fishing trips and 133 fishers), then 1.23 tons for gear 1 (201 fishing trips and 9 fishers). One way Anova showed significant difference among catches ($F = 19.12$; $p < 0.05$) found in the three stations from the gear 2, confirmed by the Tuckey test for practically all the stations, particularly for station 1 [station 1 (23.98 tons); station 3 (12.31 tons); station 2 (4.10 tons)] and in the station 2, there was a significant decrease in productivity. Significant difference was also observed between gear 1 (1.23 tons) and 2 (12.31 tons) in the station 3 ($F = 32.45$; $p < 0.05$). This implies that gear 2 catch more shrimps than gear 1.

Table 1. Mean Catch Per Unit Effort (CPUE) and related parameters (fishing trips: Nb. Trips; total catches (kg) registered during 2009 in the three stations with "N'zrè" (gear 2).

	Related parameters		CPUE (kg/trip)					
Landing stations	Nb.Trips	Catches (kg)	Min	Max	Mean	SD	$F_{2,12}$	P
station 1 (gear 2)	253	23.98	1.16	4.37	2.85	1.09	0.62	0.55
station 2 (gear 2)	253	4.1	1.33	4.03	2.66	0.76		
station 3 (gear 2)	305	12.31	1.03	4.17	2.41	1.03		
Mean					2.64	0.96		
Total	811	40.39						

The mean annual value of daily Catch Per Unit Effort (CPUE) varied from 2.41 kg trip^{-1} at station 3 to 2.85 kg trip^{-1} at station 1. A comparison of the daily CPUE showed no significant difference among the annual CPUEs pointing to a possible stability in the catches over all the stations (Table 1). The ANOVA-test per gear showed no significant difference in the station 3 (Table 2). Besides, whatever the station and gear, monthly changes of the mean CPUE and mean rainfall showed that the highest values of CPUE occurred in rainy month, when fishing effort was high while, the lowest values of this index are recorded in dry season (Fig. 2 and 3) ($F = 19.12$; $p < 0.05$). The highest average annual effort was observed for station 1 (26 fishermen observed per days), against 17 in station 3 and 4 for station 2. The mean annual fishing effort for all three stations surveyed is 47 fishermen per day.

Table 2. Mean Catch Per Unit Effort (CPUE) and related parameters [fishing trips: Nb. Trips; total catches (kg)] registered during 2009 in the station 3 between "Papolo" (gear 1) and "N'zrè" (gear 2).

	Related parameters		CPUE (kg/trip)					
Landing stations	Nb. Trips	Catches (kg)	Min	Max	Mean	SD	$F_{2,12}$	P
station 3 (gear 1)	201	1.23	1.24	3.8	2.78	0.85	0.9	0.35
station 3 (gear 2)	305	12.31	1.03	4.17	2.41	1.03		
Mean					2.6	0.94		
Total	506	13.54						

Species composition

Yields of 0.201 tons from 253 fishing trips were used to determine catch composition. The species composition in percent by weight is presented in Figure 4. A total of two shrimp families (Palaemonidae and Atyidae) were identified. Three *Macrobrachium* species, *M. vollenhovenii, M. macrobrachion* and *M. felicinum*, contributed as high as 81.13 %, 18.79 % and 0.05 % by weight, respectively. However, the one Atyidae species, *Atya gabonensis* contributed about 0.03 % to the landed shrimps weight.

The mean annual value of daily CPUE varied from 0.0006 ± 0.0023 for *Atya gabonensis* to 2.3214 ± 0.80 for *Macrobrachium vollenhovenii*. A comparison of the daily CPUE showed no significant difference among the three taxa of *Macrobrachium macrobrachion*, *Macrobrachium felicinum* and *Atya gabonensis*. However, a significant difference ($F = 58.26$; $p < 0.05$) appeared among *Macrobrachium vollenhovenii* (2.32 ± 0.80) and three other species (0.5270 ± 0.5985; 0.00162 ± 0.0035; 0.0006 ± 0.0023), respectively for *Macrobrachium macrobrachion*, *Macrobrachium felicinum* and *Atya gabonensis* (Table 3).

Table 3. Mean Catch Per Unit Effort (CPUE) for each species registered during 2009.

	CPUE (kg/trip)					
Species	Min	Max	Mean	SD	F	P
Macrobrachium vollenhovenii	1.157	3.817	2.32	0.8	58.26	0.001
Macrobrachium macrobrachion	0.003	1.855	0.53	0.59		
Macrobrachium felicinum	0.000	0.010	0.002	0.003		
Atya gabonensis	0.000	0.008	0.001	0.002		

Economic characteristics and viability of shrimp fishery

From the total catch of 41.62 tons of shrimp, $121,114.2 was projected with a market price of $2.91 (Table 4). The cost structure of small scale shrimp fishing in each station and between the two gears was compared from the data collected during field studies. The different cost components of total costs are shown as percentages and distribution of main cost components in Table 4. Running cost (TVC) was the most important element followed by license and fees. Regarding differences in the cost structure, it can be noted that small-scale shrimps fishing operating in station 1 had relatively higher running costs (65.87 %) than shrimp fishing in other stations. The analysis of variance on operating costs of shrimp fishery for all the stations was found to significant at 5% level.

This implies that the operating cost of shrimp fishery differs from one station to another. Fishers in station 1 had the highest running cost which was however significantly different from shrimp fishers in station 2 and 3, considering gear 2. Operating cost of gear 2 was higher compared with gear 1, in station 3. Shrimp fishermen had no crew, implying that small-scale shrimp fishery used no additional labor.

In the three stations which used gear 2, bait expenditure is the most important cost component of the running costs. Between gear 1 and 2, in the station 3, the most important cost component is gear changing for gear 1 (28.23 %) and bait for gear 2 (45.79 %). The highest proportion spent on bait with gear 2, in the three stations was recorded in station 1 (63.84 %) while the least was in station 3 (45.79 %).
Table 4 also highlights the summary of the fixed cost components of the total costs of shrimp fishing in all stations surveyed. The cost constituents were depreciation on canoe, gears (traps), paddle and box. The result shows that total fixed costs (TFC) varied from 34.13 % in station 1 to 66.29 % in station 3. No significant difference was observed across the stations for gear 2 (Table 5). But in the station 3, between gear 1 and 2, significant difference was observed in total fixed cost (Table 6). Gear 1 had the highest share of total fixed costs. License and fees was the most

important cost component of the fixed cost, accounting for 20.77, 24.12, 29.68 and 31.29 % in station 1, station 2, station 3 considering gear 2 and station 3 with gear 1 respectively. Moreover, no significantly difference was observed, whatever the station and gear.

The proportion of depreciation cost in the three stations varied from 6.77 % in station 3 (gear 1) to 21.63 % in station 3 (gear 2). The ANOVA on depreciation cost was insignificant across the stations considering gear 2. But in the station 3, depreciation cost was significantly different. Least proportion was observed with gear 1 (6.77 %) and highest with gear 2 (21.63 %).

Table 4. Cost, returns and income per shrimp fishermen in Bandama river.

	Station 1		Station 2		Station 3			
		%		%	"Papolo" (gear 1)	%	"N'zrè" (gear 2)	%
Catch wet weight (kg)	23980		4100		1230		12310	
value $	69781.8		11931		3579.3		35822.1	
Annual average CPUE (kg trip-1)	2.84		2.66		2.78		2.41	
Fishing effort (trip)	253		253		201		305	
Catch per fisher per annum	718.52		672.98		558.78		735.05	
Average price of shrimp ($)	2.91		2.91		2.91		2.91	
Total Revenue (TR) ($)	2090.89		1958.37		1626.05		2139	
Variable costs (TVC) ($)								
Bait	229.09	63.84	172.5	55.81	13.05	5.48	115	45.79
Repair and maintenance	7.27	2.03	7.27	2.35			7.27	2.9
Gears changing		0		0	67.27	28.23		0
Total Variable Costs (TVC)	236.36	65.87	179.77	58.16	80.32	33.71	122.27	48.69
Gross margin (GM) = TR-TVC	1854.53		1778.6		1545.73		2016.73	
Fixed cost ($)								
Depreciation	47.95	13.36	54.77	17.72	16.13	6.77	54.31	21.63
License and fees	74.54	20.77	74.54	24.12	74.54	31.29	74.54	29.68
Gear					67.27	28.23		0
Total Fixed Cost (TFC)	122.49	34.13	129.31	41.84	157.94	66.29	128.85	51.31
Total Cost (TC) = TVC + TFC	358.85		309.08		238.26		251.12	
Net Income (NI) = TR-TC = GM-TFC	1732.04		1649.29		1387.79		1887.88	
Average income per fisher per annum	144.34		137.44		115.65		157.32	
Profit Margin (%) = NI/TR	83		84		85		88	
Profitability = NI/TC	4.83		5.34		5.82		7.52	
Operating Expense Ratio (%) = TVC/TR	11		9		5		6	
Benefit Cost Ratio (BCR) = TR/TC	5.83		6.34		6.82		8.52	

Economic and financial performance of shrimp fishery

The small-scale shrimp fishery in the three stations achieves satisfactory financial and economic results. Tables 4 and 5 show that, the entire fishing stations generated positive share income, for the small-scale shrimp fishery. However, in terms of annual revenue, average gross margin (GM) and net income (NI) or in other words net profit (NP), Benefit cost ratio, costs, the shrimp fishery in study areas have positive economic results. The mean gross revenue varied from $1626.05 in station 3 (gear 1) to $2139 in station

3 (gear 2). The overall mean gross revenue for the entire stations was $1953.58. The ANOVA showed that the means of revenue for all the stations were not significantly different (F = 0.06, p >0.05) and (F = 0.22, p >0.05) respectively for gear 2 station 1, 2, 3 and for gears 1 and 2 station 3. This implies that levels of mean revenue did not differ across all the stations. The mean gross margin ranges between 1545.73 in Station 2 to 2016.73 in station 3 (gear 2). For the net income, there was no significant difference across the stations whatever the stations and gear. The F-value was 0.07 (p > 0.05) for the gear 2 in the three stations and F = 0.22 (p > 0.05) in station 3 between gear 1 and 2 implies that there was no significant difference in the net income of the shrimp fishers across the various stations. In terms of financial performance, which is also called profitability, shrimp fishery in the study area showed positive results. Profitability performance with gear 2 in station 1, 2 and 3 were 48.3, 53.4, 58.2 and 75.2 % respectively. The ANOVA on performance of shrimp fishery for the entire stations and the two gears revealed no significant difference. Moreover, the level of profitability is more than 10 %.

Table 5. Economic and financial performance of shrimp fishery in Bandama river with "N'zrè" (gear 2) in the three stations.

Cost component	Station 1			Station 2			Station3			F	p
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV		
Gross margin ($)	1854.53	1280.49	0.65	1778.60	515.95	0.29	2016.73	1786.29	0.79	0.07	0.93
Total cost ($)	358.85	12.99	0.04	309.08	3.40	0.01	251.12	4.24	0.02	87.95	0.00
Total fixed cost ($)	122.49	10.29	0.08	129.31	1.93	0.01	128.85	0.00	0.00	0.80	0.53
Total variable cost ($)	236.36	2.70	0.01	179.77	5.33	0.03	122.27	4.24	0.03	363.45	0.00
Effort (trip)	253.00	73.54	0.29	253.00	73.54	0.29	305.00	70.71	0.23	0.34	0.73
Annual average CPUE (kg trip^{-1})	2.84	0.41	0.14	2.66	0.17	0.06	2.41	0.58	0.24	0.52	0.64
Price ($)	2.91	0.51	0.17	2.91	0.25	0.09	2.91	1.03	0.35	0.00	1.00
Profit Margin (%)	83.00	10.58	0.13	84.00	4.23	0.05	88.00	10.85	0.13	0.13	0.88
Profitability	4.83	3.35	0.66	5.34	1.62	0.31	7.52	6.97	0.83	0.33	0.74
Benefit cost ratio	5.83	3.35	0.55	6.34	1.62	0.26	8.52	6.97	0.74	0.33	0.74

Furthermore, economic performance (Benefit cost ratio and profit margin), are shown in Table 6. Economic performance obtained from the entire stations systems were very good and close. Whatever the station and gear, there was no significant difference in averages observed. The profit margin of shrimp fishers were 88, 85, 84 and 83 % respectively in stations 3, 2 and 1. The benefit cost ratio (BCR) was greater than 1 in the three stations.

The ANOVA on fishing effort, catch rates and average price show no significant difference across the stations and between the two gears, which imply that these did not vary across the stations

Discussions

The market scenario, due to the variable number of fishermen looking for source of income, may interfere with the landing (Moss, 1982; Steele and Bert, 1998) and change the focus to more profitable resources. During rainy seasons, gillnet and cast net fisheries are difficult because of draught water loaded with branches, leaves that can tear nets. Therefore, in rainy season, several fishermen turn to the shrimps as a promising resource, to fill the gap of the fish low-profit period. A possible consequence is an increase in shrimps fishing effort. Variation in number of fishers in the study area could be attributed to migration of fishers from one area to another during more productive seasons. Shrimp fishers concentrated more at Station 1 (23.98 t), than the other stations.

Catch Per Unit Effort (CPUE)

As shown by variation of CPUE and catches in this study, lower catches were observed during dry season, while higher catches were reported in the rainy season. It was recorded that the fishery of shrimps was confined to the rainy season (Marioghae, 1990; Enin *et al.*, 1991; Nwosu and Holzlohner, 2004; Babatunde, 2010). As a reflection of the abundance of the prawn during this season, variations in catch according to season reflect the behavior of the shrimps and the response of fishery to the different season. An abundance of shrimps during rainy season is due to reproductive in-migration from the many fresh water streams emptying into Grand-Lahou lagoon in the south. Ville (1970) and Marioghae (1990) have made similar observations in Ebrié lagoon, Côte d'Ivoire and Lagos lagoon, Nigeria, respectively. This observation is in contrast with the results of Gooré Bi *et al.* (2001) and Deekae *et al.* (2010) for Bia River and Luubara Creek (Niger Delta), respectively. These authors observed heavy catches of *Macrobrachium* species during dry season when water level is low.

Table 6. Economic and financial performance of shrimp fishery in Banadama River between "Papolo" (gear 1) and "N'zrè" (gear 2) in the station 3.

Cost component	Gear 1 (*N'zrè*)			Gear 2 (*Papolo*)			F	p
	Mean	SD	CV	Mean	SD	CV		
Gross margin ($)	1545.73	917.65	0.56	2016.73	1786.29	0.79	0.20	0.70
Total cost ($)	238.26	0.78	0.00	251.12	4.24	0.02	17.78	0.05
Total fixed cost ($)	157.94	0.18	0.00	128.85	1.41	0.01	832.16	0.01
Total variable cost ($)	80.32	0.78	0.01	122.27	4.24	0.03	189.18	0.01
Effort (trip)	201	57.98	0.29	305.00	70.71	0.23	2.59	0.25
Annual average CPUE (kg/trip)	2.78	0.40	0.14	2.41	0.58	0.24	0.56	0.53
price ($)	2.91	0.38	0.13	2.91	1.03	0.35	0.00	1.00
Profit Margin (%)	85	8.75	0.10	88.00	10.85	0.13	0.03	0.88
Profitability	5.82	3.83	0.62	7.52	6.97	0.83	0.16	0.73
Benefit cost ratio	6.82	3.83	0.54	8.52	6.97	0.74	0.16	0.73

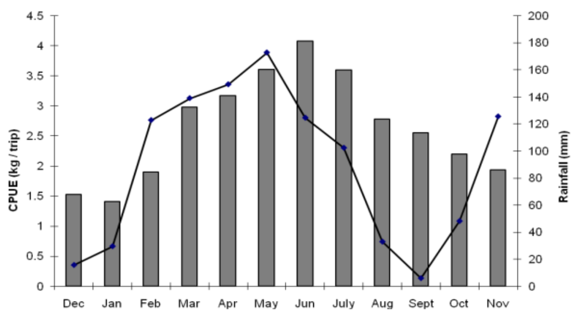

Fig. 2. Monthly changes in average Catch Per Unit Effort (CPUE): kg trip^{-1}) and rainfall in the 3 main stations from January to December 2009.

Catches

The abundance of an organism is determined by a number of factors such as hydrology, physico-chemistry, predators and diseases (Williams, 1955; Babatunde, 2010; Deekae and Abowei, 2010). In station 1, the presence of the dam is an important factor, which contributed to the heavy catches in the area. The dam is a trap of plankton rich in mineral and detritus (Chen, 2002), important for shrimps feeding. A comparison of the catches showed difference among the three stations. In the present study, total annual catch was 41.62 tons. Catch was 23.98 tons at station 1, 4.1 tons at station 2 and 12.31 tons at station 3 for gear 2. The difference could be due to the number of sites surveyed and the productivity of the area as reported by Loesh (1965). As for gear 1 (1.23 tons) and gear 2 (12.31 tons) in the station 3, difference may be linked to the bait. Fishers used cassava and oil palm fruit as bait in gear 1. Whereas, in the gear 2, fishermen used flour (rice or / and maize) cooked, locally called "Boue", which attract shrimps thanks to flavor.

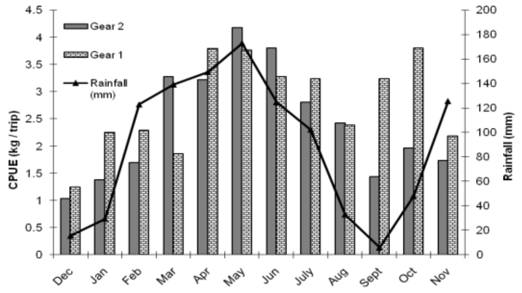

Fig. 3. Monthly changes in CPUE (kg trip^{-1}) and rainfall in the stations 3 (gear 1 and 2) from January to December 2009.

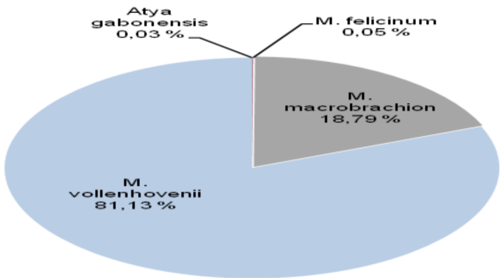

Fig. 4. Species composition by weight of the shrimp catches in River Bandama from January to December 2009.

Species composition

The dominance of *Macrobrachium* species in the artisanal shrimp fisheries of Côte d'Ivoire has been documented by various studies and is also supported by the present one. N'zi *et al.* (2008) reported that in the River Bandama *Macrobrachium vollenhovenii* was the most dominant contributing about 13.65 % (by weight), *Macrobrachium macrobrachion* was not caught. However Goore Bi *et al.* (2007) reported that *M. macrobrachion* was dominant in landings in the Bia River (48.1 %), while *M. vollenhovenii* contributed about 44.3 %. Similar results were obtained in Nigeria by Enin (1998) and Nwosu (2010) in the Cross River estuary, *M. macrobrachion* contributed 80.6 % and 83.4 % by number, followed by *M. vollenhovenii* with 6.7 % and 9.7 % respectively. According to Nwosu (2010), *M.vollenhovenii* contribution could increase if the difficulty (mainly cost) in reaching the trap fishing community is eliminated. Deekae *et al.* (2010) studying the abundance of *M. macrobrachion* in Niger Delta reported that the all year round occurrence of this species may be related to the high fecundity of the species and the availability of females that can spawn. According to N'zi (2003) the occurrence of species in catches may be due to the fishing gear/method, sampling season and area.

Economic and financial performance

From the total catch of 41.62 tons of shrimp, $121,114.2 was projected with a market price of $2.91. Goore bi *et al.* (2001) estimated a total income of $4,727.27 for the river Bia in the locality of Aboisso (south-west) with a market price of $2.36 per kg. Da Costa and Dietoa (2007) estimated a total income of $9,507.27 in lake Faé (south-east) Côte d'Ivoire with a market price of $2.73 per kg. The variation in the total estimated values of the Bandama River from elsewhere, could be attributed to (1) fishing effort as a result of the number of station survey (2) catch rate and resource biodiversity as a result of physic-chemical parameters and (3) the market prices. Goore Bi conducted his survey only in one village. Lake Faé is lentic environment with relatively low oxygen level, whereas shrimp are mostly caught in oxygen-rich environment (N'zi, 2008). Shrimp prices increased from $2.36 per kg in 2001 to $2.91per kg in 2009. The market prices are high compared with fish in the same market. For instance, at the time of this study, while a kilogram of shrimp was sold $2.91, fish price average $1.82-$2.36 kg^{-1}. Thus weight of the shrimp fetched more money than fish. Regarding differences in the cost structure, small-scale shrimps fishing operating in station 1 had relatively higher running costs (TVC), than shrimp fishing in other stations. The high cost could be attributed to the bait expenditure. In station 1, fishers bought bait component in another locality located at 5 km of this station. Higher running cost is then the combined effect of bait cost and transportation. In the others stations, bait components were locally sold. In stations 3, fishers used cassava and oil palm fruit as bait in gear 1. These are not costly, compared to maize and rice flour. Total fixed cost (TFC) was high with gear 1 in the station 3, because of gear replacement. Gear 1 (N'zrè) had short lifetime. Each 6 months, fishers should replace them in order to remain stable catches. Level of total revenue, gross margin, net income, profitability, profit margin and benefit cost ratio don't differs across the entire stations. The results of economic and financial performance gives a clue as to the source of none divergent performance in all the stations, since it is clear that there were not inter-stations differences in respect of utilization rates (day of fishing per year), average prices and catch rate. The profit margins obtained from the entire stations were good and close. Profitability in station 1, 2, 3 implies that for every $ 1 invested in shrimp fishery there is a return of $ 4.83, 5.34, 5.82 and 7.52 respectively to the fisher. The operating cash expenses ratio denote that 11, 9, 5 and 6 % of the gross revenue was used to cover the operating expenses. About 89, 91, 95 and 94 % of gross revenue went to the fisher's equity. The benefit cost ratio (BCR) is greater than 1, showing that the business is profitable. Monthly income per fisher were highest opposed to guaranteed minimum wages and guaranteed minimum agricultural wage which stood at $68.36 and $29.1 respectively. Shrimp fishing could substantially contribute to reduce rural exodus for trained and untrained young boys and to improve on the living standard of the people.

Conclusion

During rainy season, shrimps fishing effort and catches increase. Most of the shrimp was caught in this season but occurred throughout the year. The traps set at station 1 were observed to catch more shrimp than those at station 2 and 3. In the River Bandama *Macrobrachium vollenhovenii* was the most dominant. Budgetary analysis results show that shrimp fishing is viable and profitable. There were not significant differences among the annual CPUEs, economic and financial performance pointing to a possible stability over all the stations. Shrimp's high prices encourage regular and active *Macrobrachium* fishing in Bandama River. These results are sufficient for providing a basis for developmental plans in the River Bandama. Shrimp fishing should therefore be monitored during the rainy months for effective management of the fishery. Shrimp fishing could substantially contribute to reduce rural exodus for trained and untrained young boys and to improve on the living standard of the people.

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