Rev. Ivoir. Sci. Technol., 23 (2014) 178 - 198 178
ISSN 1813-3290, http://www.revist.ci

ESTIMATION OF FRESHWATER SHRIMP *MACROBRAHIUM VOLLENHOVENII* (HERKLOTS, 1851) CAPTURES IN RIVERS AND LAGOONS OF CÔTE D'IVOIRE (WEST AFRICA)

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ABSTRACT

The objective of the study is to describe fisheries of freshwater shrimp or "black shrimps" or "crayfish" *Macrobrachium vollenhovenii*, *Macrobrachium macrobrachion* catches in Ivorian lagoons; Sassandra and Comoe rivers from 2007 to 2009. In this context, interviews with fishermen were conducted to characterize them and their activities. Landing catches were followed monthly from 2007 to 2009 at the dock of Sassandra for Sassandra River, Fresco village for Fresco lagoon, Lahou Pkanda for Grand-lahou lagoon, Grand Bassam for Comoe river and Adiaké for Aby lagoon.

The results of the works showed that the total catch of fresh water shrimps were low (12 tons in 2009) compared to pink shrimp *Penaeus notialis* catches in lagoons (400 to 500 tons per year for all lagoons). However, with high market value price per kilogram between 600 and 2000 FCFA, the fisherman of freshwater shrimps receives a net monthly income that enables him to be classified according to the indicators of the Strategy Paper on Poverty Reduction (PRSP) among people who are not poor. However, with the pressure of fishing on these resources, the fisheries management authority shall take measures for sustainable management of shrimp and especially to initiate the culture of "crayfish" to contribute to the sustainability of fisheries and the resource.

Keywords : *freshwater shrimps, "Crayfish ", lagoons, river mouths, captures, Côte d' Ivoire.*

RÉSUMÉ

Estimation des captures de crevettes d'eaux douces *Macrobrachium Vollenhovenii* (Herklots, 1851) dans les fleuves et les lagunes de Côte d'Ivoire (Afrique de l'Ouest)

La présente étude a pour objectif de décrire les pêcheries et les captures des crevettes d'eaux douces ou « crevettes noires » ou « écrevisses » *Macrobrachium vollenhovenii, Macrobrachium macrobrachion* dans les lagunes et les fleuves Sassandra et Comoe de 2007 à 2009. Dans ce cadre, des entretiens avec les pêcheurs ont été réalisés pour caractériser les acteurs ainsi que leurs activités. Les captures ont été suivies mensuellement de 2007 à 2009 dans les débarcadères de Sassandra pour le fleuve de Sassandra, Fresco pour la lagune Fresco, Lahou Pkanda pour le complexe lagunaire de Grand-Lahou, Grand Bassam pour le fleuve Comoe et Adiaké pour le complexe lagunaire Aby-Tendo-Ehy.

Les résultats des travaux ont montré que les captures totales des crevettes d'eaux douces dans les lagunes ivoiriennes et les fleuves Sassandra et Comoe sont faibles (12 tonnes en 2009) comparativement aux captures de crevette roses lagunaires *Penaeus notialis* (400 à 500 tonnes par an). Cependant, avec la valeur marchande élevée du prix au kilogramme comprise entre 600 et 2000 FCFA, le pêcheur de crevettes d'eaux douces perçoit un revenu net mensuel qui lui permet d'être classé selon les indicateurs du Document de Stratégie de Réduction de la Pauvreté (DSRP) parmi les populations qui ne sont pas pauvres. Toutefois, avec la forte pression des pêcheurs sur ces ressources, l'autorité de gestion des pêches doit prendre des mesures de gestion durable des dites crevettes et surtout d'initier la culture des « écrevisses » afin de contribuer à la durabilité des pêcheries et de la ressource.

Mots-clés : *crevettes d'eaux douces, Macrobrachium vollenhovenii, Macrobrachium macrobrachion, lagunes, embouchures des fleuves, captures, Côte d'Ivoire.*

I - INTRODUCTION

Côte d'Ivoire, located in West Africa, in the northern of Gulf of Guinea area, covers a continental area of 322,463 km². The country has a coastline that extends from Cape Palmas to the West Cape Three Points in the east, along 566 km. It also has a network of lagoon complexes including Fresco, Grand Lahou, Ebrié and Aby lagoons.

Besides this, the country is characterized by an extensive network of rivers, the most important drain from north to south and flow into the lagoons before going to sea such as Comoe, Bandama and Tanoé rivers and some rivers flow directly into the sea as Sassandra. In addition, the country has rivers and coastal rivers such as La Bia, La Mé, Agneby and Boubo. On some of these rivers, hydroelectric dams have been built and they have created artificial lakes or reservoirs as Ayame 1 and 2, Kossou, Taabo and Fahe. Finally, the development of agriculture has led to creation of many agro pastoral small dams. All these aquatic environments, excepted coastal marine waters, are visited by freshwater shrimps. These freshwater shrimps belong to the family of Palaemonidae and include seven genera: *Nematopalaemon, Palaemon, Palaemonetes, Leande; Branchycarpus; Desmocaris and Macrobrachium*. Two species of the latter genus namely *M. vollenhovenii* and *M. Macrobrachion*, commonly called "crayfish ", are being actively fishing in all the above mentioned aquatic environments.

Given their socio-economic and ecological importance, *M. vollenhovenii* and *M. macrobrachion* have been studies by [1-4], [5] and [6]. The life cycle of these animals takes place in freshwater and in lagoon waters for reproduction with gonad maturation, development of eggs, larvae and post-larvae and finally a part of the growth of the juveniles according to [1]. [5] worked on the systematic, biology and socio-economic of the two species in freshwater and finally [6] worked with the tool Elephant on the parameters of growth, mortality, recruitment and production of *M. vollenhovenii* in Fahe lake on the Fahe river. Very few data are available on catches of *M. vollenhovenii* in almost all Ivorian rivers and lagoons where these crustaceans are found in abundance from June to December. They are the basis for the development of a very artisanal fishery dynamics; hence, the need for conducting a study to better understand and to propose sustainable management of these fisheries.

III - MATERIALS AND METHODS

III-1. Study area

The study area includes ***(Figure 1a and 1b***):

III-1-1. Fresco Lagoon

Lagoon Fresco, with an area of 17 km ², is located in Central coast, 5°06 ' north latitude and 5°35' west longitude. It receives freshwater from Gni and Boubo rivers and communicates with the sea by a non-permanent channel called channel of Fresco.

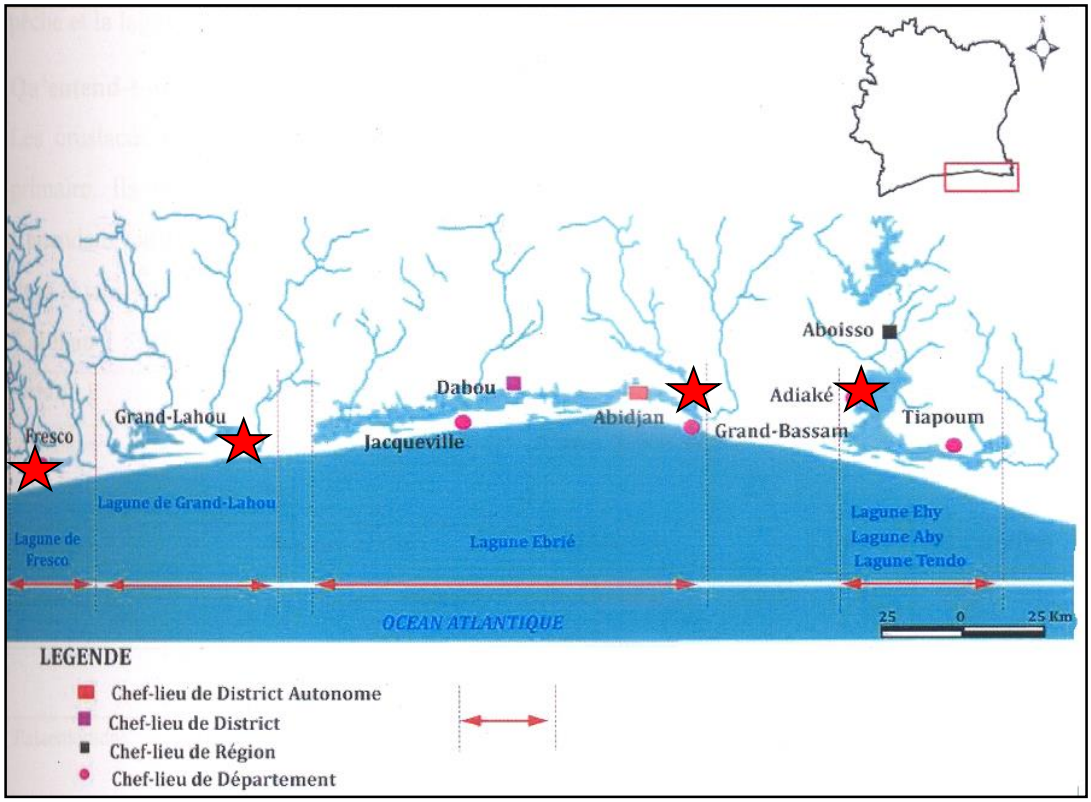

Figure 1a : *Côte d'Ivoire lagoons and sites of study*[★]

Figure 1b : *Mouth of Sassandra river and site of study*

III-1-2. Grand-Lahou lagoon

The lagoon of Grand Lahou, oriented east-west with a length of 50 km and an area of 190 km ² is connected at its eastern end with the mouth of the Bandama river. It includes Tadio, Niouzoumou, Mackey and Tagba lagoons and communicates with the sea through the permanent and dynamic channel of Grand- Lahou.

III-1-3. Ebrié Lagoon

The lagoon Ebrié, located in the central part of the littoral stretched from east to west and measures 130 km with a width of 7 km, covers an area of 525 km ² with Aghien and Potou lagoons. The average water depth is 4 m and pits more than 20 m is observed in the port area and the Abu-Abu bay. It receives in its eastern part, the Comoe and La Mé rivers, in its central part, the Agnéby, Boubo and coastal rivers. In the past, Ebrie lagoon enters in the sea thorough the "Grau" of Bassam. Nowadays, Ebrié lagoon communicates with the sea by the channel of Vridi opened artificially in 1951. The Grand-Bassam "Grau" has been naturally closed following the opening of the artificial channel of Vridi. Therefore, the Comoe river flows cannot directly enter the sea but are oriented in the region of Grand- Bassam and Abidjan and enter the sea through the channel of Vridi.

III-1-4. Aby Lagoon

The Aby lagoon system is located in the extreme southeast. L-shaped, it occupies an area of 424 km ² and includes Aby, Tendo and Ehy lagoons. Inland waters entering the lagoon are mainly from rivers La Bia north -west and east from Tanoé river. Exchanges of the lagoon with the sea is realized through the natural channel of Assini.

III-1-5. Estuarine region of the mouth of Sassandra

The Sassandra river flows directly into the sea in the region of Sassandra. Taboo-Sassandra-Fresco area, 230 km long, is both rocky and sandy. It consists of medium cliffs granite sets to reach the ocean, with handles in Grand Béréby and Monogaga, berries in altered granites at San Pedro. This marine area receives fresh water directly from Sassandra River. The main features of the physico-chemical parameters according to the work done by various researchers such as [7-10] are summarized as follows: The water temperature is relatively warmer than the air, on the order of 2 to 3°C. It is maximum at low water (31°C in April) and (27°C in August) and minimum during the rainy seasons (25-27°C).

The spatial variability of temperature is low, not exceeding 3°C, except in areas under the direct influence of the sea with relatively cooler waters. Salinity is maximum during hot, dry seasons (salinity of surface waters is greater than 5‰ and greater than 20‰ for deep water), and lowest during the rainy season and floods (less than 3‰ for surface water). However, it is still high, regardless of the season, in the regions of communication with the sea (surface and deep waters greater than 20‰).The oxygenation rate is close to saturation and that, regardless of the depth for all lagoons except in certain bays (bays Marcory, Cocody, Biétri, Kumasi in Ebrié lagoon) and deep water (in the pits of the Aby Lagoon). Transparency of t waters in all lagoons is highest during low water and can reach 3-4 meters deep in some areas and minimum during floods (less than 2 meters). It is generally low (1 meter) in the lagoons of Fresco and Aby (except in the area of the channel connecting the lagoon to the sea). Phytoplankton biomass is very high in all the lagoons and chlorophyll generally exceed 35 mg/m3 in desalted area where gross primary production hovering around 300 mg Carbone/m3/h. The pH of the sector under marine water influence is relatively alkaline, and the water directly in contact with the fresh water is rather acid. Overall, the pH is high in March (about 8) and minimum in July and October (less than 7).The dissolved inorganic phosphate concentrations are between 0.3 and 1.4 µatg/l and have a spatio-temporal variation. Dissolved nitrate are highest during the rainy season (about 10 µatg/l) in dry seasons and lowest (below 2 µatg/l).

III-2. Data collection

The study involved the area of the mouth of Sassandra, Fresco, Grand Lahou, Ebrié and Aby lagoons as described above and took place from 2007 to 2009. Landing sites at Sassandra for Sassandra , Fresco village for Fresco, Lahou Pkanda for Grand Lahou lagoon, Grand-Bassam for Ebrié lagoon and Adiaké for Aby lagoon have been investigated. These sites were chosen because they are representative of all landing sites. For monitoring catches of freshwater shrimp, we have an investigator supervisor per site with for mission monitoring, controlling activities and summarizing the results of the field investigator. The field investigator recorded daily all information on fisheries activity (gears, catches, expenses (purchase of bait, gear production), sales and income and actors). In addition, some fishermen were interviewed by focus group in each region using a guide of questionnaires to better understand the actors and their organization.

III-3. Data processing

For each fishery, a unit of effort has been determined, it is typically an outlet for all gears but this can be adjusted to the unit. In general, shrimp fishermen go out once a day excepted during prohibited days or special ceremonial days. The data collected were processed using software including Excel and a series of mathematical calculations described by [11] and [12]. Thus, collected data allow us to define following parameters:

- Number of gears in activity (per day, week, month and year);
- Number of fishermen per gear in activity (per day, week, month and year);
- Fishing effort per gear (number of trips per day, week, month or year) ;
- Number of day of activity per gear (number of effectif day of activity per week, month and year) ;
- Catch per unit effort (CPUE = Catch per trip expressed in kg for all gear);
- Monthly catch per site (CPUE X average number of activity's day per month X number of fishermen) ;
- Total capture of the lagoon per gear (CPUE X average number of activity's day per month X total number of fishermen X number of month in the year).

IV - RESULTS AND DISCUSSION

IV-1. Gear and fishing techniques

Fishing gears of freshwater shrimps include baited traps and fishing techniques using palm leaves or branches of tree. The first gear has been described by [11]. Material needs to practice fishing technique that combines the leaves of palm or branches or clusters are palm leaves (*Elaeis guineensis*), various branches, a nylon rope to tie palm leaves or branches for forming trap units, one or two stake for mooring trap units and fishing space. The branches with fresh or dried leaves are tied with a nylon rope to achieve trap unity and it is docked to two stake implanted in the shallow waters of the lagoon environment (high funds and lagoon banks or watercourses low current). Instead of the branches, are recorded in some place, palm leaves. This technique resembles the "acadja" which is a traditional technique for trapping fish with branches covering an area of up to one hectare. The fisherman may have a chain of twenty units or branches of palm leaves tied.

Fishing or collection of the capture of the traps is made once a week in the lagoon environments and every day in the river. To do this, fishermen operate in pairs. One is concerned with the slide gently scoop net mesh size of 5 mm under the branches or leaves of the palm while gently the second facilitate the sliding of the scoop net. Like the "acadjas" elements (branches and palm leaves) are renewed when they get older. This fresh water shrimp fishing technique capture all sizes of freshwater shrimp including juveniles and even intermingled post larvae in the leaves.

IV-2. Fishing effort

During the work, the inventory of observed actors allocated as follows by region : Sassandra : 166 fishermen using artisanal trap; Fresco : 26 fishermen using artisanal trap; Grand Lahou : 92 fishermen using artisanal trap , Grand -Bassam : 109 fishermen including 69 fishermen with palm leaves and 40 using artisanal trap, Aby : 87 fishermen with 30 fishermen using artisanal traps and 57 fishermen using palm leaves corresponding to a total of 480 fishermen including foreigners that dominate numerically in the region of Sassandra (80 % of the population of fishermen) and Ivorian. The ivorians were recorded in abundance Ebrié lagoon (Grand Bassam with 60%) and Aby Lagoon (Adiaké with 90% Ivorian). This result, as regards the Sassandra river is greater than that found by [13]. Indeed, these authors, studying seven sites along Bandama river, recorded only 94 fishermen, 12 wholesalers/shrimp merchant and 10 detailing.

Among these fishermen, some have other activities in addition to shrimp fishing. This is often not the case of most fishermen in Sassandra region. According to fishermen reports and field observations, fishing freshwater shrimp in the year is divided into two major periods: the bad season that usually goes from December to May therefore lasts 6 months and the period of good season which runs from June to November, which also lasts 6 months. During the good season, the fisherman goes fishing regularly excepted during rest days and days of special events. During the bad season, some fishermen stop fishing activity to engage in another activity. But others continue to practice fishing but at a slower frequency. Finally the last category that continues to practice daily fishing migrates along the resource and creates camps throughout their itinerary.

IV-3. Catches of freshwater shrimps

IV-3-1. Catch per unit effort

Catches, expressed here as the catch per trip by region are based only on the period in which the catches were highest in the year. The best way was to express the catch based on the average of good and bad seasons. But, as we have mentioned, some fishermen simply stop fishing during the bad seasons, while others migrate with resources.

This is why we have deliberately focused the effort taken during the month in which catches were abundant in each area unit. Catch per unit effort were divided as follows: Sassandra 27.7 kg/trip (July), Fresco: 4 kg/trip (July), Grand Lahou : 3.5 kg/trip (July), Grand Bassam 58.5 kg/trip (August) and Aby : 3.5 kg/trip (July)

IV-3-2. Total catch of freshwater shrimps

Total catch of freshwater shrimp recorded in 2009 in all regions was 12000 kg or 12 tons. The largest total catch are those of Sassandra recorded in 2007 of nearly 8000 kg , followed by those of Grand-Bassam with Over 2000 kg. Other observed in other regions of the catch is about 300 to 500 kg for 2009 ***(Figure 2)***

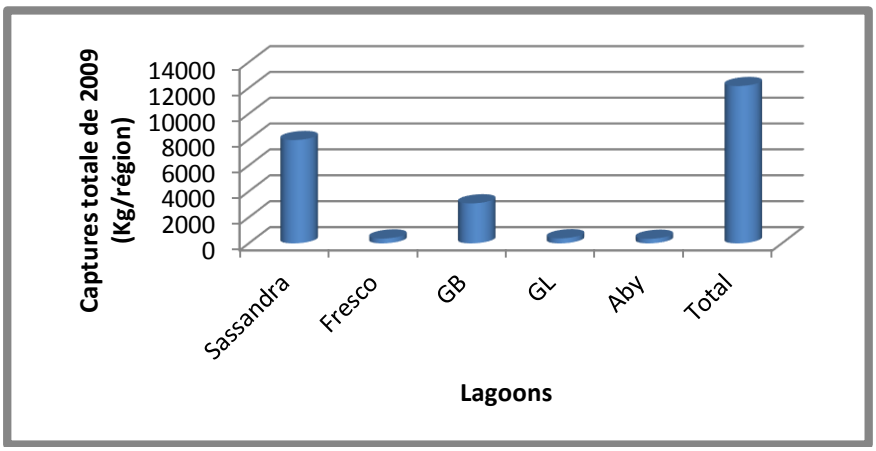

Figure 2 : *Total catches of freshwater shrimps recorded in all sites in 2009 (Captures totales des crevettes d'eaux douces enregistrées dans tous les sites en 2009)*

The total catches of Sassandra region from 2006 to 2008 were around 25,000 kg or 25 tons. These captures were high in 2006 with about 15 000 kg, fell to less than 5000 kg in 2008 ***(Figure 3).***

IV-3-3. Seasonal variations in catches of freshwater shrimp

Monthly changes in catch have the same feature in all visited regions. They are weak or non-existent except from January to April in Grand- Bassam and Fresco, then they gradually increase to reach the maximum in July-August, then they decrease again from September to December. However, the shape of the curve is somewhat different from that observed in other regions at Fresco, because it shows more important values of catches in January, June and October. Detailed monthly variations of shrimp catches are summarized as follows:

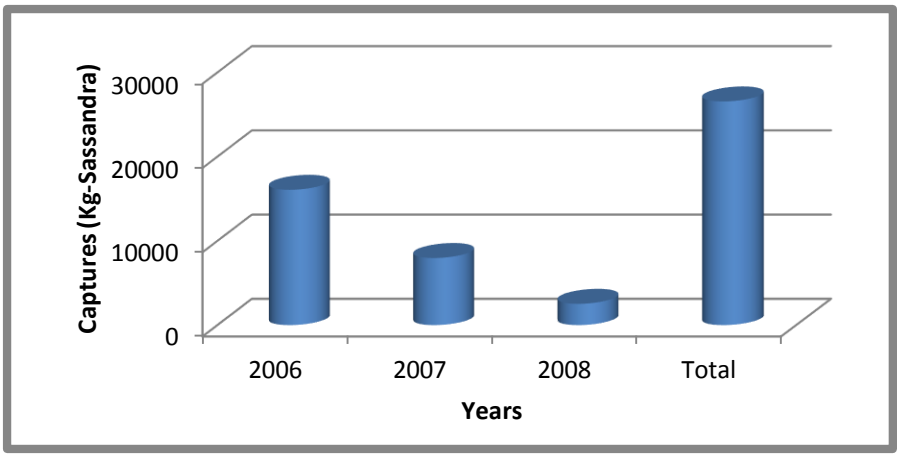

Figure 3 : *Total catches of freshwater shrimps recorded in Sassandra region from 2006 to 2008 (Captures totales des crevettes d'eaux douces de la région de Sassandra de 2006 à 2008)*

- **Grand Bassam**

Total catches in 2008 were around 5200 kg and were more important than the total catch of 2009 which were of the order of 3000 kg. Besides this, the catches are low from January to April, and then they gradually increased to reach the maximum value in July with more than 1000 kg, then decreased again to a very low level from November to December ***(Figure 4).***

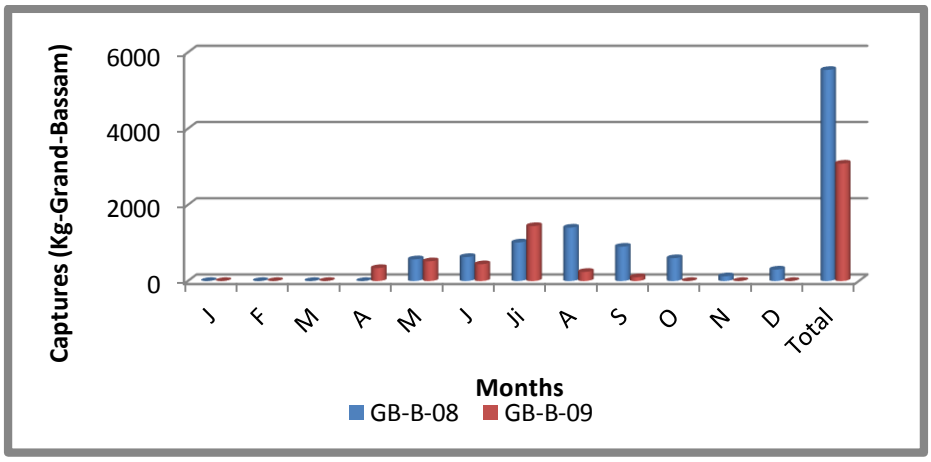

Figure 4 : *Monthly variation of freshwater shrimp capture from 2008 to 2009 in the lagoonal region of Grand-Bassam (Variations mensuelles des captures de crevettes d'eaux douces en 2008 et en 2009 à dans la région lagunaire de Grand-Bassam)*

➢ **Fresco**

The total catch is 350 kg for 2009. Monthly variations showed three high values during three months: 100 kg in January, 90 kg in July and 50 kg in October. Values are insignificant in other months ***(Figure 5).***

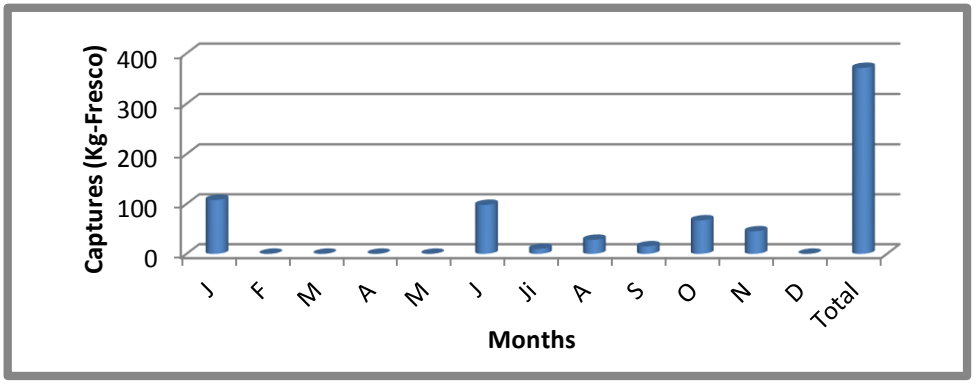

Figure 5 : *Monthly variation of freshwater shrimp capture in 2009 in the lagoonal region of Fresco (Variations mensuelles des captures de Crevettes d'eaux douces en 2009 dans la région lagunaire de Fresco)*

➢ **Grand Lahou**

The total catches recorded in 2009 in Grand Lahou lagoon was slightly higher than 350 kg. Catches were low from January to May, and then it increased gradually to reach the highest value of more than 50 kg in July before declining gradually and vanish in December ***(Figure 6).***

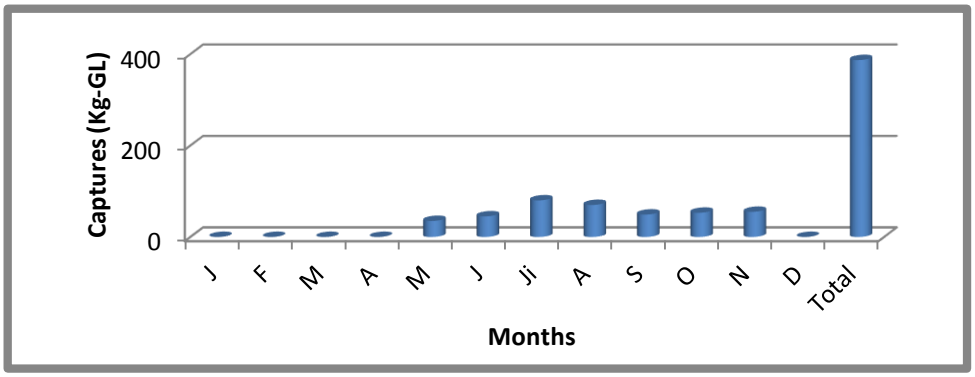

Figure 6 : *Monthly variation of freshwater shrimp capture in 2009 in the lagoonal region of Grand-Lahou (Variations mensuelles des captures de crevettes d'eaux douces en 200ç dans la région lagunaire de Grand-Lahou)*

➢ **Aby**

The total catch observed in 2009 in Aby lagoon was 350 kg. Monthly changes in catches indicated that they were low from January to April, and then increased to reach the peak of more than 50 kg and then gradually decrease from August to November and became insignificant in December ***(Figure 7).***

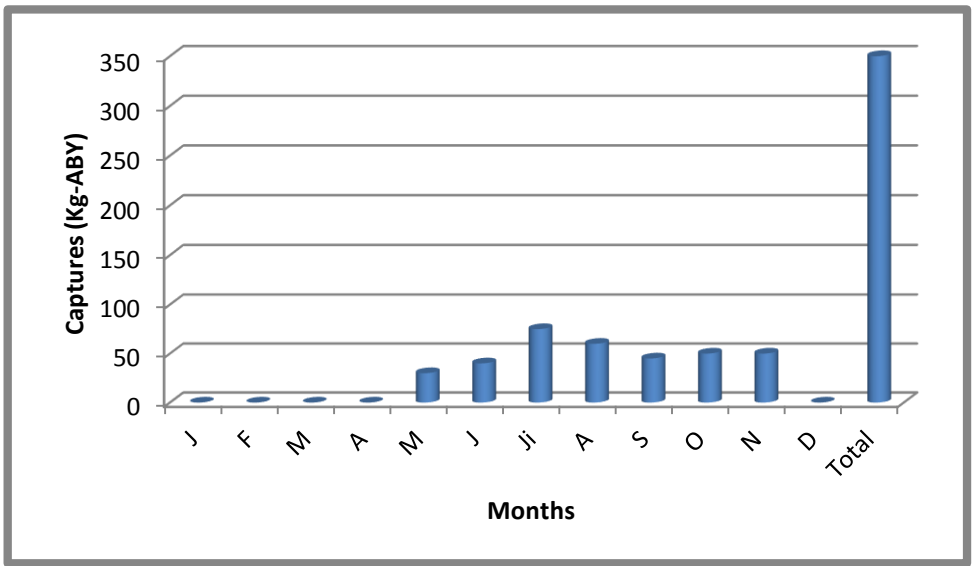

Figure 7 : *Monthly variation of freshwater shrimp capture in 2009 in the lagoonal region of Aby (Variations mensuelles des captures de crevettes d'eaux douces en 2009 dans la région lagunaire Aby)*

IV-4. Monetary values of catches of freshwater shrimps

Monetary values of freshwater shrimp catch recorded during the work in 2009 were about eighteen million FCFA (18 million FCFA). Two regions showed the highest monetary values: Sassandra with about 10 million FCFA and Grand-Bassam with about 8 million FCFA. Other regions contributed to the monetary value less than 2 million FCFA ***(Figure 8).***

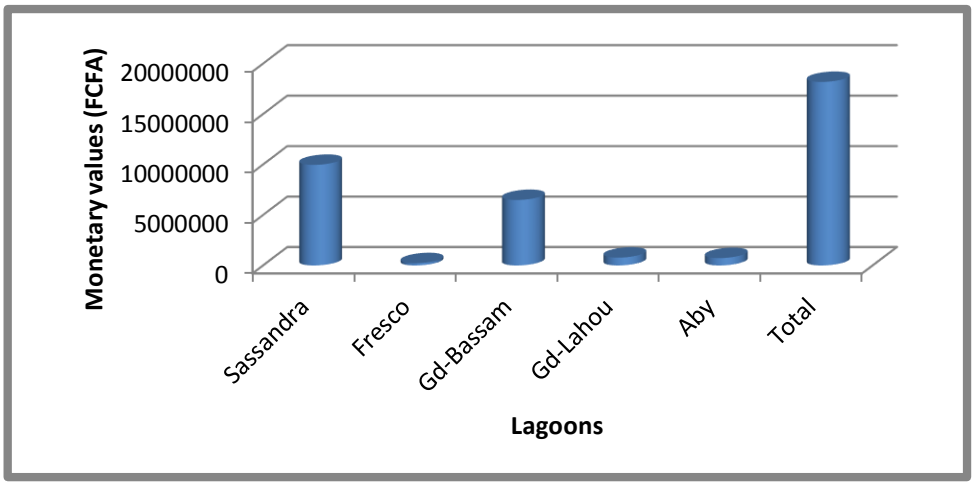

Figure 8 : *Monetary values of freshwater shrimp recorded in 2009 for all lagoons and the mouth of Sassandra river (Valeurs monétaires des captures de crevettes d'eaux douces dans les lagunes et embouchures étudiées en 2009)*

- **Sassandra**

Total monetary values recorded for Sassandra region from 2006 to 2008 are 16 million FCFA. These values were 5,000,000 FCFA in 2006 and 7,000,000 FCFA in 2007 and fell in 2008 to 2,000,000 FCFA ***(Figure 9).***

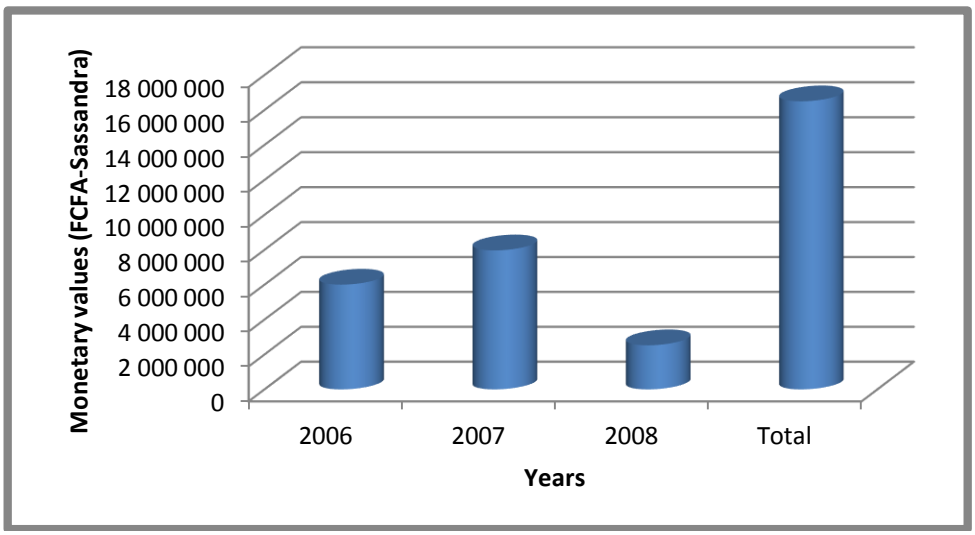

Figure 9 : *Monetary values of freshwater shrimp recorded from 2006 to 2008 in Sassandra region (Valeurs monétaires des captures de crevettes d'eaux douces dans la région de Sassandra de 2006 à 2008)*

➢ **Fresco**

The total monetary values were low during the study period and were about 230,000 CFA. High monetary values recorded in the region of about 50 000 FCFA were observed in January and in June ***(Figure 10).***

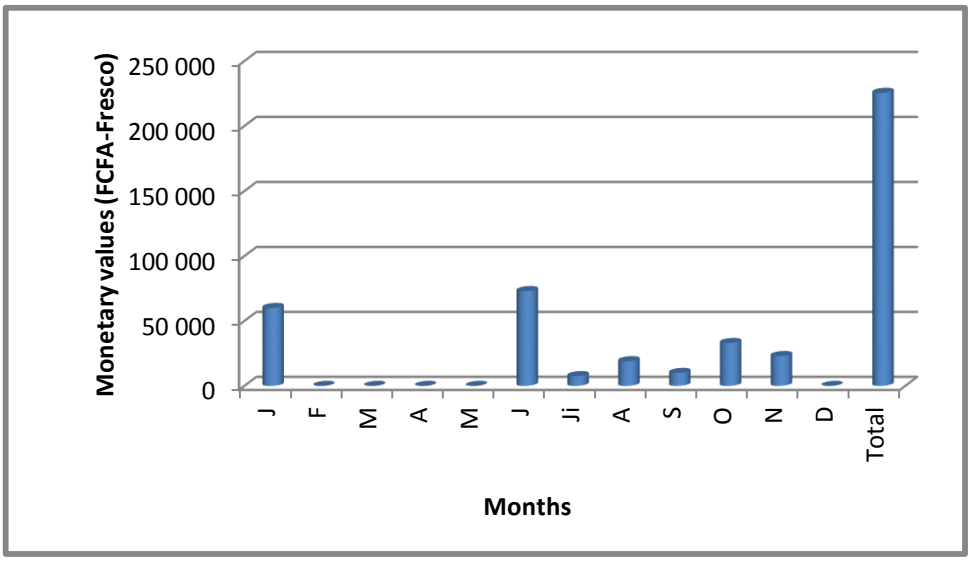

Figure 10 : *Monthly variation of monetary values of freshwater shrimp recorded in 2009 in Fresco region (Variations mensuelles des valeurs monétaires des captures de crevettes d'eaux douces à Fresco en 2009)*

➢ **Grand Bassam**

Total monetary values recorded were over 6 million FCFA. The highest monetary value observed was in July with more than 2 million FCFA. Other months of the year have provided monetary values of less than one million FCFA ***(Figure 11).***

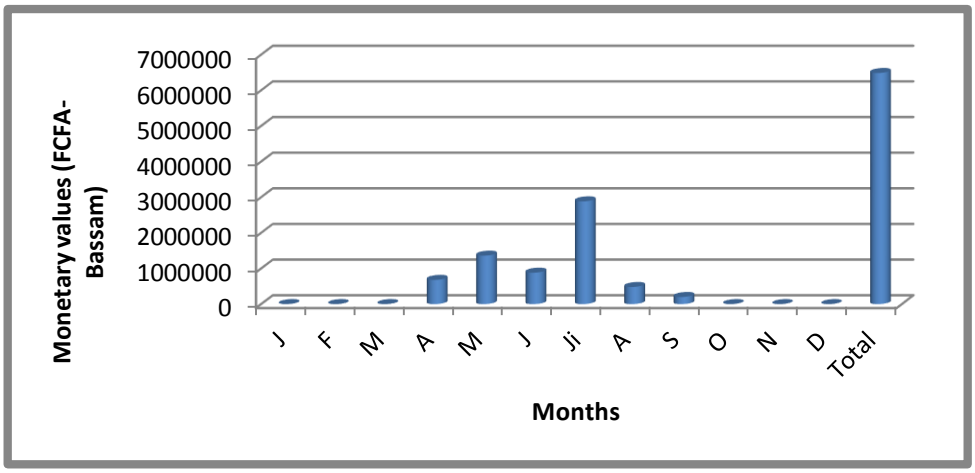

Figure 11 : *Monthly variation of monetary values of freshwater shrimp recorded in 2009 in Grand-Bassam region (Variations mensuelles des valeurs monétaires des captures de crevettes d'eaux douces à Grand-Bassam en 2009)*

- **Grand Lahou**

Total monetary values recorded were more than 700 000 FCFA. The highest monetary value observed is that of July and August, with more than 100 000 FCFA. Other months provided less than 100 000 FCFA per month ***(Figure 12)***

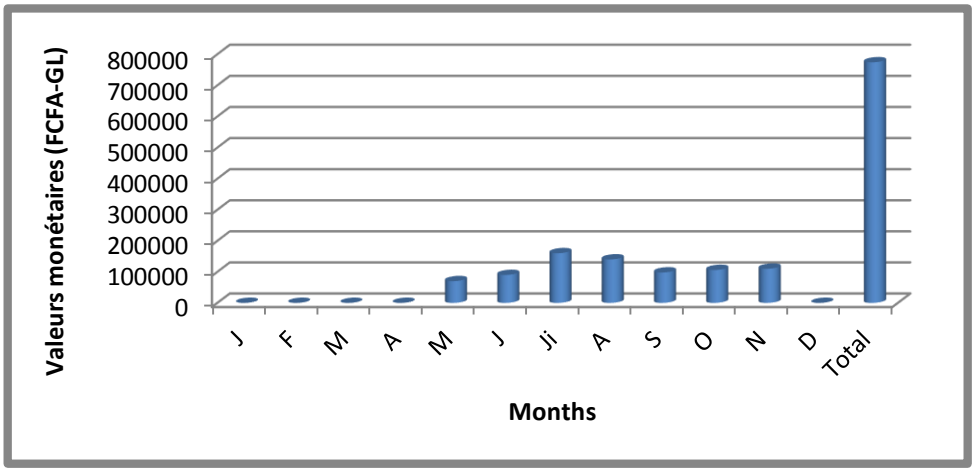

Figure 12 : *Monthly variation of monetary value of freshwater shrimp recorded in 2009 in Grand-Lahou region (Variations mensuelles des valeurs monétaires des captures de crevettes d'eaux douces à Grand-Lahou en 2009)*

- **Aby**

Total monetary values recorded during the study period in Aby lagoon was 700,000 CFA francs. The analysis of monthly changes indicated that the months of July, August and October provided at least 100,000 FCFA. Other periods showed less than 100 000 FCFA per month ***(Figure 13).***

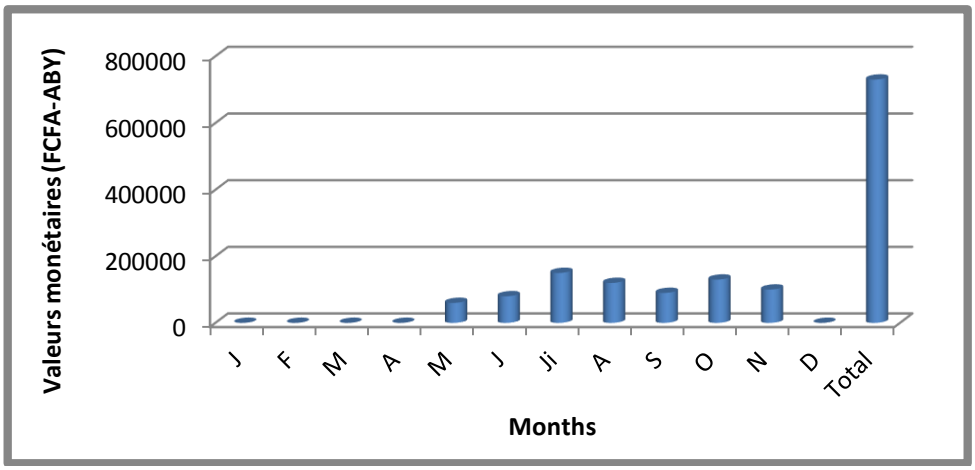

Figure 13 : *Monthly variation of monetary value of freshwater shrimp recorded in 2009 in Aby region (Variations mensuelles des valeurs monétaires des captures de crevettes d'eaux douces dans la lagune Aby en 2009)*

IV-5. Spatial variation in catches of freshwater shrimps

Environmental conditions (physical, chemical, habitat), biological (predators, competitors, food), the type and number of gears, the number of actors/fishermen and fishing effort directly influences the catch in a given region. Thus; catches were important in Sassandra and in Grand Bassam regions compared to catches in the lagoon environments. These habitats are mouthpieces (embouchures) therefore places of exchanges between marine and lagoon waters with fresh water and are very rich. For example, Sassandra river flows directly in the sea consequently it is influenced by the hydrology of the coastal marine waters and hydrological seasonal characteristics in the sector are as follows:

- Small cold season (December-January), characterized by a coastal upwelling that concerns all the littoral of the country with sea water temperature of 24-25°C and salt (> 35‰);

- Great hot season (February to May) with ocean waters whose temperature varies between 27°C and 28°C and salinity differed very little from 35‰;
- Great cold season (July-October), characterized by a very strong upwelling with relatively cool water (< 23°C) and salt (35‰);
- Small warm season (November-December), during which hot and desalted waters originated from Libero-Guinea overlie those of the upwelling.

During upwelling periods, we assist the upwelling of the bottom waters to the surface. This promotes the release of nutrients that were trapped in the sediment, which in turn contribute to the growth of phytoplankton and organic matter suspended in the milieu. This environmental enrichment phenomenon enters in the inferior course and occurs to nearly 70 km in the course of Sassandra river. In the region of Grand-Bassam, it is the Comoe river which is in contact with the lagoon and which contributes to the release of nutrients from the sediment and promotes the growth of algae during floods and post-flood. Besides this, we note the presence of mangroves, wetlands and vast meadows aquatic vegetation in both regions.

These constitute habitats/shelters and nursing areas for freshwater shrimp. This is not the case of lagoon environments themselves. In these environments, freshwater shrimp are limited in areas of low salinity medium and rich detritus. These areas are located in bays and lagoon banks. These areas are subject to human aggression through sand mining, deforestation and pollution. In doing so, freshwater shrimp over time have little habitat in lagoon environments. In total, the mouths of Sassandra at Sassandra and Comoe at Grand-Bassam are proper environments for development of freshwater shrimps which explains their abundance in these regions. The total catches of 12 tons of freshwater shrimp for all sites found during the work seem insignificant. Since, [13] estimated the annual production of 10 tons for only the Bandama river with 86 % for Taabo lake at N'Denou site, 11% for the area of Tiassale and 3% for Grand Lahou.

Those results indicate that the production of freshwater shrimps may be higher and the difference between the results is due to disparity of docks and migration of shrimp fishermen. Low catches of freshwater shrimp are also linked to insufficient coverage of all landing points of these animals. Indeed, these crustaceans are found in all aquatic environments including rivers, lakes, ponds, temporary fresh waters (rice culture, swamps…), lagoons, mangroves and even in temporary waters of urban channel. Besides that, compared to catches of prawns *Penaeus duorarum notialis* estimated between 400 and 500 tons per year for all the lagoons by [14,15], freshwater shrimp captures were very low. Here, the difference in capture between freshwater shrimps and prawns is due to the bio-ecology of species and pressure on these animals according to [13, 16].

Indeed, these two taxa are both amphidromic, prawn is found in lagoon for growth for both sexes, while the female freshwater shrimp occurs in lagoon for breeding. In the first case, we observe in the lagoons the full stock of the shrimps composed of male and female animals, whereas, in the second case only female individuals migrate into the lagoon waters for egg laying and post-larvae and juveniles return in freshwaters for growth. This differential distribution of the sexes is the cause of low catches of shrimp in the inferior course and mouth of rivers and lagoons. In addition, the pressure on prawns is much greater than the pressure on freshwater shrimp in lagoons. This is due to the nutritional value given to two taxonomic groups by the Ivorian people. Indeed, the prawns are more popular and therefore more expensive per kilogram compared to freshwater shrimps. Therefore, prawns are actively fish and more captures than fresh water shrimps.

IV-6. Temporal variation in catches of freshwater shrimps

Environmental factors, especially climatic factors affect the hydrology of rivers, lagoons and estuaries and contribute to create four hydrological seasons. To assess the relationship between these hydrological seasons and abundance of freshwater shrimp we put them in parallel as shown in Table 1.

Table 1 : *Relative abundance of freshwater shrimp capture in relation with hydrological seasons (bondance relative des captures de crevettes d'eaux douces en relation avec les saisons hydrologiques)*

Ab/S	J	F	M	A	M	J	Ji	A	S	O	N	D
FC												
fC												
GSS												
GSP												
PSS												
PSP												

FC : *high abundance - Forte abondance des crevettes d'eaux douces*
fC : *low abundance - faible abondance des crevettes d'eaux douces*
GSS : *Big dry season - Grande saison sèche*
GSP : *Big rainy season - Grande saison des pluies*
PSS : *Small dry season - Petite saison sèche*
PSP : *Small rainy season - Petite saison des pluies*

Catches of freshwater shrimp are important in lagoons and estuaries during the long rainy season and early dry season. These periods are characterized by fresh water with less than 25°C and average surface salinities are low and comprised between 5 and 15 ‰. Based on the work of [12] on gonad maturation, development of eggs, larvae, post-larvae and early juveniles of fresh water shrimps occur in waters with an average salinity that is between 5 and 10 ‰. Beyond this range of salinity, the larvae cannot develop properly. This is not the case during the long dry season and early rainy season. Indeed, during these seasons water temperatures are high and salinity of surface and bottom can reach 15 to 25 ‰ in some areas. In addition, during the short rainy season, there are often floods of post major rivers that enrich lagoons and during this period the water is almost completely desalted. These conditions do not favor larval development. These periods are also characterized by offshore upwelling processes which are observed in the lower course of Sassandra. Outside this range of salinity, freshwater shrimp migrate into freshwater because the environmental conditions are not favorable for breeding or living.

IV-7. Economic importance of fresh water shrimps

Prices of freshwater shrimps fluctuate between 600 FCFA/kg and 2000 FCFA/kg. They are low in areas with high production as Sassandra and high with low production especially in urban areas like Adiaké, Grand Bassam and Lahou. Monetary values recorded are directly related to catches. Thus, if the catches are high, even if the price per kilogram is low, the monetary values are important. Finally, the activity of fresh water shrimp fishing is profitable in all the localities visited. The daily net income of fishermen is between 700 and 5000 FCFA. According to [13], taking 1,550 FCFA/kg as the average price per kilogram, they found a gross income of 435 100 FCFA per fisherman per year. After deducting the estimated cost of 76,150 FCFA (Canoe, traps, paddle and bowl) equipment , they conclude that the activity provides an annual income of 308,950 FCFA/year or 25,745 FCFA fisherman along the Bandama river (with nuts, coconut bait 88,000 FCFA and fishing effort or work time 104 500 FCFA not deducted). Overall, the activity remained relatively profitable for fishermen throughout the year according to the document of poverty reduction written in 2008 which defined as poor in Côte d'Ivoire, one that has a consumption expenditure of 241,145 F CFA per year or 661 FCFA/day. Under the poverty line, it can be argued that freshwater shrimp fishermen are not poor. However, their lives are marked by insecurity (seasonal fisheries) of the resource and the access to basic social services.

V - CONCLUSION

The results of the conducted studies have shown that the total catch of freshwater shrimps in river mouth of Sassandra and Comoe rivers and lagoons are small (12 tons in 2009). Those catches are low compared to prawn catches (400 to 600 tons per year). However, with high market value price per kilogram between 600 and 2000 FCFA/kg, the shrimp fisherman freshwater receives a net income above the minimum wage and SMAG and is not considered by the indicators of the PRSP as poor. However, with the pressure of fishing on these resources, the fisheries management authority shall take measures for the sustainable management of fresh water shrimp and especially encourage the culture of the species *Macrobrachium vollenhovenii*.

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