Available online at http://www.journalijdr.com

International Journal of DEVELOPMENT RESEARCH

ISSN: 2230-9926

International Journal of Development Research
Vol. 3, Issue, 10, pp.087-094, October, 2013

Full Length Research Article

THE OYSTER FARMING IN THE COASTAL ECOSYSTEM OF SOUTHERN BENIN (WEST AFRICA): ENVIRONMENT, GROWTH AND CONTRIBUTION TO SUSTAINABLE COASTAL FISHERIES MANAGEMENT

***Adite, A., Abou, Y., Sossoukpê, E. and Fiogbé, E. D.**

Unité de Recherches sur les Zones Humides (URZH), Département de Zoologie, Faculté des Sciences et Techniques, Université d'Abomey-Calavi, B.P. 526, Cotonou, Bénin

ARTICLE INFO

Article History:
Received 26th July, 2013
Received in revised form
19th August, 2013
Accepted 10th September, 2013
Published online 04th October, 2013

Key words:
Benin;
Coastal zone;
Crassostrea gasar;
Fish conservation;
Food habit;
Oyster aquaculture.

ABSTRACT

The oyster farming is widespread at the Benin (West Africa) coastal zone and provides sustainable revenues for grass-roots. This study assessed environmental conditions, farming systems, growth, yields and revenues of the cultivated shellfish, *Crassostrea gasar*. Results indicated that rearing milieu meets ecological conditions for successful oyster cultivation. Production stages were seed collection and stocking, oyster spreading, growth control, harvesting and processing. Mean stocking density of *C. gasar* recorded in the rearing milieu was 500 oysters per square meter. Dominant preys consumed by *C. gasar* at the rearing site were phytoplankton with volumetric proportions reaching 73%. Final mean total length reached 72.6 ± 5.78 mm (mean weight = 63.16 ± 18.16 g) corresponding to a mean monthly growth of 3.31 mm- total length (4.57 g - total weight). Total length – total weight relationships of *C. gasar* were significant (p< 0.05) with a positive slope indicating that the weight increase with size. Growth variations across the three seasons (dry, wet, flood) were significantly different ($F_{2,\ 10}$ = 7.156, p = 0.02). Also, seasonal mortalities were significantly different ($F_{2,\ 10}$ = 4.579, p = 0.047) and higher values were recorded during the flooding season. Oyster farming at the Benin coastal waters generated an annual yield of 30 kg/m^2 with estimated mean yearly revenues of 160,000 FCFA (US$330) per individual. Habitat disturbances such as the destruction of mangroves, input of anthropogenic contaminants, nutrient enrichment and the hydroelectric dam built on the Mono River were among the major stressors that could affect the traditional oyster farming. As an alternative source of revenues, the great establishment of the oyster farming in the Benin coastal waters may greatly contribute to coastal fish conservation and sustainable fisheries management. The development of the oyster farming in Benin requires further scientific knowledge in order to increase productivity and to contribute to restore fish community structure.

INTRODUCTION

African coastal fish stocks are continuously depleting and the overall catches per unit of effort has been reduced, presumably because of the increasing human population and grass-roots poverty causing overfishing, and the degradation of aquatic ecosystems (Adité, 1995; 2002; Anato *et al.*, 2003; 2004; Chikou, 2006). At the Benin coastal zone, ecosystem degradation led to habitats loss and primary threats come from mangrove destruction, alteration of freshwater regime due to hydro electrical dam effects, wetlands loss, pollution and the use of destructive fishing gears (Adité *et al.*, 1995; Lalèyè *et al.*, 2003). In order to rebuild the depleted fish stocks of the coastal ecosystem, it is required to shift from and overexploited stocks to an underexploited stocks through various strategies such the diversification of aquaculture to lessen the fishing pressure (NMFS, 1996 ; Montchowui *et al.*, 2007). At the Benin coastal zone, the existence of traditional oyster (*Crassostrea gasar*) farming is a response and an alternative source of proteins and revenues capable to reduce fishing effort and contribute to restore the degrading coastal ecosystem (Moussa and Debleo, 2006). In the West African countries, and particularly in Benin, the shellfish aquaculture has been neglected and reduced to the traditional and empirical techniques (Kinkpé *et al.*, 2005). FAO (2008) reported an annual production of 1500 tons of oysters and other shellfishes

****Corresponding author:** Adite, A.*
Unité de Recherches sur les Zones Humides (URZH), Département de Zoologie, Faculté des Sciences et Techniques, Université d'Abomey-Calavi, B.P. 526, Cotonou, Bénin

for Senegal, Sierra Leone and South Africa. This production is far away from that of the Pacific oyster, the leading farming species (*C.gigas*), which world estimated production reached 4.6 million (FAO, 2008). Several mollusk species have been listed from the west coast of Africa, but not all are potential cultivable species (Nickles, 1950). At the Benin coastal zone *C. gasar* (Phylum: Mollusca, Class: Bivalvia, Subclass: Pteriomorphia, Order: Ostreoida, Family: Ostreidae, Genus: *Crassostrea*), satisfy the conditions of cultivable shellfishes, that is (1) species occurs freely and easy to obtain, (2) species reproduces easily, (3) species grows fast and (4) is accepted as a worthwhile protein source and commercially important (Buchanan, 1954; ICES, 2009).

Like the pacific oyster (*C. gigas), C. gasar* is relatively inexpensive and easy to produce and does not require additional food to sustain its growth (FAO; 1976). Moreover, its capacity to adapt to various environmental conditions such as temperature and salinity fluctuations, resistance to highly turbid areas, coupled with its relatively rapid growth contributes to its success (FAO; 1976). Through its farming, *C. gasar* provides sustainable revenues and is a good source of cheap protein for the people of the coastal towns and villages of the Benin coastal zone (Kinkpé *et al.*, 2005). The development of the oyster aquaculture is considered as an opportunity for the grass-roots to reduce fishing pressure, to diversify commercial fishing activities, to generate sustainable incomes and to contribute to mangrove ecosystem restoration and coastal fish conservation. However, despite its socio economic importance in Benin, very little is known about the oyster farming, especially, the production process, the growth and yields of the dominant cultivated oyster, *C. gasar*. This study evaluates the oyster farming at the Benin coastal zone and its contribution for coastal fish conservation.

STUDY AREA AND METHODS

Study area

The Benin coastal lagoon (Figure 1) lays at the Southern Benin on 130 km and covers about 30 km^2 with swamps reaching 60 km^2 during the high-water period (Adite, 2002). The coastal zone undergoes a sub equatorial climate composed of three (3) hydrological seasons namely (1) wet season (April - July), (2) transitional or flooding season (August-November) and (3) dry season (December - March). Annual mean rainfall is about 1307.3 mm (Akouegninou *et al.*, 1993) and flooding at the coastal lagoons depends on the Mono River. This river supports a hydro electrical dam which greatly affects water flows, water quality, fish community structure, productivity and fisheries of the coastal zone (Kakpo, 2011). Coastal plant communities are dominated by mangrove species such as *Rizophora racemosa* and *Avicennia africana* which are being intensively destroyed for domestic use, firewood, house construction and to make space for local salt industries. Intense and permanent fisheries activities leading to overfishing take place at the coastal zone and targeted to the whole fish community including genus like *Sarotherodon, Tilapia, Hemichromis, Kribia , Dormitator, Eleotris, Gerres, Ethmalosa, Chrysichthys, Liza, Mugil etc.* Moreover, oyster collection and traditional oyster farming dominate the coastal lagoon and generate a substantial income for grass-roots.

Sampling site

To assess the water quality of the rearing milieu and the growth and yields of the cultivated oyster (*C. gasar*), a rearing site of 20 m^2 belonging to a woman from Degoue village (Ouidah town) was selected. This site lies between 06°19’36.2”N and 002°03’38.3”E at the coastal zone (Southern Benin) (Figure 1). The sampling site was then bordered with steaks to facilitate future identification and to maintain the oyster in situ. Rearing and sampling were completed in a participatory approach with the owner of the site.

Survey on oyster farming distribution and management

Using a pre-elaborated questionnaire, interviews were made with individual and organized groups involved in oyster farming to survey on information regarding geographic distribution of oyster farming at the Benin coastal zone, collection of the juvenile oysters to stock, rearing techniques, follow-up, harvesting, oyster processing and marketing, revenue, degradation issues of the rearing site and importance of oyster farming among other activities.

Evaluation of water quality of the cultivation milieu

Before the stocking of the juvenile oysters (seed) at rearing site, water features were evaluated. Moreover, monthly measurements were done during the rearing period. Water depth and turbidities were measured to the nearest millimeter using a calibrated rope and with a secchi disk respectively. Temperature and dissolved oxygen were measured to the nearest 0.1 degree Celsius and 0.1 mg/l with a digital oxythermometer. The pH was measured to the nearest 0.1 with a portable pH meter. Salinity was measured to the nearest 1%o, with a refractometer. In addition, bottom type and substrate were evaluated.

Evaluation of oyster growth and yield

Oyster’s growth and yields were assessed through monthly measurements of sizes and weights. Ten thousands juvenile oysters, corresponding to a density of 500/m^2 were stocked and spread evenly on the rearing site of 20 m^2. Estimation of the oyster number was done by counting the oyster contents of a specific measurement bowl and by extrapolating to the whole boat content. Before the stocking of the seeds in the rearing ground and also at the end of the rearing, total length (TL), width (W), height (H), total weight (TW), shell weight (SW), flesh weight (FW) have been measured on 500 juvenile oysters randomly selected. TL is the maximum horizontal distance between the two extremities (tips) of the oyster, W is the maximum horizontal distance taken from side to side and H is the maximum vertical distance taken between the bottom and the upper valves (Kinkpé *et al.*, 2005). TL, W, and H have been measured with a vernier caliper ruler to the nearest 1 mm. TW, SW and FW have been measured with an electronic scale (Philips) to the nearest 0.1 g. For monthly follow-up of growth control, TL, W, and H and TW were measured on 500 individual oysters. After measuring, the oysters were brought back in the rearing site to maintain the original density.

Stomach content analysis

The valves of alcohol preserved specimens were separated and the gut was opened and all the stomach contents were removed and spread on a glass slide for examination both under a binocular and photonic microscope. Preys were identified to the lowest possible taxonomic level using the identification keys of Needham (1962). Prey volume was estimated by water displacement using an appropriately sized graduated cylinder.

Data Analysis

Monthly means of growth factors have been calculated with Excel software. Frequency histograms of size intervals have been constructed for both juvenile and reared oysters. A length–weight relationship has been examined following linear regression:

$$\mathrm{Log}_{10}\,TW = \mathrm{Log}_{10}\,a + b\mathrm{Log}_{10}TL$$

where WT is the total weight, TL the total length, *a*, a constant and *b* the allometry coefficient (Tesch 1971). The linear regression was obtained by a logarithm transformation of TW and TL (Pauly, 1985; Enin, 1994, 1995). Also, a linear regression between monthly mortalities and total length has been performed to search for correlations. One way analysis of variance was performed for growth factors using SPSS computer program (Morgan *et al.*, 2001). For diet analysis, volumetric data has been recorded on Excel software spreadsheet and proportions of each food item consumed by *C. gasar* was computed as follows:

$$Pi = (\sum_{i=1}^{n} vi)/Vt$$

where p_i is the proportion of food item *i* in the diet, n is the number of stomachs (n=630), vi is the volume of food item *i* in a single stomach, Vt is the total volume of food ingested by n stomachs.

RESULTS

Distribution of oyster farming at the coastal zone

The survey revealed that the oyster farming is a dominant activity practiced mainly by women from two coastal towns, Ouidah and Grand-popo. More than 2,000 women from 25 villages of five counties including Dokloboé, Avlo and Avlo-plage (Grand-Popo town) and Djegbadji, Ouakpe-Daho, Avlékete (Ouidah town) were involved in the oyster farming at the coastal zone (Figure 1). Annually, each woman stocked and reared about 10.000 to 50.000 juvenile oysters.

Characteristics of the rearing milieu

The oyster farmings were settled in shallower and sandy-muddy locations adjacent to grass-roots villages and houses. Water depths and transparencies varied between 38 - 63 cm and 33-59 cm respectively. Water temperature, pH, and dissolved oxygen ranged from 26.6 to 31.7°C, 6.3 to 7.4, and 3.0 to 6.9 mg/l respectively. Salinities is the major water parameter that affect the growth of *C. gasar* and varied between 4.1-17.9 %o (Table 1). Overall, water physico-chemical parameters exhibited significant variations (P<0.05) during the rearing periods.

Production process

Seed oyster collection

The juvenile oysters (seeds) (3 months-old) to be stocked at the rearing milieu were collected from the wild at the saltier (salinity ≥25%o) coastal aquatic habitat, adjacent to the sea. The collection sites, located at about 15 km from the rearing site, are the major reproduction ground for *C. gasar* where a huge a bed of juvenile oysters is found, collected, sold and transported to the rearing grounds. Seeds were purchased and brought to the rearing grounds with a boat containing about 10.000 individuals costing about 10.000 FCFA (US $20). For this study, the total length and total weight of the seeds purchased varied between 14 - 67 mm and 0.5 - 55.6 g respectively.

Seed stocking and follow-up

After collection and purchasing, seeds were evenly spread and stocked at the rearing site at a mean density of 500 oysters/m^2. Every 2 months, aggregated oysters and those covered with mud and silt were spread at the rearing site to enhance higher oxygen and nutrient consumption for better development and growth rate (MacKenzie, 2005). Also, during spreading, the women visually appreciate the oyster's size for growth control. Harvesting, processing and marketing occur when oyster reached commercial sizes.

Prey consumed

The diet analysis revealed that the dominant preys consumed by *C. gasar* at the rearing site were phytoplankton with volumetric proportions of 73% and substrate particles (23%). Phytoplankton included Diatomophycea (34%), Chlorophycae (17%), Scenedesmacae (14%), Dictyosphaeriacae (4%) and other minor food items such as Pleurococcacae, Chloroococcacae, Desmidiacae and Peridiniacae.

Survival, growth and yield

Oyster survival

Low monthly mortalities were recorded and varied between 0% and 1.6% during the rearing period. Though not significant ($p>0.05$), the regression (Mortality = -0.022TL + 1.724; r = 0.49) between total length and mortality indicated that mortalities decreased as total length increased (Figure 2). Up to about 59 mm - total length, no mortalities were recorded.

Growth, yields and revenues

Table 2 shows the monthly mean values of growth factors recorded on *C. gasar* at the rearing site. The result revealed that the sizes (total length, width, height) and total weight, recorded for *C. gasar* exhibited significant variations ($p<0.05$) during the 12 months-rearing periods. The study revealed that sizes structures from juvenile oysters (seeds) and reared oysters from wet, flood, and dry periods exhibited an unimodal distribution for total length with mode shifting progressively from 25 mm to 65 mm after 12 months of rearing (Figures

Table 1. Monthly variation of water features of the rearing milieu of *Crassostrea gasar* at the Benin's coastal lagoon

Month	Depth (cm)	Transparency (cm)	Temperature (°C)	pH	dissolved oxygen (m/l)	Salinity (%o)
June	49	49	26.6	6.9	4.3	11.1
July	59	59	27.4	7.3	6.7	4.8
August	61	37	27.1	6.9	4.7	5.5
September	63	33	29.1	7.4	6.9	5.8
October	60	42	31.7	6.32	6.51	4.5
November	58	55	29.9	6.5	5.22	4.1
December	50	43	30	6.6	5.04	6.9
January	45	41	28.2	6.9	3	8.2
Febuary	40	40	29	7.4	3.4	12.5
March	38	38	28.2	7.3	6.7	17.9
April	43	43	29	7.1	6.9	14
Mai	43	43	29.2	7.2	4.4	12.7
Mean	50.8	43.6	28.8	7.0	5.3	9.0
STDV	9.0	7.4	1.4	0.4	1.4	4.5

Table 2. Monthly variation of the growth factors of *Crassostrea gasar* reared at the Benin's coastal lagoons. Sample size=500

Month	Total length (mm)	Width (mm)	Hight (mm)	Total weight (g)
June	32.84	24.42	15.43	8.34
July	34.83	25.89	17.59	9.87
August	51.58	35.95	21.29	21.27
September	55.57	36.63	22.4	23.98
October	58.13	38.2	24.16	27.09
November	59.7	39.09	25.61	27.18
December	61.73	39.65	25.9	28.59
January	62.07	42.48	26.04	35.64
Febuary	62.35	44.66	27.49	38.28
March	63.3	45.42	29.47	44.93
April	68.97	46.14	29.9	54.13
Mai	72.6	49.24	30.19	63.16
Mean	56.973	38.981	24.623	31.872

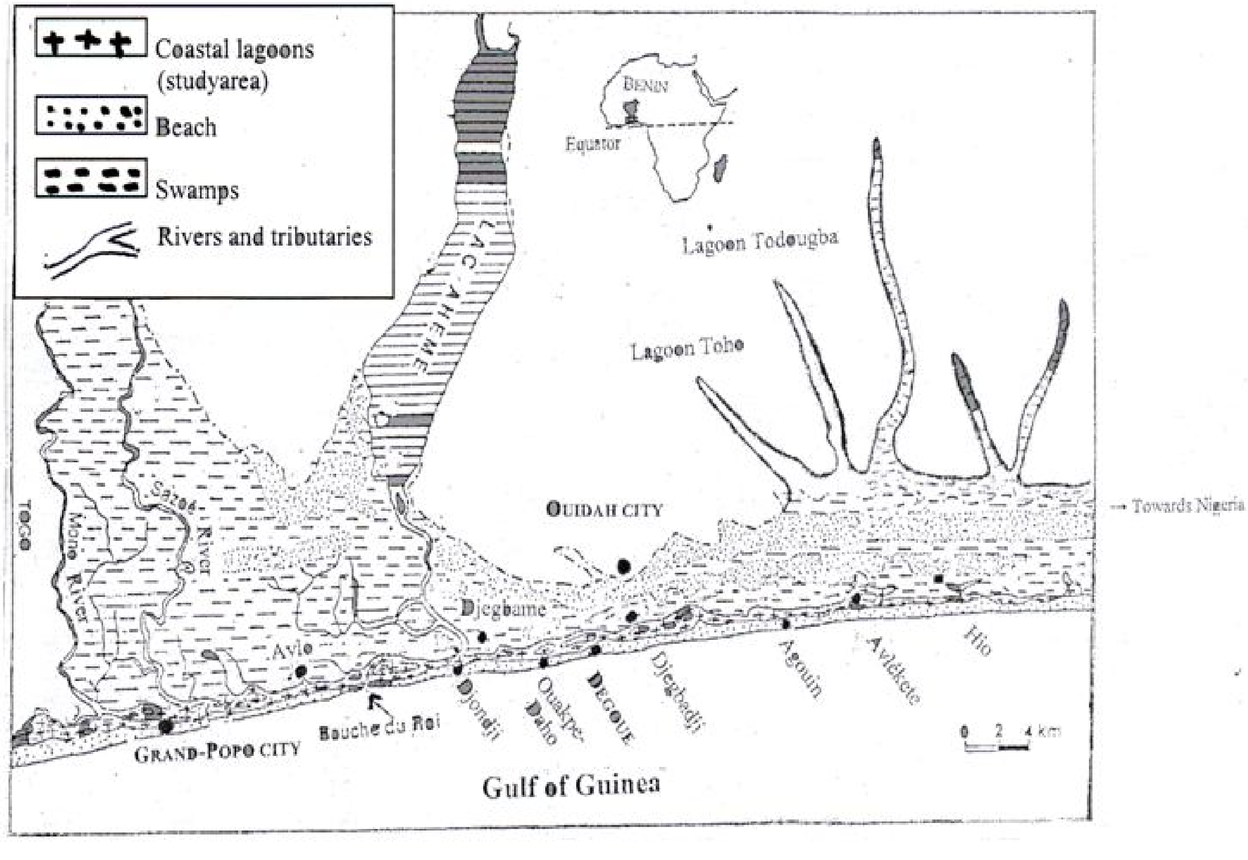

Figure 1: Map showing the locations (villages) where *Crassostrea gasar* aquaculture occurs at the Benin coastal Lagoons. Current farming evaluation was implemented at Degoue village (Ouidah City)

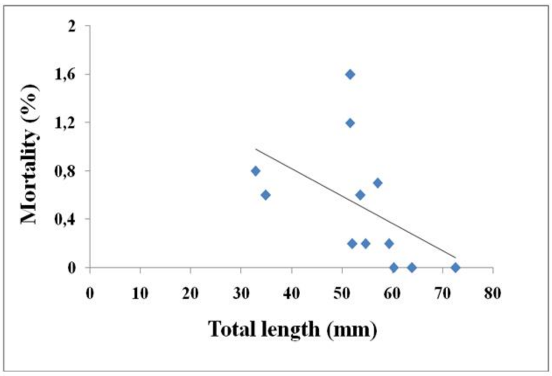

Figure 2: Linear relationships between total length (TL) and mortality of *Crassostrea gasar* reared at the Benin's coastal lagoon: M (%) = -0.022TL + 1.724; r = 0.49

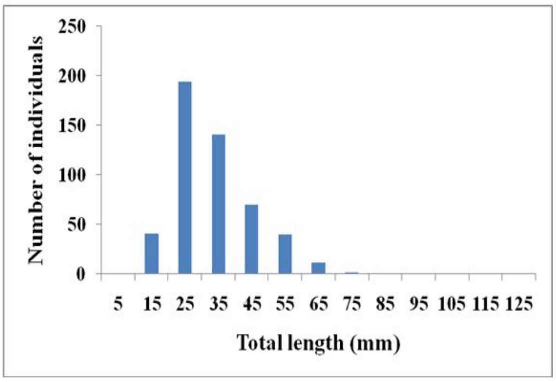

Figure 3: Size structure of the juvenile oysters (seeds) of *Crassostrea gasar* (3 months-old) collected in June at the Benin's coastal lagoon and stocked in the rearing milieu at the beginning of the aquaculture. Sample size=500

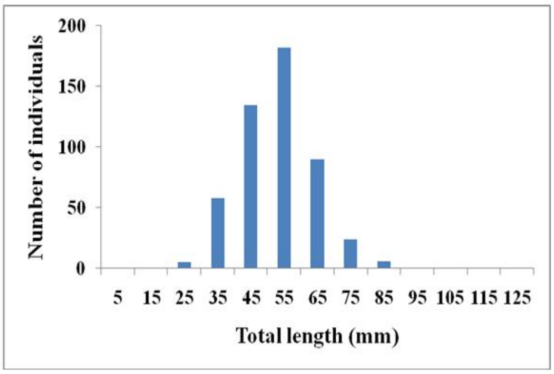

Figure 4: Size structure of *Crassostrea gasar* sampled in September (flood period) at the Benin's coastal lagoons after 4 months of rearing. Sample size=500

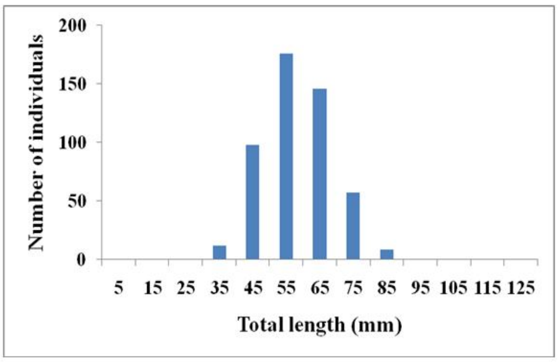

Figure 5: Size structure of *Crassostrea gasar* sampled in January (dry season) at the Benin's coastal lagoons after 8 months of rearing. Sample size=500

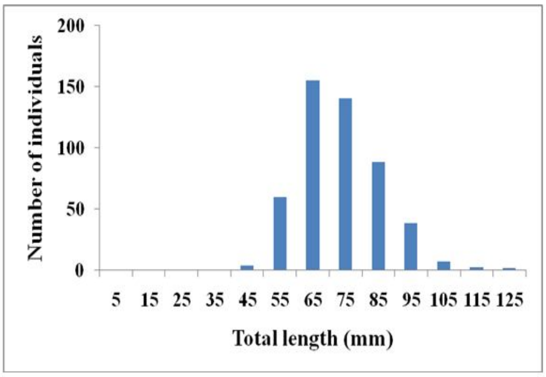

Figure 6: Size structure of *Crassostrea gasar* sampled in Mai (wet season) at the Benin's coastal lagoons after 12 months of rearing. Sample size=500

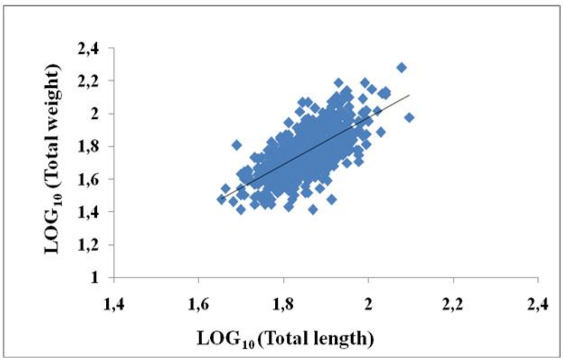

Figure 7: Linear relationships between total length (Log_{10} TL) and total weight (Log_{10} TW) of *Crassostrea gasar* reared for 12 months at the Benin's coastal lagoon:
Log_{10} (TW) = 1.421 Log_{10} (TL) – 0.869; r = 0.70; Sample size: 500

3,4,5,6). Also, length-weight regressions indicated that weights increased with lengths (Figure 7) and final mean total length reached 72.6 ± 5.78 mm (mean weight = 63.16 ± 18.16 g), corresponding to a mean monthly growth of 3.31 mm- total length (4.57 g - total weight) (Tables 2). Considering the individual mean weight reached after 12 months of rearing and the mean mortality, the yields has been estimated at about 30 kg /m^2/year of oyster (flesh and shell). The flesh yield was about 6 kg/m^2/year and the shell yield 24 kg/m^2/year which correspond to estimated yearly revenue of 160,000 FCFA (US$330) for the rearing of a boat of oyster seeds.

DISCUSSIONS AND CONCLUSION

At the Benin coastline, in addition to the important oyster fishery/collection, traditional oyster farming has been practiced since many centuries by women and provides sustainable revenues for grass-roots (Abiogba & Henadou, 2006). Primarily utilized as valuable food source for grass-roots, oysters have become a resource of high commercial value.

Habitat conditions

Suitable habitats for potential growth are common at the coastal zone and meet ecological conditions of depth, transparency, temperature, ph, dissolved oxygen and salinity for oyster cultivation (Gilles, 1991; Adité *et al*., 2007). Particularly, the succession of low and high salinities occurring at these brackish water habitats is the key condition because oysters do not tolerate prolonged exposure of high salinities (Abgrall *et al*, 2010). As reported by Gilles (1991) and Abgrall *et al.* (2010), temperatures and salinities between 20°C and 30°C, and 0%o and 40%o respectively increase survival, growth and oyster appears to increase their feeding rate. Dissolved oxygen (3.0-6.9 mg/l) at the rearing site satisfies growth condition and as reported by Jordan *et al*. (1992), large adult oysters can tolerate hypoxic conditions (<2 mg O2/l) than juvenile (seeds) which are more vulnerable to low oxygen conditions. Anyway, the intertidal conditions coupled with the relatively high water currents of the coastal area flushing the mud and the silt could act to relatively enhance oxygen availability (Jordan *et al.*, 1992). The relatively low turbidity recorded at the rearing milieu is advantage. Indeed, very high deposition and suspended materials slow growth rates, and increase mortality in most bivalve species (Mac Kenzie, 2005).

Food ingested and growth trends

Like most oyster farming in Africa (Kinkpé *et al*., 2005), the traditional oyster farming at the Benin coastal zone is an extensive aquaculture without food supply and under natural condition; hence, the food ingested by *C. gasar* for its survival and growth originated from the wild. In southern Benin, a great supply of nutrients from mangroves, salt marshes and rivers, makes coastal lagoons and bays, very productive areas for oysters farming. In this study, *C. gasar* exhibited a planktinovore feeding habit and consumed about 73% of phytoplankton dominated by diatoms, trends also reported by Newell & Jordan (1983) and Abgrall *et al.* (2010). With regard to growth, total length – total weight relationships of *C. gasar* (Figure 7) established from the final population was significant (P< 0.05) with a positive slope indicating that the weight increased with the length:

$Log_{10}(W) = 1.421\ Log_{10}(LT) - 0.869$ with $r = 0.70$

Gilles (1991) reported the same trend for *C. gasar* at the Petite Côte in Senegal, but with a higher slope (2.723). The high variation of the final sizes of the reared oyster could be attributed to the high variation of the initial sizes (Figure 3,4,5,6). Mean monthly growth was moderate and reached 3.31 mm- total length (4.57 g - total weight). The results consistantly indicated that the oyster growth at the Benin coastal zone depend on salinitiy fluctuations. For example, the maximum monthly growth (16.8 mm- total length and 11.4 g - total weight) was recorded in August as the salinity drop from 11.1 ‰ in June to 4.8 ‰ in July (Table 1). Though the oyster can tolerate a wide range of salinities (0 to 40 %o), however they do not tolerate prolonged exposure to high salinities (Abgrall *et al*. 2010). In the Casamance at Senegal, Gilles (1991) reported a lower monthly weight growth (2 g) for *C. gasar* at the Petite Côte. This low growth performance of *C. gasar* at the Petite Côte may be attributed to its high water salinities (11 %o - 58%o) compared to that of the Benin coastal water which fluctuated between 4.8 %o and 17.9 %o (Gilles,1991). Also, the mean monthly growth of the flesh weight (mean : 0.87 g) from our findings is higher than that reported by FAO (1982) (0.67 g) for *C. gasar* reared under natural condition. Also, with regard to seasons, one-way analyses of variance on the growth features of *C. gasar* revealed that the variations of total length growth across the three seasons (dry, wet, flood) were significantly different ($F_{2, 10} = 7.156$, $p = 0.02$). Indeed, the total length growths were higher during the flooding season where salinities were lower. Though not significant, the total weight growth ($F_{2, 10} = 0.890$, $p = 0.453$) and the flesh weigh growth ($F_{2, 10} = 2.160$, $p = 0.186$) exhibit a relatively higher growth during the flooding period. In contrast, mortalities across the three seasons during the rearing period were significantly different ($F_{2, 10} = 4.579$, $p = 0.047$) and higher values were recorded during the flooding season. Grass-roots (personal communication) reported that very high flooding increase oyster mortality. This is probably due not only to the prolonged exposure on low salinities (near 0%o) (Abgrall *et al*., 2010), but also to the intrusion of very trouble and black water from adjacent swamps of poor quality (low pH, low dissolved oxygen, high turbidity) which could act together to increase mortality. However, the low monthly mortality (<2%) recorded during the rearing period could be attributed to the relative high size of the seeds stocked at the beginning. Though not significant, regressions between mortalities and size showed a negative slope (b= - 0.022; r = 0.49) indicating that mortalities decreased as oyster size increased (Figure 2).

The proximity of the rearing sites to grass-roots villages or houses may negatively affect the growth rate and mortality of *C. gasar*. Indeed, as reported by MacKenzie, 2005), in most bivalve species, high deposition rates increase concentrations of suspended materials and can clog the gills and induce the reduction of pumping rate. Consequently, the growth slow down with an increase of the oyster mortality (Stern & Stickle, 1978; Shumway, 1996). Also, excess accumulation of biodeposits and sediments may lead to the burial and death of juvenile and adult oysters when the oysters are unable to reopen their valves (Galtsoff, 1964; Stern and Stickle, 1978; Shumway, 1996). However, in this traditional oyster farming at the Benin coastline, the periodic spreading of the aggregated oysters at the rearing site relatively prevents oysters from burring. At the Benin coastal waters, habitat disturbances such as the destruction of mangroves, input of anthropogenic contaminants and nutrient enrichment leading to eutrophisation, and the hydroelectric dam built on the Mono River are among the major stressors that could affect the traditional oyster farming (McDowell *et al*., 1999; Bower, 2005). In addition, unwanted harmful bacteria may cause human health problem when oyster is not appropriately cooked.

Oyster farming development and coastal fish conservation

In addition to the mangrove destruction, the coastal fish resources underwent a severe overexploitation which greatly affects the fish community structure, such as richness, diversity, abundance, productivity and reduction or loss of nursery grounds and shelters (Adite, 2001). Though traditional, the oyster culture in Southern Benin is a response not only for aquaculture diversification and wetlands valorization, but also to reduce the high fishing pressure and overexploitation caused by the increasing fishermen population and the use of various detrimental fishing gears like the cross-lake fish traps, less selective. Consequently, the oyster farming development may greatly contribute to coastal fish conservation and sustainable exploitation. The great establishment of the oyster farming in the Benin coastal waters is favored by (1) the relatively suitable rearing milieu conditions, (2) the availability of oyster seeds (juvenile oysters) at the reproduction ground, (3) the simplicity in the culture procedure (seed collection, stocking, spreading, harvesting), (4) the less effort and time its requires while providing highly commercial and valuable resources. As an alternative source of revenues, the oyster farming in the Benin coastal waters may greatly contribute to coastal fish conservation and sustainable fisheries management. The development of the oyster farming in Benin requires further scientific knowledge on the identification of potential rearing, seed size, stocking densities, food habit, habitat alteration and ecological follow-up for sustainable oyster farming management.

Acknowledgements

This study was supported by the « Programme de Recherches pour la Conservation de la Biodiversité (PRECOB)» of the « Faculté des Sciences et Techniques (Université d'Abomey-Calavi) ». We are grateful to the women association of traditional oyster farming of Degoue village (Ouidah city) for their collaboration and assistance and follow-up during the rearing. I express my gratitude to the numerous reviewers for their thorough peer-review of this manuscript and helpful insights.

REFERENCES

Abgrall, M.-J., Bastien-Daigle, S., Miron, G. and Ouellette, M. 2010. Potential interactions between populations of Soft shell Clams (*Mya arenaria*) and Eastern Oysters (*Crassostrea virginica*) in temperate estuaries, a literature review. Canad. Tech. Rep. of Fish. and Aqua. Sci. 2892.

Abiogba, O.E. and Henadou, J. 2006. Contribution à l'étude des huîtres exploitées au lac Nokoué: Etat des lieux. Mémoire pour l'obtention du Diplôme d'Etude Agricole Tropicale- DEAT/LAMS. 87 P.

Adite, A. 1995. Fisheries ecological surveys of natural coastal lakes of Benin, West Africa. Master's of Sciences Thesis. Depart. of Wildlife and Fish. Sci., Texas A&M University, USA. 114 p.

Adite, A. 2002. The mangrove fishes in the Benin estuarine system (Benin West Africa): Diversity, degradation and management implications. Ocean Docs-Africa-African Marine Sciences-Oceanography-Fisheries. http:// hdl.handle.net/1845/455.

Adite, A. and Moussa, A.D. 2007. Croissance de l'huître du genre *Crassostrea sp* en élevage traditionnel au Sud – Bénin. Tech. Rep., PRECOB/FAST/University d'Abomey-Calavi.

Adite, A. and Van Thielen, R.O. 1995. Ecology and fish catches in natural lakes of Benin (West Africa). Envi. Biol. of Fish. 43: 381-391.

Akoegninou, A., Oyede, L.M, and Toffi, M. 1993. La mangrove du Benin: Environment physique, vegetation, et essais de gestion. Doc. Tech. no2. FAST-UNB.

Anato, C.B., Sossoupkè, E. and Dossou, C. 2003. Biodiversité des poissons et potentialités halieutiques des côtes béninoises : cas des sparidae. Pages 67-68 in Poissons et Pêches Africains.

Bower, S.M. 2005. Synopsis of infectious diseases and parasites of commercially exploited shellfish: Haemocytic Neoplasia of Clams. [Available online]: http://www-sci.pac.dfo-mpo.gc.ca/shelldis/pages/hncc_e.htm, 08/01/2005.

Buchanan, J.B. 1954. Marine Molluscs of the Gold Coast. J. Wes. Afri. Sci. Asso. 1(1): 30–45.

Chikou, A. 2006. Etude de la démographie et de l'exploitation halieutique de six espèces de poissons-chats (Teleostei, Sliluriformes) dans le delta de l'Ouémé au Bénin. Thèse doct. Sci., Univ. Liège (Belgique).

FAO, 1982. Coastal aquaculture development perpectives in Africa and case studies from other regions. CIFA Tech. paper. CIFA/CPCA/T9. 272 P.

FAO, 1995. Effects of riverine inputs on coastal ecosystème and fisheries resources. FAO Fish. Tech. Paper T349.

FAO. 1976. Conférence technique de la FAO sur l'aquaculture, Kyoto, Japon, 26 Mai – 2 Juin 1976. Rap. FAO Pêches, N°188.

Fisheries and Oceans Canada, 1996. By the sea: a guide to the coastal zone of the Atlantic Canada. [Available online]: http://www.glf.dfo-mpo.gc.ca/sci-sci/bysea-enmer/index-e.html, 03/11/2005.

Fisheries and Oceans Canada, 2001b. Integrated commercial oyster fishery management plan: Eastern New Brunswick area, Gulf Region. [Available online]: http://www. glf.dfompo.gc.ca/fm-gp/mgmt-plan/nb-nb/oyster_huitre_ 2001_2006-e.html. 24/11/2005.

Galtsoff, P.S. 1964. The American oyster *Crassostrea virginica* Gmelin. Fish. Bull. U.S. Bur. Comm. Fish. 64:1-480.

GCLME. 2006. Guinea current large marine ecosystem report. GEF/UNIDO/UNDP/UNEP/ US-NOAA. http://Projects. csg.uwaterloo.ca/inweh/content/1188.

Gilles, S. 1991. Observations sur le captage et la croissance de l'huître creuse ouest-africaine, *Crassostrea gasar*, en Casamance, Sénégal. Rev. Hydroliol. frop. 21 (.Y): 197-297.

Jordan, S.J. 1987. Sedimentation and remineralization associated with biodeposition by the American oyster *Crassostrea virginica* (Gmelin). PhD thesis, University of Maryland.

Kakpo, D.B.E. 2011. Biodiversité et exploitation des poisons du Bas-Mono: implications pour la conservation et la gestion durable des resources halieutiques. Mémoire de Master. PRECOB/FAST/University d'Abomey-Calavi.

Kennedy V.S., Newell R.I.E. and Eble A.F. (eds.). Maryland Sea Grant College, College Park, Maryland. pp. 467-513.

Kinkpé, R., Sossa, G.N, and Viaho C.C. 2005. L'ostréiculture traditionnelle: état des lieux et perspectives d'amélioration. Mémoire pour l'obtention du Diplôme d'Etude Agricole Tropicale- DEAT/LAMS. 92 Pages.

Lalèyè, P., Chikou, A., Philippart, J.C., Teugels, G.G. and Van De Walle, P. 2004. - Étude de la diversité ichtyologique du bassin du fleuve Ouémé au Bénin (Afrique de l'Ouest). Cybium, 28: 329-339.

Lalèyè, P., Niyonkuru, C., Moreau, J. and Teugels, G.G. 2003. Spatial and seasonal distribution of the ichthyofauna of Lake Nokoué, Benin, West Africa. Afri. J. of Aqu. Sci. 28: 151-161.

Little, C. 2000. The biology of soft shores and estuaries. Oxford University Press.

MacKenzie CL Jr. 2005. History of oystering in the United States and Canada, featuring the Eight greatest oyster estuaries. [Available online]: http://www.the-boat zone.com/Cheap-Boat- Loans-California/Chesapeake-Bay---1800's---Steam-Boats.htm, 19/01/2006.

McDowell, J.E., Lancaster, B.A., Leavitt, D.F., Rantamaki, P. and Ripley, B. 1999. The effects of lipophilic organic contaminants on reproductive physiology and disease processes in marine bivalve molluscs. Limnol. Oceanogr. 44 (3, part 2) 903-909.

Milewski, I. and Chapman, S. 2002. Oysters in New Brunswick: more than a harvestable resource. Conservation Council of New Brunswick, Fredericton, NB.

Montchowui, E., Niyonkuru, C., Ahouansou Montcho, S., Chikou, A. and Lalèyè, P. 2007. L'ichtyofaune de la rivière Hlan au Bénin (Afrique de l'Ouest). Cybium, 31: 163-166.

Morgan, G.A., Grieggo, O.V., Gloeckner, G.W. 2001. SPSS for Windows: An introduction to Use and Interpretation in Research. Lawrence Erlbaum Associates, Publishers, Mahwah, New Jersey.

Moussa, A.D. and Debleo, L.S. 2006. Etude des performances zootechniques de l'huître du genre *Crassostrea sp* en élevage traditionnel au Sud – Bénin: Cas de la lagune côtière. Mémoire pour l'obtention du Diplôme d'Etude Agricole Tropicale- DEAT/LAMS.

Newell, R.I.E. and Jordan, S.J. 1983. Preferential ingestion of organic material by the American oyster *Crassostrea virginica*. Mar. Ecol. Prog. Ser. Vol. 13: 47-53.

Nickles, M. 1950. Mollusques testaces marins de la Côte occidentale d'Afrique. Manuels Ouest Africains, Ed. 2, Paris.

Shumway, S. 1996. Natural environmental factors. In The Eastern Oyster Crassostrea virginica.

Stern, E.M. and Stickle, W.B. 1978. Effects of turbidity and suspended material in aquatic environments. USEPA Dredged Material Research Program, Final report, Vicksburg, MS.

Swift, D.R. 1985. Aquaculture training manual. Fishing News Books Ltd. Farnham Survey England.

Texier, H., Colleuil, B., Profizi, J.-P. and Dossou, C. 1980. Le lac Nokoué, environnement lagunaire du domaine margino-littoral sud-béninois: bathymétrie, lithofaciès, salinités, mollusques et peuplement végétaux. Bull. Inst. Géol. du bassin d'Aquitaine, Bordeaux n°28.

****