The Manche-à-Eau Mangrove Lagoon, Guadeloupe (16°16'N; 61°33'W), French West Indies, in the Life Cycle of Coastal Fish Species

JEAN-LUC BOUCHEREAU[1] and PAULO DE TARSO CHAVES[2]
[1]*Université des Antilles-Guyane, UMR 7138 CNRS IRD MNHN UPMC, Systématique, Adaptation, Évolution, Dpt de Biologie, Campus Fouillole, BP 592, F-97159 Pointe-à-Pitre, France*
[2]*Depto de Zoologia, Universidade Federal do Paraná (UFPR), Brazil.*

ABSTRACT

The functioning of the Manche-à-Eau lagoon and of its mangrove environment with the population of marine fish of Guadeloupe has been studied since 1983, and particularly in the 2000s. This ecosystem supports a stable fish assemblage structure because of its twice a day turnover (14.8%) of marine water. It is a favorable and important site for the reproduction (38%) and growth (46%) of a large number of species. The life cycle of these fish species share, for the most part, an ecophase in the mangrove in brackish water and a marine ecophase outside the lagoon. The mangrove plays a vital role in the retention of continental nutrients. This facilitates the trophic exploitation of vegetal and animal detritus bases by the fish in high population density. The majority of populations present individuals reaching length at least 40% from the known maximum length for the species, although only 38.1% have individuals longer than 300 mm. The mangrove aids in the spawning activity of fish species (41% to 58% of the total abundance) and in the reproductive (maturation, migration) process (58% in density and 70% in biomass). The sedentary species lay their eggs in the mangrove, whereas the temporary species stay there during their trophic ecophase or after a genesic migration from the sea to assure sexual maturation for both sexes in the species.

KEY WORDS*:* Life cycle, guilds, trophic, genesic, ecophase

El Ciclo de Vida de los Peces Costeros en una Laguna de Manglar: La Manch-à-Eau (16°16'N; 61°33'O), Guadalupe, Antillas Francesas

El funcionamiento de la laguna de *la Manche-à-Eau* y de su ecosistema de manglar en conjunto con el samblaje de peces marinos ha sido estudiado desde 1983 y particularmente en los años 2000. Este ecosistema alberga una samblaje de peces de estructura estable a causa de la renovación bicotidiana del agua marina (14,8%). Es un sitio favorable e importante para la reproducción (38%) y el crecimiento (46%) para un gran número de especies. El ciclo de vida de la mayor parte de ellas se descompone en una eco fase en el agua sometida a al manglar y la otra al exterior de la laguna en la mar. El manglar juega un papel crucial en la retención de nutrientes de origen continental. Este facilita la explotación trófica del detritus de base vegetal o animal para los individuos de poblaciones presentes en gran número. En la mayor parte de las poblaciones de peces, al menos 40 % de los individuos llegan a su talla máxima conocida aunque solamente el 38,1 % poseen individuos de una longitud superior a 300mm. Los manglares contribuyen al desove de la diferentes especies de peces (41% a 58% de la abundancia total) y a los procesos reproductivos de migración y/o de maduración (58% en densidad y 70% en biomasa). Las especies sedentarias depositan sus huevos en el manglar en tanto que las especies temporales se quedan allí durante su eco fase trófica o después de una migración genésica del mar para asegurar la maduración sexual de ambos sexos en la especie.

PALABRAS CLAVES*:* Ciclo de vida, gremios, eco fase, trófico, genésico.

Le Cycle de Vie des Poissons Côtiers dans une Lagune à Mangrove: La Manche-à-Eau (16°16'N; 61°33'O), Guadeloupe, Antilles Françaises

Le fonctionnement de la lagune de la Manche-à-Eau et de son écosystème à mangrove avec l'assemblage des poissons marins de la Guadeloupe à été étudié depuis 1983, et particulièrement dans les années 2000. Cet écosystème héberge une structure stable de l'assemblage de poisons à cause du renouvellement biquotidien d'eau marine (14,8%). C'est un site favorable et important pour la reproduction (38%) et la croissance (46%) d'un grand nombre d'espèces.. Le cycle de vie de la plupart d'entre elles se décompose en une écophase en eau saumâtre de mangrove et l'autre à l'extérieur de la lagune en mer. La mangrove joue un rôle crucial dans la rétention de nutriments d'origine continentale. Ceci facilite l'exploitation trophique des détritus de base végétale ou animale par les individus de populations présents en grand nombre. Dans la plupart des populations de poissons, au moins 40% des individus atteignent la longueur maximum connue pour l'espèce, bien que 38,1% seulement ont une longueur individuelle supérieure à 300mm. La mangrove participe à l'activité de ponte des espèces de poissons (41% à 58% de l'abondance totale), et aux processus reproductifs de migration et/ou de maturation (58% en densité et 70% en biomasse). Les espèces sédentaires déposent leurs œufs dans la mangrove, alors que les temporaires y accomplissent une écophase trophique pour leur croissance ou génésique pour leur reproduction.

MOTS CLÉS: Cycle de vie, guildes, écophase, trophique, génésique.

INTRODUCTION

The characteristics of the ecosystems in shallow depths belong to the paralic domain. The dense concentration of suspended matter associated with an important biological productivity provides excellent conditions for the colonization of these environments by a large number of invertebrate and vertebrate species (Yáñez-Arancibia *et al.* 1993). Because of their mobility and influence on many trophic levels, the fish play a very important role in the functioning of the paralic ecosystems. The fish occupy them at different stages of their life history in using them as a nursery to benefit the young through the abundance of food present and as shelter against predators (Thayer *et al.* 1987). Also, it is used as a place of permanent residence, in the case of sedentary species; it is temporary for the anadromous and catadromous species, those that seasonally migrate, (trophic or genesic), or for many occasional incursions for those who use these environments only in an irregular fashion (Quignard 1984). This study describes, with the results of several authors, how a mangrove ecosystem, such as the Manche-à-Eau lagoon, is used by the fish assemblage living there.

MATERIAL AND METHODS

The Manche-à-Eau lagoon (MAE) is located (16°15'N; 61°35'W) at the Northeast of the Island of Basse-Terre in Guadeloupe, French West Indies, in the Caribbean Sea (Figure 1). This semiclosed 0.26 km^2 lagoon receives continental freshwaters from diffuse peripheral running waters and marine waters via a semidiurnal tide of low amplitude (40 cm). The average depth ranges from 1.5 m to 2.0 m (Assor 1987), and the movements of the water masses are slow and complex. This lagoon is linked with the Grand-Cul-de-Sac-Marin (GCSM) lagon by a channel, the Rivière-Salée, which delimits the two main islands of the Guadeloupe archipelago: the Basse-Terre and the Grande-Terre Islands (Figure 1). The lagoon is totally fringed by a typical vegetation of mangrove trees (*Rhizophora mangle*, *Avicennia germinans* and *Laguncularia racemosa*). The fish were caught with a passive fishing gear called *capéchade* (Quignard and Farrugio, 1981), with high selectivity, including a 45-m-long stopping net (the *paradière*) suspended with floats. Fish are driven to three bow nets sustained with arches forming funnels with mesh sizes decreasing from 8 to 6 mm (Bouchereau *et al.* 1989).

Description of the Ecosystem and Fish Community Studied

Seasonality of the abiotic factors and the presence of important relationships between the marine and continental regions — The composition of the MAE lagoon is influenced by the entry of marine water all year long. The water volume turnover at each tide (14.8%) twice a day combined with an active and various hydrodynamism (Mantran *et al.*, submitted to *Geomorphology*) contribute to vivify the lagoon more and provide information for a better interpretation of the Well-Being Index values and the populational parameters gradients of the fish assemblage living in this ecosystem. No gradient are observed with the abiotic variables. The water characteristics are homogeneous (Mantran *et al.* In press) everywhere in the lagoon, in the water column and whatever the period studied (temperature: 30.02°C; salinity: 36.16 ‰; pH: 8.29; turbidity: 6.10 mg/L; conductivity: 5.51 S/m; dissolved oxygen: 7.18 mg/L; dissolved solids: 32.78 g/L; osmolarity: 1021.7milliosmoles). Salinity is not a global explanatory factor in the understanding of the fish assemblage structuration in the MAE (Bouchereau *et al.* 2008). During the dry season in February or April, the salinization influence due to marine water entrance or hydric deficit consequently to evaporation is little spread because only two stations are concerned from the seven visited. During the rainy season, the desalinization mainly governed by the direct *impluvium* and the continental water percolation exerts a larger influence since it concerns five stations in July and four in December.

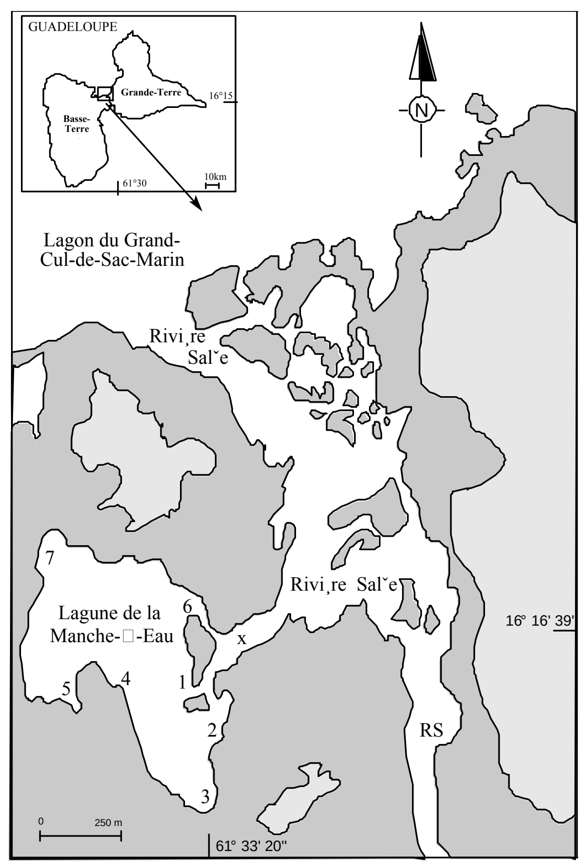

Figure 1. Guadeloupe's position in the French West Indies and the location of the Manche-à-Eau lagoon, with its connexion to the *Grand Cul-de-Sac Marin* lagoon.

The biological zonation of the Manche-à-Eau lagoon, according to the quality observed, is made of three zones, from II to IV: the zone II is more spread at South and narrow along the island, the zone III occupies the greater part of the ecosystem and the zone IV centered on the two main depressions at South and West, on the shallows and its North-West border and the end of the sector enclaved at South-West. The geomorphology, hydrodynamism and current populational descriptors relationship are to be more taken into account to understand the fish assemblage structure and other biological compartments.

An ichtyofaunistic composition of strong marine identity — Except when salinity could be supposed to attain sometimes low values in certain part of the lagoon and then freshwaterfish like *Poecilia vivipara* are observed (Nelson 2003), more than 98.4% of the 64 species of fish counted (from the studies of Louis 1983, Bouchereau *et al*. 2008, Caberty *et al*. 2004, Chantrel 2002, Fréjaville 2002, Lopes 2003, Moura 2003, Veilleur *et al.* 2008) are saltwater fish. The Perciforms (Gerreidae, 53,26%; Sciaenidae, 3,64%; Haemulidae, 0.03%) and the Clupeiforms (Clupeidae, 34.38%; Engraulidae, 5.58%) dominate in biomass and number (96.89%) of species. Among the species, a majority occupies the lagoon, either occasionally, or to carry out a trophic or reproductive (genesic) ecophase. Only a small fraction of the fish assemblage fulfills all of its life cycle in the ecosystem (Figure 2).

Even though the number of species in this fraction is small, its members are numerous (Bouchereau *et al.* 2008). This was observed by Chaves and Bouchereau (1999) in the Guaratuba Bay, Southern Brazil.

Constancy of the totality of the assemblage — A group of seven species constitutes between 75% and 98% of the abundance of the fish population. Depending on the year, this group is shared between any of 14 species. The species that has the maximum abundance is not uniform throughout the year, even though they are present there almost permanently. One can say that the species change, but their functions remain essentially the same, regardless of the year (Bouchereau *et al.* 2008, Chantrel and Bouchereau 2002, Fréjaville and Bouchereau 2002, Lopez 2003, Moura 2003) as it was observed in the Guaratuba Bay (Chaves and Bouchereau 1999).

One can notice two peaks of abundance of the ichtyofauna, one after the dry season (April) and the other after the hurricane season (December), that are transition periods with dry and rainy seasons. This is probably linked to a primary productivity more important to this time period, resulting from an increase in the transparency of the water and of the availability of nutrients, brought to the system by the bay's tributaries during strong rains. Here the mangrove plays a very important role in the functioning of this assemblage (Yáñez-Arancibia *et al*. 1993). The fact that the roots favor the retention and sedimentation of the suspended materials permits their ulterior incorporation in the primary productivity when the photosynthesis becomes more important (Caberty *et al.* 2004).

Tendency to concentrate small sized species — It is well known that the laguno-estuairian environments are normally rich in small fish. The presence of reduced length individuals can be explained at the following levels (Bouchereau *et al*. 2000, Veilleur *et al.* 2008):

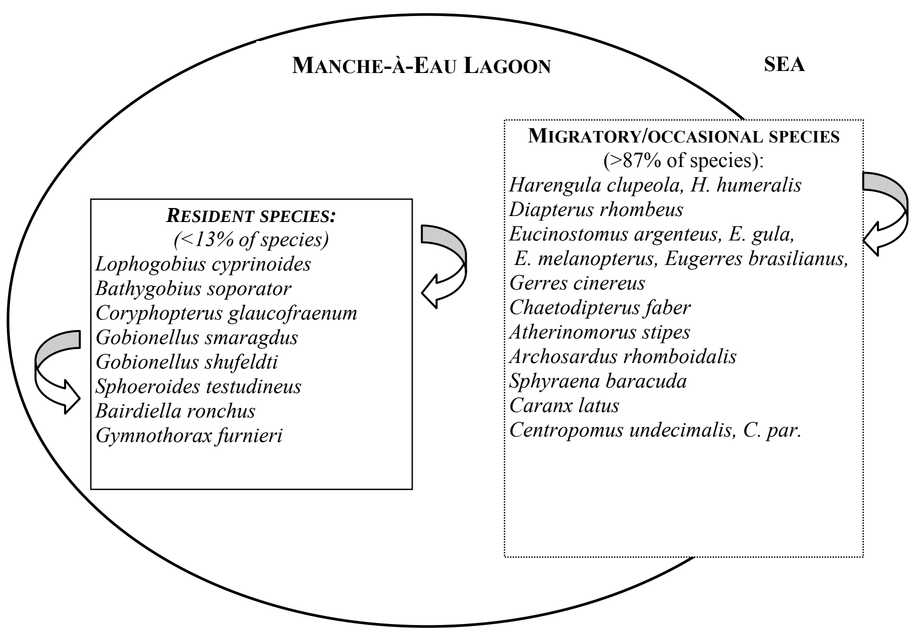

Figure 2. Examples of residing, occasional or migrant species occupying the Manche-à-Eau lagoon.

i) *Specific* — if the individuals belong to a species whose maximum size is naturally reduced;
ii) *Populational* — if the species to which they belong demonstrates a slower and/or more limited growth in the estuaries when compared to populations of the same species in other ecosystems, and
iii) *Ecophase* — if the ecosystem only accommodates the individuals of these populations in the early stages of their life cycle.

In the MAE lagoon, the distribution in those three groups of 42 species studied is the following : A, 33.33%; B, 40.47%; C, 26.19%. Group B is the most important. In A the individuals own to species whose potential size is week or correspond to a little advanced development stage. In B they cannot reach in lagoon the MLO noted elsewhere because their growth is limited in mangrove system. The fish populations of this group are found in the workshop lagoon at juvenile or sub-adult stages. Group C contains all species able to exceed the 300mm MLO elsewhere than the MAE workshop lagoon (Bouchereau *et al.* 2008).

The relationship "maximum length observed in the lagoon (MLO) - maximum available length in scientific documentation (MAL)" can be expressed by the equation:

$$MLO/MAL = -0.389 \times MAL^{-0.0002695}$$

$$(n = 41; r = 0.391; \text{for } \nu = 40, Pr > F = 0.011).$$

This formula can be used to compare this mangrove with other mangroves or other coastal regions in general as a favorable site for different sized fish. Bouchereau *et al.* (2000) present an approach considering these descriptions and their implications for the aquaculture.

Flexibility of feeding habits and dominance of detritivorous bases — Many studies show the role played by the mangroves as a place of growth of the fish and crustaceans. These studies are founded on the idea that in these ecosystems exists a larger availability of food, either in plant matter, or refuse (Yáñez-Arancibia *et al*. 1993). All the trophic and occupancy guilds are represented in the MAE lagoon. In the fish assemblage studied by Caberty *et al.* (2004) made up with 39 species and 25 families, the fishes feed preferentially on invertebrates associated or not with plants or fish, like that of Guaratuba Bay. The small number of piscivorous species is a very common trait to many mangrove ecosystems. The occupancy guilds are represented differently in biomass: in the lagoon, migrant and occasional species dominate in different proportions whereas in the Guaratuba Bay resident and migrant dominate in equivalent proportions (Chaves and Bouchereau 2004). The resident of both ecosystems exploit similarly the available resources, showing their strong adaptativeness. Resident, primarily detritivorous, and migrants, exploit alternatively detritus and primary production without trophic competition. The trophic guilds and migrants are eeuitably represented.

These facts reinforce the importance of the primary consumers, associated with the producers, as a dietary resource for the ichthyofauna of the mangrove. Flexible feeding habits are observed at MAE lagoon within the major part of the studied group; their general diet is susceptible to overlap between other species. Yet, according to Albaret (1994) lagoon fish have a common famous strategy, in which trophic opportunism is necessary for their population to face strong seasonal variations and trophic competitors in this type of environment.

An important reproductive site not only for paralic species but also thalassic species — The Manche-à-Eau mangrove lagoon is used as a spawning area, regularly or occasionally, by the fish in the region. In addition to the species that spawn in the mangrove, the bay also attracts other non-resident species that carry out their sexual maturation there. As a result, direct participation of the mangrove in the reproductive activity concerns an estimated 58 to 70% of total fish abundance (38% of species). This reinforces the importance of mangrove environments for the success of the life cycle of fish species in this coastal region.

The reproductive patterns of MAE fish assemblage can be classified in four types (Figure 3), according to the model proposed by Chaves and Bouchereau (2000) on the use of mangrove habitat for reproductive activity by the fish community. Two types from the four spawn in the mangrove.

Type 1 - Regular spawners. Spawning activity occurs regularly in the mangrove. These species are not necessarily residents of region, but always use it to spawn. Examples: *Bairdiella ronchus*, *Lophogobius cyprinoids* and several other Gobiidae.

Type 2 - Occasional spawners. Spawning activity in the mangrove is merely random. This region can be used to spawn, but there is no evidence that a great number of individuals in this group of species use it. These species are not as abundant in the mangrove as those belonging to Type 1. Examples: *Centropomus parallelus, C. undecimalis*, *Dasyatis americana* (Capapé *et al.*, 2002).

Type 3 - Mature in system. Spawning activity does not occur in the mangrove, but this region is frequented regularly during the final phase of maturation. Examples: *Diapterus rhombeus*, *Mugil curema*.

Type 4 - Do not mature in system. Spawning activity does not occur in the mangrove, nor does gonadal maturation, in many individuals. Examples: *A. chirurgus, Anchoa lyolepis*, *Harengula clupeola, Lutjanus griseus, Hyporhamphus unifaciatus*. Of the latter species, only juvenile individuals were found in the mangrove.

From the 50 species registered in the MAE lagoon in 2002, and after the literature data and personal observations, 14% is type 1, 20% type 2, 4% (type 3) and 62% (type 4). The density is for each type 1, 2, 3 and 4: 3.9, 20.8, 33.4, 41.9, respectively. Therefore, the spawning activity in a regular or eventual frequency (types 1+2) concentrates on species that represent a minimum of 41% (number) or 58% (biomass) of the stock occupying the lagoon. The fish species participation in the reproductive process, in a larger sense (types 1+2+3), is represented by at least 58% (density) or 70% (biomass) of the total abundance.

Considering the reproductive features of some of these species, more specifically fish populations from the French West Indies mangrove lagoons, it appears that they are generally multiple spawners, producing little small eggs per batch. Some of Gobiid fish family provide particular type of parental care as nest guarders.

The biomass (except the gobiidae not captured by the fishing net used) is: 9.2, 32.9, 27.9, 30.0, respectively (Figure 4).

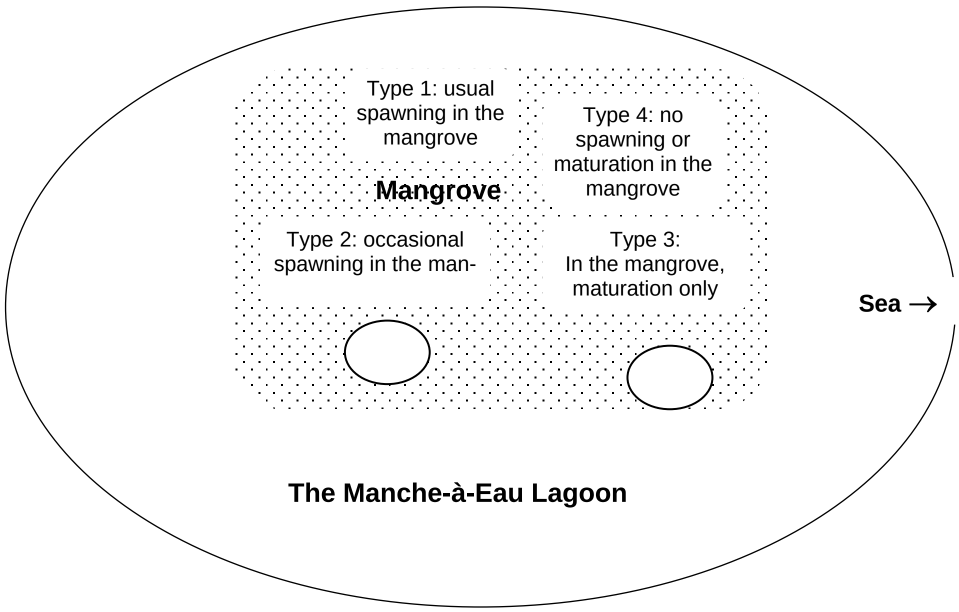

Figure 3. Use of Manche-à-Eau mangrove lagoon by the fish assemblage for reproduction. The circles represent spawning and gonadal maturation achieved partially or entirely in or around the mangrove (adapted from Chaves & Bouchereau, 2000).

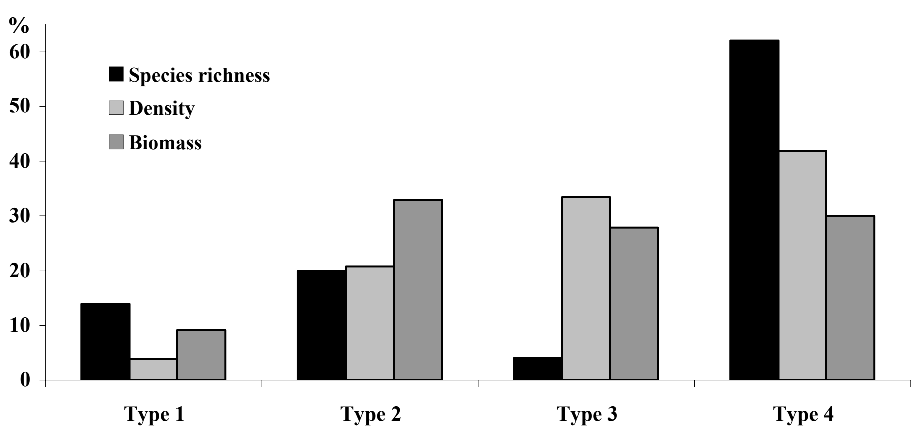

Figure 4. Percentage of fish species number, density and biomass *versus* each type of reproduction activity in the MAE lagoon. Types 1 and 2: spawn in the mangrove: type 1 always, type 2, occasionally; type 3: maturation only; type 4: not used for maturation or spawning.

CONCLUSION

The Manche-à-Eau lagoon and its mangrove environment largely occupied by ichthyofauna, also present on the coastal border, contribute considerably to the growth and reproduction of many species, which reside there permanently, temporarily or as regular migrant. The seasonal variations of the climate influence lightly the abiotic parameters in the ecosystem. The geomorphology, hydrodynamism and current population descriptors relationship must be more taken into account to understand the fish assemblage structure and other biological compartments. The high marine water turnover in the MAE lagoon contributes to vivify the brackish water quality and to support a stable structure in the fish assemblage regularly renewed by fish population coming in from the sea. The mangrove provides shelter and food shared by all the ecological guilds composing the fish assemblage.

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LITERATURE CITED

Albaret J.-J. 1994. Les poissons, biologie et peuplements. Pages 239-279 in: J.R. Durand, P. Dufour, D. Guiral, and S.G.F. Zabi (Eds.) *Environnement et Ressources Aquatiques de Côte-d'Ivoire*, *tome II – Les milieux lagunaires*. Éd. Orstom, Paris, France.

Bouchereau, J.-L., P. de T. Chaves, and J.-J Albaret. 2000. Selection of fish species for farming in the Bay of Guaratuba, Brazil. *Brazilian Archives of Biology and Technology*, Curitiba **43**(1).

Bouchereau, J.-L., P. de T. Chaves, and D. Monti. 2008. Factors Structuring the Ichtyofauna Assemblage in a Mangrove Lagoon (Guadeloupe, French West Indies), *Journal of Coastal Research* **24** (4): DOI n° 10.2112/06-0804.

Bouchereau, J.-L., J.-C. Joyeux, and J-P. Quignard. 1989. Structure de la population de *Pomatoschistus microps* (Krøyer, 1838) Poissons, Gobiidés, lagune de Mauguio (France). *Vie et Milieu* **39**(1):19-28.

Caberty, S., P. de T. Chaves, and J.L. Bouchereau. 2004. Organisation et fonctionnement trophiques de l'ichtyofaune d'une lagune à mangrove: la Manche-à-Eau (Guadeloupe). *Cahiers de Biologie Marine* **45**:243-254.

Capapé, C., R. Hamparian, A. Marquès, and J.-L. Bouchereau. 2002. First morphometric data of a gravid female of the southern stingray, *Dasyatis americana* Hildebrand and Schrœder. 1928, (Chondrichthyes: Dasyatidae) in Guadeloupe waters (French West Indies). *Acta Adriatica* **43**(2):97-104.

Chantrel, J. et J.-L. Bouchereau. 2003. Régime alimentaire des Gerreidae *Diapterus rhombeus*, *Eucinostomus argenteus*, *Eucinostomus gula* et du Sciaenidae *Bairdiella ronchus* dans une lagune à mangrove: la Manche-à-Eau, Guadeloupe. Communication orale; Actes des Deuxièmes Rencontres de l'Ichtyologie en France, PARIS, 25-28 mars 2003: 15.

Chaves, P.T.C. and J.-L. Bouchereau. 1999. Biodiversité et dynamique des peuplements ichtyiques de la mangrove de Guaratuba, Brésil. *Oceanologica Acta, França* **22**(3):353-364.

Chaves, P.T. and J.-L. Bouchereau. 2000. Use of mangrove habitat for reproductive activity by the fish assemblage in the Guaratuba Bay, Brazil. *Oceanologica Acta* **23**(3):273-280.

Fréjaville, Y. and J.-L. Bouchereau. 2003. La faune ichtyologique dans l'organisation biologique d'une lagune de mangrove: la Manche-à-Eau (Guadeloupe). Communication orale; Actes des Deuxièmes Rencontres de l'Ichtyologie en France, Paris, 25-28 mars 2003:37.

Lopes, R. 2003. Étude temporelle de la faune ichtyologique d'un lagon de mangrove : la Manche-à-Eau. Mémoire de Maîtrise. Convention Socrates-Erasmus. Université des Antilles et de la Guyane. Universidad de Aveiro. 35 pp.

Louis, M. 1983. *Biologie, Écologie et Dynamique des Populations de Poissons dans les Mangroves de Guadeloupe (Antilles Françaises)*. Thèse doctorat, Université des Antilles et de la Guyane, 275 p.

Mantran, M., R. Hamparian, and J.-L. Bouchereau. 2008. Évolution de la morphologie de la lagune de la Manche-à-Eau (Guadeloupe, Antilles françaises) de 1950 à 2004; bathymétrie et courantologie, soumise à *Géomorphologie*, le 01/06/08.

Mantran, M., R. Hamparian, P.T. Chaves, and J.-L. Bouchereau. [In press]. Relations entre géomorphologie, hydrodynamisme et assemblage des poissons dans une lagune à mangrove: la Manche-à-Eau (Guadeloupe, Antilles françaises), soumise au 61th annual meeting of the GCFI 2008.

Moura, C. 2003. Variation spatiale de l'ichtyofaune d'une lagune à mangrove antillaise: la Manche-à-Eau, Guadeloupe. Mémoire de maîtrise. Université des Antilles et de la Guyane. Université de Aveiro (convention Socrates-Erasmus). 66 pp.

Nelson, L. 2003. Eléments de biologie et de dynamique du poisson sédentaire *Lophogobius cyprinoides* Pallas, 1770, (Gobiidé): systématique, régime alimentaire, structure populationnelle, dans une lagune à mangrove antillaise, la Manche-à-Eau, Guadeloupe. Mémoire de DEA. Université des Antilles et de la Guyane. 42 pp.

Quignard, J.-P. 1984. The biological and environmental characteristics of lagoons as the biological basis of fisheries management In Management of coastal lagoon fisheries. Kapetsky and Lasserre (Eds.) *Studies and Reviews* FAO, 61, Volume1.

Quignard, J.-P. and H Farrugio. 1981. Les pêcheries fixes lagunaires: caractéristiques et possibilities. *Pêches Maritimes* **1238:**289-293.

Thayer, G.W., D.R. Colby, and W.F. Hettler, Jr. 1987. Utilization of the red mangrove prop root habitat by fish in south Florida. *Marine Ecology Progress Series* **35**:25-38.

Veilleur M., P.T. Chaves, and J.L. Bouchereau. [In press]. Utilisation de la taille maximale des poissons de mangrove en vue de la sélection d'espèces natives pour leur pisciculture aux Antilles, *Proceedings of the Gulf and Caribbean Fisheries Institute*.

Yáñez-Arancibia, A., A.L. Lara-Dominguez, and J.W. Day, Jr. 1993. Interactions between mangrove and seagrass habitats mediated by estuarine nekton assemblages: coupling of primary and secondary production. *Hydrobiologia* **264**:1-12.