



Peixes na Lagoa do Guanandy. Itapemirim, Espírito Santo - Brazil

## **FISHERIES RESOURCES OF RAMSAR SITES OF THE STATE OF MARANHÃO (BRAZIL)**

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### **PRESENTATION**

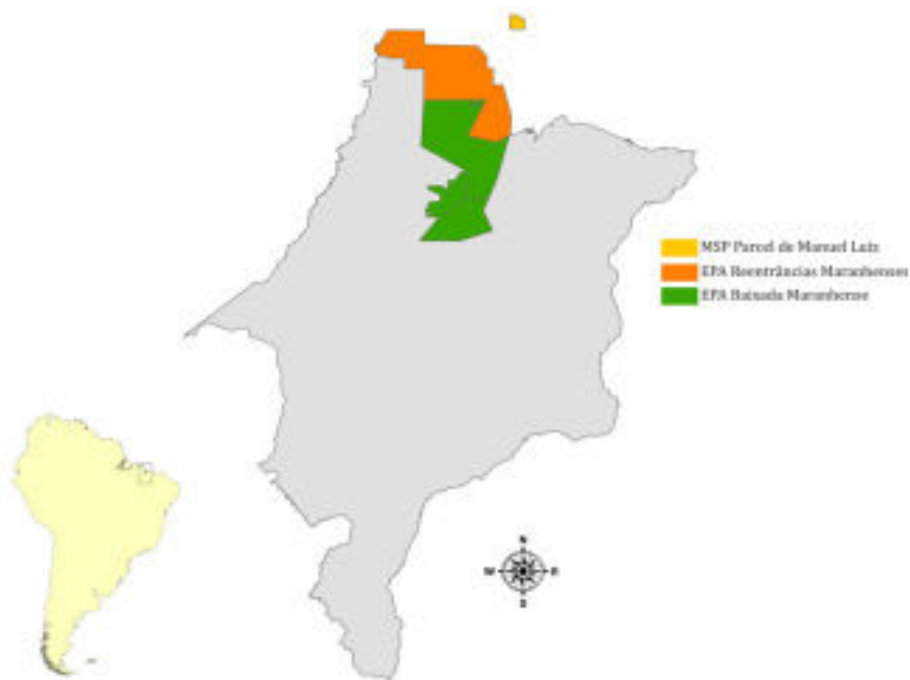
Aquatic environments, both the marine and freshwater, have a great biological diversity and species richness. Therefore they have a wide ecological complexity and are considered important gene banks. From the socio-economical perspective the wealth of these environments is translated as a place of immense biological productivity, setting up a storehouse of resources to feed the human population.

### **WHAT IS A RAMSAR SITE**

The RAMSAR Sites meet the criteria of settled wetlands, following the standard created during the International Convention on Wetlands (Wetlands Convention), held in 1971 in the city of Ramsar (Iran). The aim the RAMSAR Sites implies the conservation and the sustainable use. The creation of the sites was initially suggested by a member nation of the convention. A convention committee judged their dimension, especially their value as heritage sites. The main criteria to establish a wetland as a Ramsar Site are based on their ecological, zoological, botanical and limnological or hydrological conditions. Wetlands are characterized as the gene bank,

important to humanity. According to the Convention, wetlands are considered areas of marsh, swamp, peat, natural or artificial water body, perennial or temporal, inland waters, transitional and marine environments.

Figure 1 - Map of Maranhão State with the three conservation units that constitute the RAMSAR areas.



The four countries with the largest amounts of Ramsar Sites are: United Kingdom (166), Mexico (112), Spain (63) and Australia (65), respectively with the following areas of 917,988 ha, 8,818,827 ha, 281,768 ha and 7510. 177 hectares. Brazil has eleven Ramsar sites corresponding to 6,434,086 hectares. Among the Brazilian sites this study highlights those located in the state of Maranhão: the Marine State Park Parcel de Manuel Luiz, the Environmental Protection Area Reentrâncias Maranhenses and Baixada Maranhense Environmental Protection Area (Maranhense Marshlands) (Figure 1). The other Brazilian sites are, indicating the Brazilian state

they are located and their area: Bananal or Araguaia National Park (TO, 562.312ha), Lagoa do Peixe National Park (RS, 34.400ha) Mamirauá Biological Station (AM, 1,124.000 ha), Pantanal Matogrossense National Park (MT, 135.000ha), SESC Pantanal Private Reserve Heritage Natural (MT, 87.871ha), Abrolhos National Marine Park (BA, 91,300) and Rio Doce State Park (MG, 35,973) and Fazenda Rio Negro Private Reserve Heritage Natural (MS, 7,000).

### **THE MARINE STATE PARK PARCEL DE MANUEL LUIZ**

According to the International Convention on Wetlands the Marine State Park of Parcel de Manuel Luiz (PML) is inserted between the Ramsar Sites of Brazil. In addition to PML itself the Shoals Mestre Álvaro and the Tarol Banks, totaling 34.554ha (Ramsar, 2008), are included too, consisting the only reef complex located on the northern coast of Brazil.

The Marine State Park Parcel de Manuel Luiz, created by Decree 11902/1991 in June 1991, was the first park of its kind in Brazil. It is the largest area of coral reefs of South America (Coura, 1995; Amaral et al., 2007). Under the morphological aspect it has numerous irregular formations like pillars (buds), visible at low tide (Rocha & Rosa, 2001, Amaral et al., 2007). Being located along the main shipping route in the north of Brazil, the buds are considered as a major obstacle hindering the navigation as it can be noticed by the large number of shipwrecks in the region (Globo Ciência, 1995).

Geographically, the PML is located about 500km from the mouth of the Rio Amazonas, and considered as the main physical barrier between the marine biogeographic provinces of the Caribbean and Brazil (Moura et al. 1999; Floeter & Gasparini, 2000, Rocha & Rosa, 2001; Rocha et al., 2005, Floeter et al., 2008). Its area corresponds to 40km<sup>2</sup> in the middle of the continental shelf, distant about

86km from the coastline of the municipality of Cururupu and 51km from the continental slope (Palma, 1979, Rocha & Rosa, 2001). Adding the Shoals Mestre Álvaro and the Tarol Banks, the area corresponds to 360km<sup>2</sup>, the Shoals are as extensive as the PML, besides having great resemblance to its northeastern part; the Tarol Banks are of a flat surface covered with coralline algae in the absence of buds, with depth ranging from 14m to 33m and three miles in diameter (Coura, 1995).

Despite its invaluable importance the PML still is little-known, there are only few studies because of the severe sea conditions and the difficult access (Nunes *et al.*, In prep.). The water has a high transparency throughout the year, the North Brazil Current, South Equatorial Current and Equatorial Undercurrent greatly influence the local hydrodynamics, especially in the second half of the year when the winds are also present (Travassos *et al.*, 1999).

Studies on the biogeographical patterns of reef fish have been realized in Brazil since the 90's, thus recognizing the zoogeographic provinces in the western Atlantic Ocean: the province of the Continental Margin, the Brazilian province and the Oceanic Islands province. The province of the Continental Margin is formed by the Caribbean province, which stretches from North Carolina and Bermuda to the influence of the freshwater plume of the Rio Amazonas; in direction from the plume the province of Brazil is located, whose length corresponds from the maranhense PML to the state of Santa Catarina. The Oceanic Islands province is constituted by the oceanic islands of the South Atlantic, composed by both Brazilian islands (Atol das Rocas, Fernando de Noronha, Trinidad and Saint Peter and Saint Paul) and the islands of the Central Atlantic (Floeter & Gasparini, 2001; Joyeux *et al.*, 2001).

The Rio Amazonas with the Rio Pará contribute to the great energy of the equatorial Atlantic system with a large volume of continental waters. The first works with

a discharge of  $180.000\text{m}^3\text{s}^{-1}$ , which is about 20% of the fresh water contributed to the oceans (Muller-Karger et al., 1988). The plume of the Rio Amazonas is known as a body of fresh water from the two rivers above with a range that can exceed 1000 km from its mouth (Lentz & Limeburner, 1995). The different rainfall patterns in the region cause a seasonal variation in the size of the plume between the maximum discharge and minimum discharge (Silva et al., 2005a, b, 2009) and their three-dimensional configuration. According to Silva et al. (2005a, b) there is seasonal variation in wind shear over the surface layer (Coastal Water and Tropical Water) too, which is accompanied by the pattern of winds influenced by the Intertropical Convergence Zone (ITCZ), while subsurface water masses are influenced by the North Brazil Current (NBC) in addition to the anticyclonic vortex of retroflexion on the CNB, also on a seasonal basis.

Many definitions represent the oceans as a continuous body of salt water, but they owe natural barriers to the dispersal of organisms too. These barriers usually are a result of the shaping actions of the planet since the beginning of earth's history. The large freshwater plume of the Rio Amazonas is an example of a natural barrier that has much influence on evolutionary processes in marine organisms between the Caribbean and the Brazilian province (Floeter et al., 2001, 2001, Muss et al. 2001 Rocha et al., 2005).

Brazilian corals have a high degree of endemism of approximately 35%, suggesting a relatively ancient isolation of the Brazilian reefs (Laborel, 1970; Vilaça, 2002). On reef fishes the rate of endemism is associated with a reproductive strategy with benthic posture, short generation and fast ripening, beyond the low dispersal ability, as most of these species are small. Another important aspect is the decrease in the proportion of species with a demersal posture strategy of the Caribbean (45%) to those of Brazil (30%), and the Brazilian oceanic

islands present these same proportions even smaller (Floeter & Gasparini, 2000, 2001). Occasionally a connectivity between the Caribbean and Brazilian province is possible for a few species, that can surpass the barrier of freshwater from the Rio Amazonas (Rocha *et al.*, 2000, Joyeux *et al.*, 2001).

Finally, the distribution patterns for reef fish in the South Atlantic indicate that there were events of allopatric speciation, interaction of great dispersal ability and ecological processes. The success of colonization in remote locations seems to be less dependent on the dispersal ability than to their competence or preference for habitats (Joyeux *et al.*, 2001). The rate of diversity of fish species may have other ways for their formation: although the gene flow between the Caribbean and Brazilian province is small it is constant, these ways contrast between different environments setting another alternative to the success of specialization in these provinces (Richards, 2003). It should be remembered that events of regression and transgression of sea level deserve special attention in understanding speciation events, as well as all the geography potentially involved in the mechanism of speciation is reformed from time to time in geologic periods (Joyeux *et al.* 2001 Rocha, 2003).

The cnidofauna of the PML presents a great diversity of corals and hydroids in magnitudes similar to those of the National Marine Park of Abrolhos in the state of Bahia (Amaral *et al.*, 2007), which is considered one of the most studied of the Brazilian coast and one that holds the highest species richness of corals in the South American part of the Atlantic (Hetzl & Castro, 1994). Their diversity is due to conditions of water temperature, transparency and shallow (Lion, 1996, Leão & Kikuchi, 2001). According to Amaral *et al.* (2007) in a study on the PML, its distance from the shoreline may help to understand its wealth of species of corals and calcified hydroids. The constant presence of strong ocean currents

between the coast and the PML limits the arrival of sediment loads from the mouth of the Rio Amazonas that otherwise could overwhelm or inhibit the growth of benthic cnidarians. Even though these conditions are favorable to diversity and development of the cnidofauna these authors highlighted the presence of many corals suffering bleaching.

An analysis of the biodiversity of the macrobenthos of the PML verified the following: The Parcel de Manuel Luiz (PML) always showed higher values of species richness and number of individuals than the Tarol Bank and the Shoals Mestre Álvaro, the Tarol Bank presented a greater diversity than the Shoals Mestre Álvaro (Silveira & Oliveira, 1998). The same authors report that the Porifera, Cnidaria, Mollusca, Oligochaeta, Polychaeta, Crustacea and Echinodermata are the most common organisms of the macrobenthos. These organisms are important representatives of the dynamics of this ecosystem. They act as agents of erosion allowing the association of other species and builders of sediment or substrates formations as new micro-habitats for benthic organisms.

The ichthyofauna of the PML is composed of 132 species (Actinopterygii and Condrichthyes) belonging to 52 families. Among these, seven are endemic species with a distribution restricted to the southern portion of the western Atlantic Ocean, highlighting: *Grama brasiliensis*, *Apogon americanus*, *Clepticus brasiliensis*, *Thalassoma noronhanum*, *Starksia brasiliensis brasiliensis* and *Lythrypnosus Priolepis dawsoni*, corresponding to 14.4% of the endemic species of the Brazilian province.

The most exploited fish stocks of the PML are commonly known as snappers and lobster. Each of these resources presents a specialized system of fishery with needs of specialized equipment to explore the resources target. The so called "sistema pargueiro" (snapper system) received its name from the capturing of pargos



(snappers), dentões ("big teeth"), vermelhos (red snappers) and cioba, thus being common names of the species *Lutjanus purpureus*, *L. analis*, *L. jocu* and *L. synagris* (Figure 2). This system has as implements of fishing a type of longline collected by a reels called "bicicleta" (bicycle). The other fishing system that operates in the same area is called "sistema lagosteiro" (lobster system). This system is characterized by the highest technological increase of all fishing systems in the state of Maranhão. The aim of survey for this system is the capture of lobster and the main species are the lobsters *Panulirus argus* and *P. laevicauda* (Almeida *et al.*, 2007, Almeida, 2009).

Figure 2 - Some Marine fishes of the Marine State Park Parcel de Manuel Luiz. Cortesy of Alfredo Carvalho Filho.



According to Almeida (2009), the PML is evident among the ecosystems most vulnerable of the state of Maranhão. This author also reports that the main problem

concerning the exploitation of fishery resources of that area is the disability or absence of data on stocks in the state. There are few national measures that regulate the surveys through mitigation measures such as licensing for the exploitation, prohibition of certain types of traps, standardization of equipment and suspension of activity during the period of breeding. In the Maranhão the main problem remains the control, although some efforts are taken to monitor and oversee the resources during the breeding of organisms such as lobster.

### **REENTRÂNCIAS MARANHENSES (REENTERINGS MARANHENSES)**

The Reentrâncias Maranhenses constitute the entire western coast of the Maranhão, which extends from the border with the state of Para to the municipality of Alcântara. They are characterized by the presence of a wide range of course cut mangroves, forming shallows and estuaries, which are connected by lateral canals (Palma, 1979; Stride, 1992). The Reentrâncias Maranhenses present along their continental margin the following geomorphological aspects: a very wavy bottom formed by numerous elongated sandbanks composed by fine quartz sand. The muddy portion of the bottom consists primarily of clay fractions corresponding to 18% of its area. This is restricted to the margins and some specific regions (SUDEP, 1976).

The climatical conditions of this region present a humid tropical Amazonian climate with a high average rainfall between 1600-2000 mm, an average temperature of 24° C, a relative humidity of the air of 80% and two well defined seasons: a rainy and a dry season (Stride, 1992). The variation of salinity in this region ranges between 13.9 psu (rainy season) and 33.6 psu (dry season), under exceptional circumstances it can reach the minimum of 6.5 psu in May. This occurs because the coast of the Maranhão receives a large drainage of inland waterways to the ocean, coming from the various basins

in addition to rainfall patterns. The region is characterized by the presence of high tides with an amplitude close to 7 m (DNH, 1972).

The geomorphological configuration, the hydrodynamic aspects and climate favor a spectacular biodiversity. This biodiversity in the first impression is striking. The vegetation of the extensive mangroves form a major forest composed of large trees (Figure 3), of which everyone presents itself as keeper of all the local and adjacent ecosystems. The mangroves complete the potential diversity of habitats found in the Reentrâncias, together with tidal pools and channels of large and small arms that harbor a lot of organisms in front of a multitude of use. This can be seen through the facility of offering numerous food items of marine origin. These are found in great abundance and ridiculous prices in most municipalities of the western coast of the Maranhão (Nunes, JLS obs. pers.).

Figure 3 - Mangrove forest in reentrâncias maranhense, next to Ilha dos Lençóis, Cururupu-MA municipal district. Photography by Nivaldo Piorski.



Its inclusion as a Ramsar Site dated on 30 November 1993, representing the eldest site of Maranhão, and its

total land area corresponding to 2.680.911ha (Ramsar, 2008).

The fishery production of the Reentrâncias Maranhenses is quite high, contributing 55% of the marine fishery production in the state of Maranhão. The area is characterized by the highest number of fishing communities and artisanal fishing (Adams, 2009). Among the communities with high quantity of haul in the state stand out: Cedral, Curupu, São Luís, Raposa and Barreirinhas, of which the first two belong to the western coast (Adams, 2009). The fleets of São Luís and Raposa are based on the island of Maranhão (ancient island of São Luis). This strategic location can access both the western and the eastern coastline. Other points scored by Almeida (2009) are the infrastructure (ports for loading and unloading) and the access (roads), which facilitate the marketing and securing supplies inputs (ice and fuel/oil); the above municipalities can unite both and this way stand out from other local fishing communities.

The Maranhense fishing fleet is in its majority artisanal (Figure 4). This is considered as one of the main problems setting the fishery resources at risk. These risks are caused by impacts on ecosystems and destructive fishing gear used by the artisanal fishing fleet. One of the most obvious examples in the Reentrâncias is the use of a large number of sticks or pieces of wood taken from the mangroves. These are stuck in the water and used to support various types of fixed traps (see below: "currais", "zangaria", "muruada") to catch fish and shrimps (Almeida et al., 2006, Nunes, JLS obs. pers.).

The "currais" are fixed traps with sticks and wires (or lianas) strategically placed to trap shoals, which are caught at running tide (Piorski et al., 2009). This kind of fishery represents about 10% of the artisanal fisheries of the state.

Figure 4 - Sandy shore with artisanal boats in the Cedral-MA municipal district., EPA Reentrâncias Maranhense. Photography by Nivaldo Piorski.



The “zangaria”, another traditional trap, is a queued setting of many rods that support a network with very small internodes and its slot is attached to the lower rods. The extension of this trap reaches up to 1,700 meters. The reason for the use of the “zangaria” is to catch shrimp, but it catches many species of juvenile fish too that are discarded.

The third trap that uses sticks and a kind of large network, called “puçá” (remembering a bag of coffee strain) is the “muruada”. As its name suggests (portuguese: murada = walled), there is a large queuing over of sticks and between them are set the “puçá” nets, it is also a trap to catch shrimp and other marine species as a bycatch (Almeida *et al.*, 2006, 2007, Almeida, 2009).

There is great difficulty in monitoring the status of fish stocks in Brazil, especially in the north coast, due to lack of information from large temporal sequences that

can serve as data for a more complex modeling of fishery. The Maranhão fits into all these characteristics and is mitigating the need of a more sophisticated scientific development to realize forecasting and an efficient subsequent monitoring (Isaac et al., 1998).

Another aspect to be considered is the lack of ecological sense of the communities. They err believing in the great abundance of their resources without worrying about disposal. It is common to see large quantities of fish floating in the sea beyond those that are found in long strips of beaches. This occurs because of the preference of few species of fish of the family Ariidae (catfish) and Sciaenida ("pescadas") and the discarding of bycatch of the shrimp catch (Nunes, JLS pers.obs.).

The tools that may have some effects to a better management of the resources are: environmental education campaigns to raise the awareness about the allocation of fish stocks, development of new affordable technologies and technical advice. These tools can have even more effects when the actors themselves are involved and if there is political commitment of the state and municipalities to enhance the management of the resources. The mechanisms to integrate engineering systems and management are available, but is missing to make it happen.

### **BAIXADA MARANHENSE ENVIRONMENTAL PROTECTION AREA (Maranhense marshlands)**

The Baixada Maranhense, one of the major biomes of the state, represents a complex floodplain that is home to rivers, lakes, lagoons, estuaries and agroecosystems (Figure 5). By Law Decree No. 11,900 of July 11, 1991 the Baixada Maranhense rose to the rank of an Environmental Protection Area (Almeida, 2005). Its area corresponds to 1.775.035 ha, involving a total of 23 municipalities; its association as a RAMSAR sites occurred on February 29, 2000 (Ramsar, 2008).

Figure 5 - Floodplains of the Quilombo do Frechal, Baixada Maranhense Environmental Protection Area, Mirinzal-MA municipal district. Photography by Nivaldo Piorski.



The inundation dynamics in this area is seasonally defined by markedly rainfall regimes. In the rainy season, from December to June, the rivers and lakes overflow permanently, flooding across the plains and transforming the landscape into a vast field full of shallow lakes. When the rains cease, from July to November, the flooded fields dry providing the growth of vegetation predominated by grasses (Costa-Neto, 1996). According to the same author, the incidence of fish in this region is probably due to the fertilization of the fields thanks to the droppings of cattle in their grazing in the dry season.

All the peculiarities of the region have suffered enormous pressure of human-made character. Among them are notorious: Deforestation, soil erosion, fishing and hunting and extensive livestock predation of buffalo in the fields of the region. The buffalo culture was introduced in Brazil in the late nineteenth century due to its multiple skills and various uses. In the Maranhão its arrival dates

from 1940 and nowadays contains up to 90% of the Maranhense flock. Up to now it has been a leading environmental modifier, destroying the vegetation and working directly as an agent of erosion, reflected by the destruction of many microhabitats, including even the aquatic environment (Almeida, 2005; Bernardi, 2005).

Another relevant aspect is the consistent conflict of the buffalo culture with the artisanal fishing and the subsistence agriculture. The not defined public and private areas create this conflict and makes it impossible to comply the environmental legislation. This type of conflict threatens the future of communities and the sustainability of these ecosystems. Therefore, it is important to mediate the conflict actors articulating environmental commitments (Bernardi, 2005).

One way to measure environmental changes was carried out by Almeida (2005). This author used the ethnobiology with the aim to identify impact indicators and tensors on aquatic ecosystems and fish assemblages by interviews with local fishermen. Her tensors scored the human action at different levels, highlighting: the buffalo culture, fires and deforestation due to subsistence farming on the banks of rivers and the building of dams and canals.

The fish have resulted as key indicators of natural and anthropogenic changes on water resources. The species "mandi judiá" (*Hassar* sp.), "jeju" (*Hoplerythrinus unitaeniatus*), "traíra" (*Hoplias malabaricus*), "bodó preto" (*Hypostomus plecostomus*), "tapioca" (*Psectrogaster falcata*) and "tapiaca chorona" (*Curimata cyprinoides*) were considered more resistant to changes (Figure 6). The most sensitive species reacting on changes with a high rate of mortality during the floods were "sarapó guruvira" (*Sternopygus macrurus*), "carão" (*Platydoras* sp.) and "viola cabeça chata" (*Loricaria cataphracta*) and "viola cabeça comprida" (*Loricariichthys* sp.).



Figure 6 - Some freshwater fishes of the Baixada Maranhense EPA. Photography by Nivaldo Piorski.



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