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Larval fish composition of a tropical estuary in northern Brazil (2º18'-2º47'S/044º20'- 044º25'W) during the dry season

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Abstract. Ichthyoplankton was collected in São Marcos Bay, in six sampling stations during the dry season (July 2000). Oblique hauls were done using a bongo net with 330 and 500 µm mesh sizes. Samples were taken during the day and ebb tide, except for one sample collected during flood tide. A total of 15 families and 17 species were identified. Members of the families Engraulidae and Sciaenidae were most abundant, and occurred in all stations. The largest number of taxa (14) were recorded in the inner region of the estuary, whereas the fewest taxa (4) occurred in the port area and near the fishery terminal. The families Auchenipteridae (*Pseudauchenipterus nodosus*), Clupeidae (*Rhinosardinia amazonica*), Engraulidae (*Anchoa spinifer*, *Anchoviella lepidentostole*), Sciaenidae (*Macrodon ancylodon*, *Stellifer rastrifer*) and Paralichthyidae (*Citharichthys* sp.) were dominant. Of these, *Anchoviella lepidentostole* was the most abundant, representing more than 84 % of the total catch.

Key words: Ichthyoplankton, estuary, São Marcos Bay, Brazil.

Resumo. Composição das larvas de peixes de um estuário tropical no nordeste do Brasil (2º18'-2º47'S - 044º20'44º25'W) durante a estação seca. O ictioplâncton foi coletado na baía de São Marcos, em seis estações, durante a estação seca (julho de 2000). Foram realizados arrastos oblíquos, utilizando-se rede bongô com aberturas de malha de 330 e 500 µm. As amostras foram coletadas durante o dia e na maré de vazante, com exceção de uma amostra coletada durante a maré de enchente. Foram identificadas um total de 15 famílias e 17 espécies. As famílias Engraulidae e Sciaenidae foram as mais abundantes e ocorreram em todas as estações. O maior número de táxons (14) foi encontrado nas estações mais internas do estuário, enquanto que o menor número (4) ocorreu nas áreas próximas ao porto e ao terminal pesqueiro. As famílias Auchenipteridae (*Pseudauchenipterus nodosus*), Clupeidae (*Rhinosardinia amazonica*), Engraulidae (*Anchoa spinifer*, *Anchoviella lepidentostole*), Sciaenidae (*Macrodon ancylodon*, *Stellifer rastrifer*) e Paralichthyidae (*Citharichthys* sp.) foram dominantes nesse estudo. Entre elas, a espécie *Anchoviella lepidentostole* foi a mais abundante representando mais de 84% do total de larvas coletadas.

Palavras-chave: Ictioplâncton, estuário, baía de São Marcos, Brasil.

Introduction

Estuaries are coastal ecotones that play a fundamental role in enriching the adjacent areas. These ecosystems have singular characteristics according to their geomorphology, water circulation, salinity and temperature variations. They comprise 15% of the coastal regions in the world (Yáñez-Arancibia 1987). Many estuaries are used for navigation and as repositories for industrial effluents and domestic waste (Raz-Guzman & Huidobro 2002, Ramos *et al*. 2006).

Estuarine regions are important areas for the reproduction and growth of many fish and crustacean species (Haedrich 1983, Neira & Potter 1992, Schwamborn & Bonecker 1996, Blaber *et al*. 2000, McLusky & Elliott 2004). Many fish species utilize estuaries as nurseries (Able & Fahay 1998, Barletta-Bergan *et al*. 2002, Joyeux *et al*. 2004) for

feeding and growth during their planktonic phase.

The Brazilian coast has many estuarine regions of different origins and geomorphology (Sinque 1980, Sinque *et al.* 1982, Muelbert & Weiss 1991, Castro & Bonecker 1996, Joyeux *et al*. 2004, Castro *et al*. 2005, Mafalda Jr. & Silva 1996). São Marcos Bay is a tropical estuary located in northern Brazil, and is singular because of the wide range of tidal amplitude (Stride 1992). Similar characteristics to those of São Marcos Bay are found in the Rance estuary in northwest France, where tidal amplitude of 13 m was recorded; and also at Pico Island in the Azores.

Although São Marcos Bay has unusual characteristics, there is little information on its larval fish community. This study aimed to evaluate the larval fish community of the estuarine region of São Marcos Bay.

Study Area

São Marcos Bay is located on the central coast of the state of Maranhão, where the Maranhão Gulf is located (Figure 1). São Luís do Maranhão Island (02°38'12''- 02°43'14''S and 044°23'35''-044°17'50''W) divides this gulf into two large bays: São Marcos Bay on the west side of the gulf, and São José Bay on the east (Stride 1992).

The climate is tropical, with a rainy season (November through June) and a dry season (July through October). Mangroves and marshes are dominant in this region (Juras *et al*. 1983, Camargo & Isaac 2003). The range of tidal amplitude can reach 7 m. In the bay mouth, the flood tide flows to the northwest and the ebb tide flows to the north, with a current speed of 3.9 knots (Stride 1992).

The mixing process of saline and continental waters, high primary and secondary production, high nutrient concentration and suspended matter characterize the waters of this region as typically estuarine (Juras *et al*. 1983). This is the largest and most important estuarine complex in the state of Maranhão.

The main source of fresh water to São Marcos Bay is a river that flows about 3.5 km from the bay (Stride 1992). A port and a fishery terminal are located in the bay (Figure 1).

Materials and Methods

Sampling was done during the dry season (July 2000) at six stations distributed over the estuary (Figure 1). The geographical locations of the sampling stations were provided by a GPS. Samples were collected during one day in the ebb tide, except for station 5 which was visited during flood tide because of logistic constraints (Table I). Stations 1 to 5 were considered estuarine and station 6 was named outer because it is more influenced by the adjacent coastal waters. Oblique hauls were done using a bongo net with 330 and 500 µm mesh sizes.

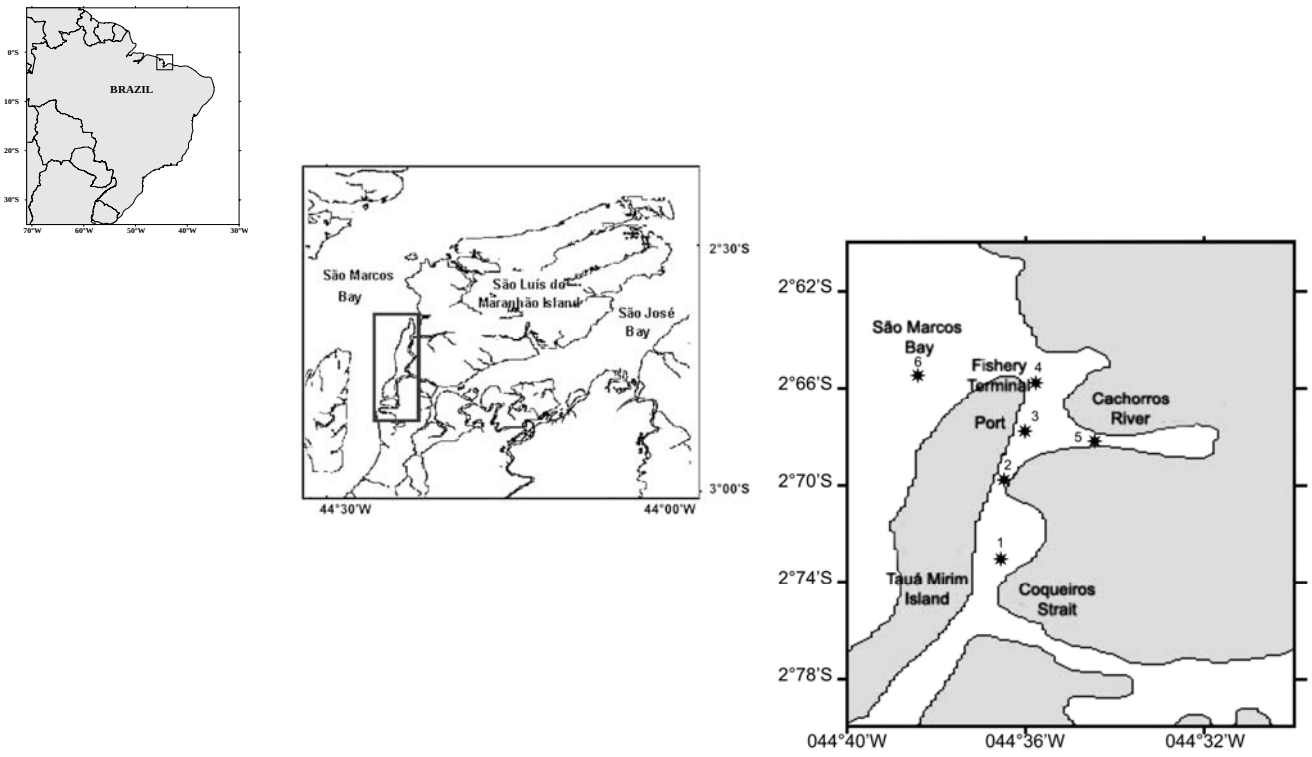

Figure 1. Estuarine region of São Marcos Bay and location of sampling stations.

The net was towed at approximately 2 knots for 10 minutes at each station. Samples were immediately fixed in 4% buffered formalin/seawater solution.

Water temperature and salinity were measured at each station, at three depths (surface, intermediate and bottom) using a thermosalinometer (Lab Comp). Water samples to determine the dissolved oxygen content were collected at the surface with a Van Dorn bottle; dissolved oxygen was measured according to Cnexo (1983).

Fish larvae were sorted from samples using a binocular microscope (Zeiss model SV6), and were identified to species level when possible, based on descriptions in the literature (Sinque 1980, Fahay 1983, Whitehead 1985, Whitehead *et al*. 1988).

All larvae identified were deposited in the larval fish collection of the Zooplankton and Ichthyoplankton Integrated Laboratory of the Federal University of Rio de Janeiro, Brazil (DZUFRJ).

Results

Environmental conditions

Salinity and temperature were homogeneous throughout the water column, and showed some variation between stations (Table II). Maximum and minimum values for temperature were observed respectively for stations 3 and 4. Salinity maximum and minimum values were observed for stations 4 and 1 respectively.

Most of the dissolved oxygen (DO) values recorded in the study area were low, except for station 6 which was located inside São Marcos Bay and showed the highest DO content (Table II).

Larval fish composition and distribution

A total of 1,098 larval fish were collected at the six stations, comprising 16 families and 17 species (Table III).

The highest number of taxa was recorded at station 1, located in the inner estuary (Table III). Larvae of *Anchoviella lepidentostole* and *Stellifer* sp. were the most frequent, occurring at all sampling stations (Table III). Although most taxa occurred at more than one sampling station, some were restricted to one part of the estuary: *Odontognathus mucronatus*, *Aspredinichthys* sp., Batrachoididae, *Scorpaena* sp., Serranidae, *Stellifer rastrifer*, *Psenes cyanophrys*, Eleotridae, *Trichiurus lepturus*, *Achirus lineatus*, *Trinectes paulistanus* and *Sphoeroides* sp. (Table III).

All taxa identified belong to demersal groups, except for *T. lepturus* and members of the families Pristigasteridae, Engraulidae and Clupeidae, which are pelagic. Most of the species that were collected only at the stations located inside the estuary are known to inhabit freshwater, estuarine and marine ecosystems. However, *Scorpaena* sp., Serranidae and *P. cyanophrys*, which were collected only inside the estuary, and *Citharichthys* sp., which occurred in both areas, are marine. Only *Achoa spinifer*, *Anchoviella lepidentostole*, *Macrodon ancylodon*, *Gobioides* sp., *Citharichthys* sp. and *Sphoeroides* sp. were recorded both inside and outside the estuary.

The family Engraulidae was the most abundant, representing more than 90% of the total larvae collected at station 4 (Figure 2). *Anchoviella lepidentostole* was the most abundant species, representing more than 84% of the total catch; it was most numerous (57%) at station 4, near the fishery terminal.

Members of the family Sciaenidae were also abundant, contributing more than 20% of the larvae collected at stations 1, 2 and 3 (Figure 2). Among the sciaenids, *Stellifer* sp. and *Macrodon ancylodon* were most abundant at stations 2 (5%) and 6 (3%), respectively.

Larvae of the families Auchenipteridae (*Pseudauchenipterus nodosus*), Paralichthyidae (*Citharichthys* sp.) and Clupeidae (*R. amazonica*) represented approximately 1% (Table III). The other taxa contributed less than 0.5% of the total larvae collected.

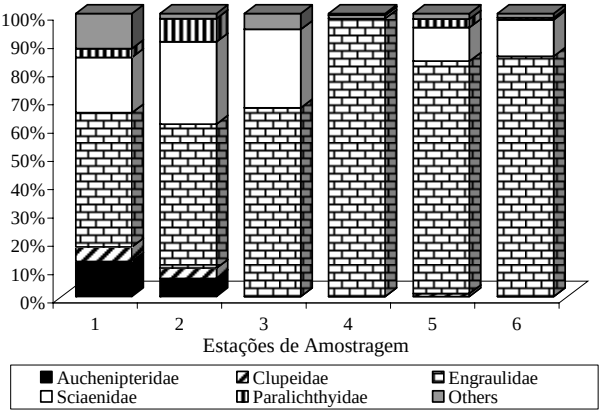

Figure 2. Percentage of the most abundant families collected with both meshes in each sampling station.

Discussion

Water temperature and salinity patterns obtained in this study are similar to those described for other tropical estuarine regions (Castro & Bonecker 1996, Barletta-Bergan *et al*, 2002, Joyeux *et al.* 2004, Barletta *et al*. 2005). The same pattern was also recorded in a previous study in São Marcos Bay (NUCLEBRAS 1984). According to Camargo & Isaac (2003), the water temperature in estuarine and coastal regions of the study area does not vary

Table I. Sampling stations, reference names, coordinates, hour of sampling, depth and tide of each station.

Station	Reference	Latitude	Longitude	Hour	Depth (m)	Tide
1	Coqueiros	2° 43'38.6"	044° 21'75.3"	12:30	7	ebb
2	Intermediate	2° 41'37.0"	044° 22'04.5"	13:30	6	ebb
3	Port	2° 40'39.7"	044° 21'53.1"	11:00	15	ebb
4	Fishery Terminal	2° 39'39.0"	044° 21'26.9"	10:10	13	ebb
5	Cachorros	2° 40'41.3"	044° 20'35.9"	09:05	7	flood
6	São Marcos Bay	2° 39'21.5"	044° 23'03.2"	15:10	20	ebb

Table II. Temperature (ºC), salinity and dissolved oxygen (DO) measured in six stations distributed in the estuarine region of São Marcos Bay in the dry season (July 2000).

Stations	Temperature (°C)			Salinity			DO
	surface	intermediate	Bottom	surface	intermediate	bottom	($mg.L^{-1}$)
1	28.5	28.5	28.4	16.4	16.5	16.6	3.86
2	28.8	28.5	28.5	17.0	17.2	17.2	4.37
3	28.9	28.5	28.4	21.9	21.9	22.0	3.6
4	22.7	28.5	28.2	22.7	23.8	24.1	3.89
5	25.0	28.3	28.4	22.5	22.4	21.6	4.11
6	28.5	28.5	28.3	20.3	20.9	21.1	5.14
Mean	27.07	28.47	28.37	20.13	20.45	20.43	4.16
Standard deviation	2.60	0.08	0.10	2.80	2.95	2.93	0.54

Table III. Taxa occurrence and percentage (%) along the six sampling stations located in the estuarine region of São Marcos Bay.

Taxa/Stations	1	2	3	4	5	6	%
Pristigasteridae (p)							
Odontognathus mucronatus Lacepéde, 1800	-	-	-	-	x	-	0.09
Engraulidae (p)							
Anchoa spinifer (Valenciennes, 1848)	x	x	-	-	-	x	0.46
Anchoviella lepidentostole (Fowler, 1911)	x	x	x	x	x	x	84.88
Clupeidae (p)							
Rhinosardinia amazonica (Steindachner, 1879)	x	x	-	-	-	-	0.91
Aspredinidae (d)							
Aspredinichthys sp.	x	-	-	-	-	-	0.18
Auchenipteridae (d)							
Pseudauchenipterus nodosus (Bloch, 1794)	x	x	-	-	-	-	1.73
Batrachoididae (d)	x	-	-	-	-	-	0.09
Scorpaenidae (d)							
Scorpaena sp.	x	-	-	-	-	-	1.18
Serranidae (d)	-	x	-	-	-	-	0.09
Sciaenidae (d)							
Macrodon ancylodon (Bloch & Schneider, 1801)	x	-	x	x	x	x	2.91
Stellifer sp.	x	x	x	x	x	x	3.37
Stellifer rastrifer (Jordan, 1889)	-	-	-	-	-	x	2.19
Nomeidae (d)							
Psenes cyanophrys Valenciennes, 1833	x	-	-	-	-	-	0.09
Eleotridae (d)	-	x	-	-	-	-	0.09
Gobiidae (d)							
Gobioides sp.	x	-	-	x	x	x	0.36
Trichiuridae (p)							
Trichiurus lepturus Linnaeus, 1758	-	-	-	x	-	-	0.09
Achiridae (d)							
Achirus lineatus (Linnaeus, 1758)	-	-	x	-	-	-	0.09
Trinectes paulistanus (Miranda-Ribeiro, 1915)	x	-	-	-	-	-	0.09
Paralichthyidae (d)							
Citharichthys sp.	x	x	-	x	x	x	1.55
Tetraodontidae (d)	-	-	-	x	x	x	0.27
Sphoeroides sp.	x	-	-	-	-	-	0.36

p = pelagic; d = demersal; x = presence; - = absence

greatly during the year, and hence does not affect the spatial distribution of the adult fish community. On the other hand, in tropical regions, salinity changes seem to be the most important factor to explain much of the spatial and temporal dynamics of biotic communities (Pauly 1994).

The low dissolved oxygen values (< 5.0 $mg.L^{-1}$) obtained in this study are characteristic of regions that receive large amounts of organic waste (Lavrado *et al.* 1991). The highest dissolved oxygen value, obtained at the outermost station, was probably influenced by cleaner seawater from the coastal region. No direct relationship was found between dissolved oxygen values and species richness.

Most families recorded in this study are common in equatorial and tropical estuarine regions, and have previously been recorded in estuaries of northern Brazil, except for *P. cyanophrys* (Camargo & Isaac 2003). All the families are marine, except for Aspredinidae (*Aspredinichthys* sp.) and Auchenipteridae (*Pseudauchenipterus nodosus*), which occur in fresh and brackish waters (Nelson 2006). According to Haedrich (1983), the occurrence of coastal species in estuaries is due to the similarity of these ecosystems to coastal waters.

The observed dominance of demersal families at the stations located inside the estuary may be related to the water transparency, which is normally low in the inner portion of estuaries; and also to the abundant food at the bottom (Camargo & Isaac 2003). According to these authors, estuaries harbor a wide diversity of demersal families such as the Sciaenidae and Aspredinidae. Pelagic species, such as engraulids and *T. lepturus*, are more abundant in coastal habitats where the water is more transparent than in estuaries (Camargo & Isaac 2003).

Members of the family Engraulidae were the most abundant group in this study. According to published information, many species of this family are very abundant, having an important role in fishery production around the world (Baxter 1967, Bendazoli *et al*. 1990, FAO 1995). The adults of the most abundant engraulid in this estuary (*A. lepidentostole*) have a coastal habitat and migrate into inner estuarine waters to spawn (Cervigón 1985). They prefer low-salinity waters and are common in tropical and temperate estuaries (Froese & Pauly 2006).

During this study, this family was also represented by *A. spinifer*, which was considered an estuarine resident by Castro (1997), using the region of São Luís as a nursery area. According to Camargo & Isaac (2003), this species is strongly euryhaline, being found from the continental shelf (≅ 40 m) to the uppermost reaches of rivers.

Sciaenids that were also important in this study are also commonly found in neotropical estuaries (Camargo & Isaac 2005). Fishes of this family tolerate wide ranges of salinity, which allows them to inhabit estuaries strongly influenced by freshwater (Camargo & Isaac 2003). Among the sciaenids collected, *M. ancylodon* and *Stellifer rastrifer* are very euryhaline (Camargo & Isaac 2003). The former species is also classified as semi-anadromous, that is, the adults spawn near the mouth of estuaries and the eggs and larvae are carried by the tides into estuarine creeks (Barletta-Bergan *et al*. 2002, Camargo & Isaac 2003, 2005).

The larval fish community observed in this study is composed by families with different patterns of ecological uses of the estuarine environment. *Gobioides* sp., *A. lineatus* and *T. paulistanus* are considered strictly estuarine (Camargo & Isaac 2003). The Cocosoda catfish (*Pseudauchenipterus nodosus*) lives in freshwater environments, but occasionally migrates into brackish waters; and the Spicule anchovy (*Anchoa spinifer*), as discussed earlier, is typically estuarine and spends its entire life in this environment (Camargo & Isaac 2003).

The diversity of adult fish previously recorded from this region (Martins-Juras 1989, Camargo & Isaac 2003) and the number of taxa identified in this study, during only one sampling period, emphasize the importance of this estuary for the Brazilian coast. The north coast of Brazil, including the study area, contributes 28% of the marine and estuarine annual average landings of the country (between 2000 and 2003), considering only the pelagic and demersal teleosteans (Haimovici *et al*. 2006).

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