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Mesozooplankton and Ichthyoplankton composition in two tropical estuaries of Bahia, Brazil

Catarina da Rocha Marcolin [1*], Bárbara Luciana da Conceição [1], Marcos Moura Nogueira [2], Paulo Mafalda Júnior [2] and Rodrigo Johnsson[1]

1 Universidade Federal da Bahia, Campus de Ondina, Instituto de Biologia, Departamento de Zoologia, LABIMAR (Crustacea, Cnidaria e Fauna Associada). CEP 40170-110 .Salvador, BA, Brazil.
2 Universidade Federal da Bahia, Campus de Ondina, Instituto de Biologia, Departamento de Zoologia, Laboratório de Plâncton. CEP 40170-110. Salvador, BA, Brazil.
* Corresponding author. E-mail: *crmarcolin@yahoo.com.br*

Abstract: The objective of this study was to describe the composition of two mesozooplankton and ichthyoplankton estuarine communities in Jandaíra, Bahia (Tabatinga River), impacted by a shrimp farm; and in Conde, Bahia (Itapicuru River), a pristine estuary. Samples were collected through horizontal hauls using a net (200 µm mesh size), coupled to a flowmeter, during the ebbing and flooding tides in April, August and December, 2007. In the Tabatinga and Itapicuru Rivers 76 and 92 taxa were registered. The most abundant groups were *Pseudodiaptomus richardii* and *Disco* sp. *Acartia lilljeborgi* was also dominant at Tabatinga, while *Temora* sp. and decapod larvae were predominant in Itapicuru River, which also presented higher densities for most planktonic taxa, particularly fish larvae. A descriptive analysis of the main taxa´s spatial distribution and new geographical records of *Disco* sp., *P. richardi*, *Pontellopsis villosa*, *Macrosetella gracilis*, *Microsetella rosea*, *Gonyiopsillus brasiliensis*, *Agetus flaccus* and *Ergasilus caraguatatubensis* were presented.

Introduction

The estuaries and mangroves are currently one of the world's most threatened ecosystems due to drastic encroachment of human activities despite their undeniable relevance (Barbier and Cox 2002; Singkran and Sudara 2005). According to Islam and Haque (2004), shrimp farming has been a great contributor to mangrove destruction, reducing biological resources such as habitats of crustaceans, mollusks and fish species of ecological and economic relevance.

Zooplankton plays a key role in the ecosystem structure due to its quick response to abiotic conditions, especially in impacted environments (Levinton 1995; Neumann-Leitão *et al.* 1999). It is, therefore, very important to describe the taxonomic diversity in tropical estuaries since there is no published information on the composition of zooplankton communities in the state of Bahia, only some unpublished academic works which focused mainly on ecological aspects.

This paper presents a description of the zooplankton and ichthyoplankton taxa density found in two similar tropical estuaries subjected to different sources of anthropogenic impact in the state of Bahia. It also highlights new records of some copepod species distribution.

Material and Methods

Study site

The Tabatinga River estuary is part of the Real River Basin located in the city of Jandaíra (11°32'45" S, 037°29'19" W) and the Itapicuru River estuary is part of the Itapicuru River Basin located in the city of Conde (11°47'38" S, 037°30'53" W), in the farthest north littoral in the state of Bahia, Brazil. They are under like climate regimes, varying from humid to sub-humid.

The Tabatinga River is adjacent to one of the largest shrimp farms in the state of Bahia, which was implemented in 1993. The discharge of effluents occurs daily, after a 24 h treatment in sedimentation ponds.

In the Itapicuru River's basin, other sources of anthropogenic impacts can be found in the main course of the river, such as sewage and industrial effluents waste. However, close to the mouth of the Itapicuru River there is a small village where no industrial activities were observed. Tourism and artisanal fishery are the most important economic activities, but both are still poorly developed.

In both rivers, four sampling stations were chosen to collect data according to the decreasing salinity gradient (Figure 1).

Data collection

The sampling strategy was carried out in four stations in each estuary during the ebbing and flooding spring tides. This data was collected in the rainy (April and August months) and dry (December month) seasons of 2007, consisting of 48 samples. Salinity and temperature were estimated through a multi-parameter probe WTW 340i/SET.

Mesozooplankton samples were collected through horizontal hauls at 0.1 m from the surface, during 3 minutes, using a conical net (200 µm mesh size) coupled to a flowmeter for filtered volume determination. Plankton samples were preserved in 4 % formaldehyde seawater solution and transported to the laboratory.

Organisms were counted and identified to their lowest practical taxonomic level through an estereoscopic microscope (Leica MZ6), an optical microscope (Olympus CH30) and the pertinent bibliography (Smith 1982; Boxshall and Halsey 2004; Boltovskoy 2005; Richards 2006). The abundance of organisms was estimated through measuring 2, 10 or 50 mL aliquots, one aliquot per sample, using a Stempel pipette. Rare taxa were counted in the whole sample and the density (D: individual per cubic meter) was calculated dividing the abundance by the total filtered volume.

The specimens referred to in this work are deposited at the Museu de Zoologia / Universidade Federal da Bahia (UFBA).

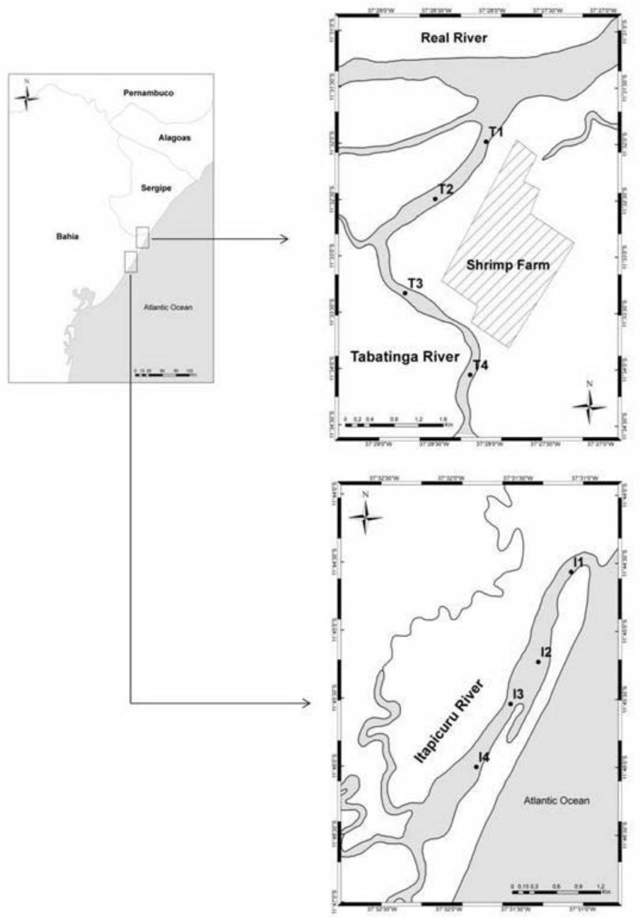

Figure 1. Sampling stations' disposition in the Tabatinga River estuary (1 to 4) surrounding a shrimp farm and in the Itapicuru River estuary (1 to 4). RR: Real River; TR: Tabatinga River; IR: Itapicuru River; P: ponds; I1-I4: stations 1 to 4 at Itapicuru River; T1-T4: stations 1 to 4 at Tabatinga River.

Results And Discussion

The temperature was similar at all the sampling stations with smaller values in August. The salinity was a very variable parameter, which represented a decreasing gradient from station 1 to 4 in both estuaries (Tabatinga River: 5.90 to 26.30; Itapicuru River: 8.60 to 36.30). The higher values were found in December during the dry season. The T-S diagram shows the existence of only estuarine waters in the Tabatinga River (Figure 2), while estuarine and coastal waters were present in the Itapicuru River (Figure 3).

In the Tabatinga and Itapicuru Rivers, 65 and 73 zooplankton taxa were registered, respectively; 59 of them were found in both estuaries such as Foraminiferida, Cnidaria, Annelida, Mollusca, Echinodermata, Crustacea, Urochordata, Cephalochordata and Chaetognatha. Rotifera was solely recorded in the Tabatinga River while Thaliacea was only registered in the Itapicuru River. In relation to fish larvae, 11 and 19 species were found on these estuaries. Considering both zooplankton and ichthyoplankton a total of 76 and 92 taxa were recorded in the Tabatinga and Itapicuru Rivers, and they are displayed on tables 1 to 4 with their respective density data. A total of 98 mesozoo- and 20 ichthyoplankton taxa were recorded taking into account both rivers.

The most relevant finding refers to the first register of Discoidae (Copepoda, Calanoida), represented by *Disco* sp. There are no previous records for *Disco* in the Southwestern Atlantic, nor in estuaries, being typically considered as an oceanic group (Boxshall and Halsey 2004). Currently the family is divided into three genera containing 29 species. However only two of them belong to *Prodisco* and four to *Paradisco*, the other 23 species are attributed to the genus *Disco*. Schulz (1993) proposed a subdivision of the *Disco* species according to the degree of mouth parts reduction. The specimens found in these estuaries represent a new species which is being described by the authors.

This study also represents the first record of other 7 copepod species in the state of Bahia: *Pseudodiaptomus richardi* Dahl, 1894, *Pontellopsis villosa* Brady, 1883, *Macrosetella gracilis* Dana, 1847, *Microsetella rosea* Dana, 1847, *Gonyiopsillus brasiliensis* Huys and Conroy-Dalton, 2000, *Agetus flaccus* Giesbrecht, 1891 and *Ergasilus caraguatatubensis* Amado and Rocha, 1995.

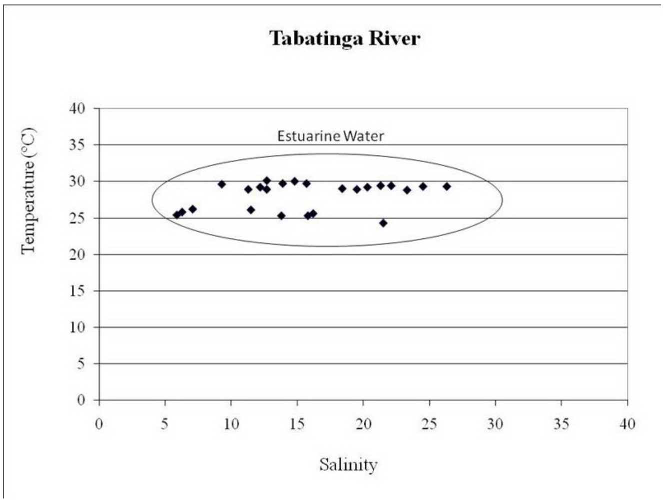

Figure 2. T-S Diagram at Tabatinga River during April, August and December, ebbing and flooding tides.

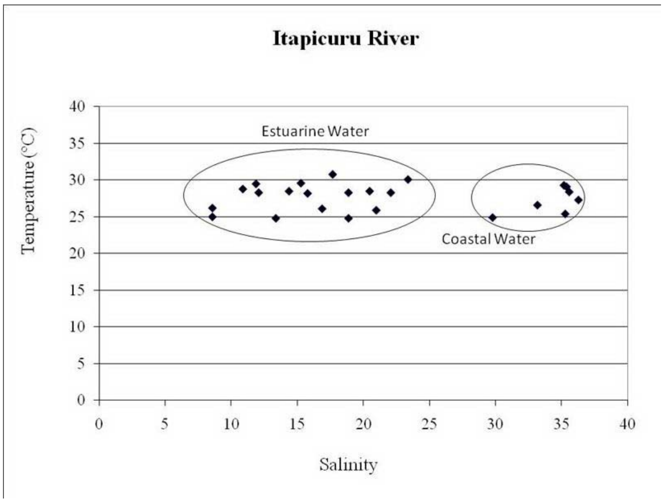

Figure 3. T-S Diagram at Itapicuru River during April, August and December, ebbing and flooding tides.

Ergasilidae is one of the most important families of copepods which are fish parasites. *Ergasilus caraguatatubensis* was first described by Amado and Rocha (1995) inhabiting the opercular cavity of Mugilidae collected in the states of Maranhão, Alagoas, São Paulo and Rio de Janeiro. Therefore the occurrence of *E. caraguatatubensis* and *Mugil liza* Valenciennes, 1836 (Mugilidae) may be linked, since both species were restricted to the Itapicuru River.

Caligus sp. (Caligidae) is also predominantly a fish parasite, including *M. liza*, but as it was found in both estuaries, its distribution may be also associated to other fish species.

Gonyiopsillus brasiliensis was described by Huys and Conroy-Dalton (2000) from samples collected in the state of Rio Grande do Sul, Brazil, on the outside opening of Lagoa dos Patos to the ocean. Huys and Conroy-Dalton (2000) also claimed that many South-American authors erroneously attributed this species to *Clytemnestra rostrata* Brady, 1883. So, our register of this species in the Itapicuru and Tabatinga Rivers confirms the hypothesis of previous misleading records along the Brazilian coast.

Among the 12 taxa exclusively reported in the Itapicuru River the distribution of some of them (*M. gracilis*, *Mecynocera clausi* Thompson, 1888, *Oithona plumifera* Baird, 1843, *Penilia avirostris* Dana, 1852 and Salpidae) was restricted to station 1, which may be explained by the higher salinity values due to the river's mouth proximity (Figure 1). On the other hand the exclusive occurrence of Augaptilidae, Paracalanidae (*Paracalanus* sp.), Centropagidae (*Centropages velificatus* Oliveira, 1947) and *P. villosa* along the entire estuary could not be associated to higher salinities and may reflect the existence of environmental differences probably related to water quality parameters, once the Tabatinga River is under the influence of shrimp farm effluent discharges.

A previously unpublished study dating from 1970 which took place in Baía de Todos os Santos (BTS), a coastal marine environment located approximately 200 kilometers away from our study area, registered the following species in common with our study site: *Liriope tetraphyla* Chamisso and Eysenhardt, 1821, *Pseudodiaptomus acutus* Dahl, 1894, *Calanopia americana* Dahl, 1894, *Acartia lilljeborgi* Giesbrecht, 1889, *Euterpina acutifrons* Dana, 1847 and *Lucifer faxoni* Borradaile, 1915. *Penilia avirostris* and *Oithona plumifera* were also found in BTS but were absent from the Tabatinga river due to lower salinity values in this estuary. The BTS study also registered species belonging to the *Microsetella*, *Centropages*, *Oithona*, *Oncaea*, *Temora*, *Labidocera* and *Oikopleura* genera, all of which were also identified in our sampling stations.

Some taxa (Rotifera, Stomatopoda and Caprellidae) occurred exclusively in the Tabatinga River, but these represent groups rarely found in mesozooplankton surface hauls and were collected due to uncommon factors such as their small size or hyperbenthic behavior.

At both estuaries there was a strong predominance of holoplanktonic organisms in relation to meroplanktonic ones and this pattern was more evident during ebbing tides (Figure 4).

Crustacean's predominance was striking for both estuaries where the highest density and dominance (%) (Tables 2 and 3) were recorded especially for calanoid copepods (*Pseudodiaptomus richardi* Dahl, 1894, *Disco* sp., *Temora* sp. and *Acartia lilljeborgi*) and decapod larvae (*Ucides cordatus* Linnaeus, 1763). This trend was congruent with most studies carried out in estuarine and coastal zooplanktonic communities (Fonseca and Klein 1976; Vega-Pérez 1993; Gaughan and Potter 1995; Neumann-Leitão *et al.* 1996; Falkenhaug *et al.* 1997; Froneman 2000; 2001; Lawrence *et al.* 2004; Kibirige *et al.* 2006; Feike *et al.* 2007).

Among the total 59 common zooplankton taxa found, only few of them were more abundant in the Tabatinga River: Cnidaria, Nematoda, Cirripedia, *A. lilljeborgi*, *Oithona* spp., *E. acutifrons*, Ostracoda, Gammaridae, Isopoda, Tanaidacea, Cumacea, *L. faxoni*, *L. typus* and *Oikopleura* spp. All the others were more abundant in the Itapicuru River. These results coincide with Champalbert and Patriti (1982), Arfi and Patriti (1987), Soetaert and Van Rijswijk (1993), Park and Marshall (2000), Uriarte and Villate (2004; 2005), and Kibirige *et al.* (2006) who found a total abundance reduction in the main zooplankton groups in sites subjected to organic pollution.

The same pattern was identified in ichthyoplankton groups. Regarding the 10 common species, 7 were more abundant in the Itapicuru River and 3 (*Harengula* aff. *jaguana* Poey, 1865, *Hypsoblennius invemar* Smith-Vaniz and Acero, 1980 and *Trinects* sp.) in the Tabatinga River (Tables 4 and 5). *Anchoa* sp. was one of the most abundant groups in both rivers, while *Harengula* aff. *jaguana* and *Ctenogobius boleosoma* Jordan and Gilbert, 1882 also presented high density values in the Tabatinga and Itapicuru Rivers, respectively.

This work brings new and relevant taxonomic information on planktonic fauna of tropical estuaries. The lower number of taxa and the lower density of most taxa, concerning zooplankton and ichthyoplankton, in the Tabatinga River may reflect poor water quality conditions in this estuary due to organic pollution caused by shrimp farm effluents disposal.

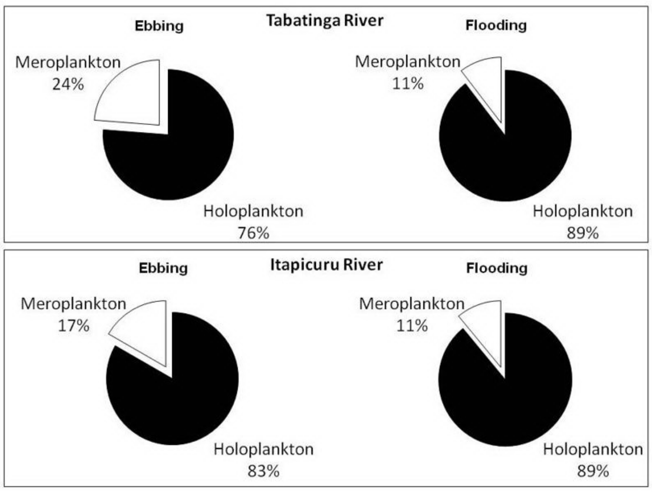

Figure 4. Relative abundance of meroplankton and holoplankton during ebbing and flooding tides.

Table 1. Average density, standard deviation (s), total density and percentage of main zooplankton groups in the Tabatinga River during April, August and December.

Tabatinga River	Density (ind.m^{-3})							
	T1	T2	T3	T4	Average	s	Total Density	Dominance (%)
Foraminiferida	7.8	1.2	0.1	0.1	2.0	4.71	19.8	0.004
Cnidaria	64.0	48.4	0.8	0.3	28.4	75.60	681.2	0.123
Bougainvillia muscus Allman, 1863	0.0	0.0	0.0	0.3	0.3	-	0.3	0.000
Liriope tetraphylla Chamisso and Eysenhardt, 1821	41.5	42.4	0.2	0.01	21.0	58.98	505.0	0.091
Family Diphyidae	0.1	0.5	0.0	0.0	0.3	0.27	0.6	0.000
Class Scyphozoa	0.2	0.0	0.0	0.0	0.2	-	0.2	0.000
Rotifera	1.5	0.1	0.0	0.0	0.8	0.99	1.7	0.000
Nematoda	2.7	5.3	0.2	0.3	2.1	5.12	33.7	0.006
Polychaeta (larvae)	0.5	1.0	0.3	0.2	0.6	0.61	9.5	0.002
Family Spionidae	0.0	0.2	0.0	0.0	0.2	0.06	0.3	0.000
Family Nereididae	0.0	0.3	0.0	0.0	0.3	0.20	0.7	0.000
Gastropoda (larvae)	40.6	171.1	26.4	10.1	64.8	151.89	1230.4	0.222
Creseis sp.	0.0	0.0	0.0	0.3	0.3	-	0.3	0.000
Bivalvia (larvae)	12.5	41.7	15.4	72.5	35.5	69.28	852.6	0.154
Class Ophiuroidea	0.0	0.0	0.2	0.0	0.2	-	0.2	0.000
Cirripedia (nauplii)	872.1	653.3	450.1	161.7	538.0	889.57	12373.3	2.236
Pseudodiaptomus richardi Dahl, 1894	268.2	389.8	2534.3	5530.6	2258.6	4556.54	51947.5	9.386
P. acutus Dahl, 1894	0.0	0.0	0.0	5.4	5.4	-	5.4	0.001
Acartia negligens Dana, 1849	22.0	0.0	0.0	0.0	22.0	-	22.0	0.004
A. lilljeborgi Giesbrecht, 1889	2033.9	2772.7	496.3	1530.1	1708.2	1843.18	40997.8	7.408
Labidocera sp.	1.0	4.0	0.0	0.1	2.2	4.16	15.2	0.003
Calanopia americana Dahl, 1894	0.0	0.0	0.0	0.1	0.1	-	0.1	0.000
Temora sp.	799.4	525.2	13.3	19.5	485.9	989.50	5344.4	0.966
Disco sp.	811.4	199.7	1195.5	3544.8	1503.0	2478.44	28557.3	5.160
Arietellidae	0.3	0.1	0.0	0.0	0.2	0.10	0.7	0.000
Oithona spp.	936.4	1247.3	6.2	7.1	549.3	1396.81	13182.6	2.382
Halyciclops sp.	7.9	2.6	3.3	5.1	4.6	6.56	92.3	0.017
Corycaeidae	0.2	0.3	0.1	0.0	0.2	0.22	1.2	0.000
Oncaea sp.	0.0	0.0	0.8	0.0	0.8	-	0.8	0.000
Ergasilus sp.	0.0	0.0	0.2	0.4	0.3	0.16	1.6	0.000
Euterpina acutifrons Dana, 1847	427.9	308.2	2.2	0.7	204.9	426.61	3073.4	0.555
Microsetella rosea Dana, 1847	1.2	0.6	0.2	0.2	0.5	0.49	4.4	0.001
Gonyiopsillus brasiliensis Huys and Conroy-Dalton, 2000	0.3	0.0	0.0	0.7	0.5	0.29	1.1	0.000
Caligus sp.	0.0	0.1	0.1	0.0	0.1	0.04	0.4	0.000
Ostracoda	28.8	43.9	28.0	22.9	31.0	51.88	588.9	0.106
Stomatopoda	0.0	0.6	0.0	0.0	0.6	-	0.6	0.000
Mysida	0.3	0.0	0.1	0.1	0.2	0.14	0.5	0.000
Gammaridae	1.6	5.0	5.1	31.6	11.1	28.30	254.7	0.046
Isopoda	1.0	0.9	1.2	2.0	1.3	1.41	29.2	0.005
Tanaidacea	0.0	0.2	0.2	0.1	0.2	0.06	0.8	0.000
Cumacea	0.3	0.1	0.2	1.1	0.6	0.89	6.4	0.001
Lucifer faxoni Borradaile, 1915	18.9	4.4	0.2	0.0	6.9	14.27	117.2	0.021
L. typus Milne Edwards, 1837	44.0	22.0	0.5	0.2	18.5	41.20	333.1	0.060
Acetes americanus Ortmann, 1893	0.05	0.0	0.0	0.02	0.04	0.02	0.1	0.000
Sergestes sp.	0.2	0.0	0.0	0.1	0.1	0.07	0.3	0.000
Penaeus sp.	0.2	0.0	0.1	0.1	0.1	0.06	0.5	0.000
Alpheus spp.	8.3	7.9	3.2	4.8	6.0	8.31	120.7	0.022
Synalpheus fritzmuelleri Coutière, 1909	1.6	0.9	0.2	1.1	0.9	0.95	10.7	0.002
Callichirus major Say, 1818	0.3	0.0	0.0	0.0	0.3	-	0.3	0.000
Petrolisthes armatus Gibbes, 1850	0.3	0.0	0.0	0.1	0.2	0.18	0.4	0.000
Clibanarius sclopetarius Herbst, 1796	1.5	0.7	1.7	2.7	1.7	2.25	29.4	0.005
Callinectes sapidus Rathbun, 1896	1.0	0.7	0.4	0.3	0.7	0.48	9.5	0.002

Table 1. (Continued)

Tabatinga River								
	Density (ind.m^{-3})				Average	s	Total Density	Dominance (%)
	T1	T2	T3	T4				
Panopeus americanus Saussure, 1857	41.7	27.2	23.3	0.0	34.0	55.26	271.7	0.049
Hexapanopeus caribbaeus Stimpson, 1871	126.0	99.2	18.8	0.1	75.1	177.63	1426.4	0.258
Pinnixa chaetopterana Stimpson, 1860	0.1	0.1	0.0	0.0	0.1	0.03	0.4	0.000
Ocypode quadrata Fabricius, 1787	0.3	0.0	0.0	0.0	0.3	-	0.3	0.000
Ucides cordatus Linnaeus, 1763	1406.5	798.5	159.9	460.2	706.3	1517.51	16950.4	3.063
Parasagitta tenuis Conant, 1896	11.7	3.6	0.2	0.2	5.9	14.48	89.1	0.016
Flaccisagitta enflata Grassi, 1881	0.0	0.1	0.0	0.0	0.1	-	0.1	0.000
Oikopleura spp.	136.6	149.0	2.5	0.3	90.8	251.56	1724.7	0.312

Table 2. Average density, standard deviation (s), total density and percentage of main zooplankton groups in the Itapicuru River during April, August and December.

Itapicuru River								
	Density (ind.m^{-3})				Average	s	Total Density	Dominance (%)
	I1	I2	I3	I4				
Foraminiferida	194.8	78.1	6.7	7.0	74.5	165.0	1712.8	0.311
Cnidaria	10.0	8.5	1.9	38.8	13.1	34.0	276.0	0.050
Bougainvillia muscus	0.0	0.2	0.0	0.0	0.2	0.09	0.3	0.000
Liriope tetraphylla	0.1	0.0	0.0	0.1	0.1	0.02	0.3	0.000
Diphyidae	0.0	0.0	0.0	0.1	0.1	0.01	0.2	0.000
Nematoda	0.2	0.6	0.4	0.8	0.5	0.5	8.2	0.001
Polychaeta (larvae)	5.0	35.4	5.4	5.9	12.3	29.0	269.7	0.049
Spionidae	0.0	0.2	0.2	0.6	0.4	0.4	2.3	0.000
Nereididae	0.2	0.0	0.1	0.1	0.1	0.1	0.5	0.000
Gastropoda (larvae)	28.0	120.7	342.3	760.1	312.8	673.1	7506.4	1.362
Creseis sp.	0.0	0.0	0.0	265.5	265.5	276.4	796.4	0.145
Bivalvia (larvae)	215.1	537.4	91.0	221.7	266.3	515.0	6391.1	1.160
Ophiuroidea	12.3	0.6	0.1	0.0	5.7	10.9	51.4	0.009
Penilia avirostris (Dana, 1852)	0.9	1.7	0.3	0.1	0.9	1.3	6.9	0.001
Cirripedia (nauplii)	0.3	214.8	842.4	998.1	383.6	678.2	5754.6	1.044
Pseudodiaptomus richardi	721.8	1749.4	20752.5	30772.6	13499.1	20590.0	323977.7	58.788
P. acutus	0.0	2.4	0.0	26.9	14.7	17.3	29.3	0.005
Acartia lilljeborgi	102.1	1580.4	646.2	1514.2	930.8	1709.4	14893.6	2.703
Labidocera sp.	34.7	36.6	6.1	0.3	26.2	30.0	183.7	0.033
Pontellina sp.	242.7	14.5	0.0	49.8	102.3	122.9	307.0	0.056
Pontellopsis vilosa Brady, 1883	8.3	34.8	0.0	0.0	21.5	32.3	129.2	0.023
Calanopia americana	17.0	18.2	0.0	19.4	18.2	1.2	54.6	0.010
Temora sp.	1468.2	8359.8	877.5	29.6	2978.7	9100.9	53616.1	9.729
Augaptilidae	93.1	132.9	3424.1	27.1	573.7	1776.5	8032.3	1.458
Centropages velificatus Oliveira, 1947	0.0	114.9	0.0	0.0	114.9	-	114.9	0.021
Paracalanus sp.	0.0	229.9	0.0	0.0	229.9	-	229.9	0.042
Disco sp.	679.8	2893.4	2893.7	5588.0	3278.4	3937.1	62289.3	11.303
Mecynocera clausi Thompson, 1888	13.9	0.5	0.2	0.0	5.7	10.3	28.7	0.005
Oithona spp.	133.2	47.8	57.6	429.7	167.1	281.1	4009.8	0.728
O. plumifera Baird, 1843	0.5	0.0	0.0	0.0	0.5	-	0.5	0.000
Halyciclops sp.	1.1	150.4	22.1	30.9	54.7	168.7	1203.7	0.218
Corycaeidae	44.1	269.3	8.7	1.4	96.4	329.6	1928.5	0.350
Oncaea sp.	1.1	3.4	0.4	0.0	1.6	2.9	16.3	0.003
Agetus flaccus Giesbrecht. 1891	0.1	0.0	0.0	0.0	0.1	-	0.1	0.000
Ditrichocorycaeus africanus	0.1	0.0	0.0	0.0	0.1	-	0.1	0.000
Ergasilus sp.	0.2	0.1	0.4	1.0	0.6	0.5	7.4	0.001
E. caraguatatubensis	0.0	0.2	0.1	0.0	0.1	0.02	0.3	0.000
Euterpina acutifrons	20.1	170.0	0.3	0.0	71.4	233.3	1141.9	0.207
Microsetella rosea	0.1	0.2	0.2	0.2	0.2	0.1	2.2	0.000
Macrosetella gracilis Dana, 1847	0.0	0.1	0.2	0.0	0.1	0.0	0.3	0.000
Gonyiopsillus brasiliensis	0.9	0.2	0.2	0.5	0.4	0.3	1.9	0.000
Caligus sp.	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.000
Ostracoda	1.1	18.9	5.4	20.7	11.5	20.1	276.5	0.050
Mysida	0.4	0.5	0.0	0.1	0.4	0.2	1.5	0.000
Gammaridae	1.5	7.4	10.3	9.6	7.3	9.4	160.7	0.029
Isopoda	0.6	0.5	0.2	0.5	0.5	0.5	10.2	0.002
Tanaidacea	0.0	0.0	0.2	0.1	0.1	0.1	0.2	0.000
Cumacea	0.2	0.2	0.2	0.2	0.2	0.1	2.1	0.000
Lucifer faxoni	4.6	14.3	0.9	0.9	5.2	12.5	103.5	0.019
L. typus	15.3	24.0	3.1	3.1	11.4	24.9	227.6	0.041
Acetes americanus	0.0	0.4	0.8	0.8	0.7	0.2	2.8	0.001
Sergestes sp.	1.0	0.5	0.7	0.5	0.7	0.5	8.3	0.002

Table 2. (Continued)

Itapicuru River	Density (ind.m^{-3})							
	I1	I2	I3	I4	Average	s	Total Density	Dominance (%)
Penaeus sp.	0.6	0.1	0.5	0.3	0.4	0.5	3.1	0.001
Alpheus spp.	1.3	14.4	3.7	10.3	7.4	16.4	148.4	0.027
Synalpheus fritzmuelleri	1.6	0.7	0.0	0.2	1.0	0.8	4.9	0.001
Callichirus major	0.1	0.3	0.0	0.3	0.2	0.1	1.5	0.000
Petrolisthes armatus	0.3	1.7	0.1	0.0	0.6	0.7	2.2	0.000
Pagurus sp.	0.7	13.5	0.2	0.0	2.5	4.9	17.8	0.003
Clibanarius sclopetarius	37.7	62.2	36.2	29.7	41.8	70.8	920.7	0.167
Callinectes sapidus	0.4	3.5	27.6	3.8	12.0	37.9	192.2	0.035
Panopeus americanus	0.0	0.0	8.8	15.1	12.0	14.4	47.9	0.009
Hexapanopeus caribbaeus	87.6	25.5	7.8	8.1	34.0	102.5	611.5	0.111
Pinnixa chaetopterana	2.2	15.3	2.2	4.3	6.3	10.6	87.5	0.016
Ocypode quadrata	0.3	15.6	0.5	1.7	4.3	12.6	55.9	0.010
Ucides cordatus	1718.7	998.1	3822.8	2103.5	2160.8	3183.3	51858.7	9.410
Parasagitta tenuis	58.9	147.6	11.4	2.2	62.1	165.5	1304.8	0.237
Flaccisagitta enflata	0.2	0.1	0.0	0.0	0.1	0.1	0.6	0.000
Oikopleura spp.	16.0	3.5	0.1	0.0	7.8	13.7	85.4	0.015
Salpidae	0.5	0.0	0.4	0.0	0.5	0.4	1.4	0.000

Table 3. Average density, standard deviation (s), total density and percentage of main ichthyoplankton groups in the Tabatinga River during April, August and December.

Tabatinga River	Density (ind.100m^{-3})							
	T1	T2	T3	T4	Average	s	Total Density	Dominance (%)
Anchoa sp.	16.7	56.5	20.2	150.3	60.9	62.2	243.7	61.94
Harengula aff. *jaguana* Poey, 1865	6.0	2.2	16.0	26.0	12.5	10.7	50.2	12.75
Ctenogobius boleosoma Jordan and Gilbert, 1882	0.0	0.0	1.4	6.8	2.1	3.2	8.24	8.2
Microdesmus cf. *longipinnis* Weymouth, 1910	0.0	3.9	3.1	1.6	2.2	1.7	8.69	8.6
Microphis lineatus Bleeker, 1853	0.0	0.0	5.1	6.5	2.9	3.4	11.6	2.94
Stellifer rastrifer Jordan, 1889	0.0	4.0	0.0	1.6	1.4	1.9	5.6	1.41
Hypsoblennius invemar Smith-Vaniz and Acero, 1980	5.4	2.0	0.0	4.2	2.9	2.4	11.6	2.93
Hyporhamphus unifasciatus Ranzani, 1842	3.0	0.0	1.8	0.0	1.2	1.5	4.8	1.21
Trinects sp.	0.0	0.0	0.0	11.6	2.9	5.8	11.6	2.96
Achirus lineatus Linnaeus, 1758	9.6	1.1	0.0	3.2	3.5	4.3	13.9	3.55
Sphoeroides sp.	0.0	0.0	0.0	1.3	0.3	0.6	1.3	0.33
Eggs	1.0	0.6	0.1	10.0	2.2	3.4	243.7	5.69

Table 4. Average density, standard deviation (s), total density and percentage of main ichthyoplankton groups in the Itapicuru River during April, August and December.

Itapicuru River	Density (ind.100m^{-3})							
	I1	I2	I3	I4	Average	s	Total Density	Dominance (%)
Lycengraulis grossidens	6.2	0.0	0.0	13.7	5.0	6.5	19.9	0.81
Anchoa sp.	31.9	103.7	355.9	186.3	169.5	139.4	677.8	27.67
Harengula aff. *Jaguana*	7.4	5.6	2.6	16.5	8.0	6.0	32.1	1.31
Ctenogobius boleosoma	123.1	397.9	298.8	209.0	257.2	118.1	1028.8	41.99
Microdesmus cf. *longipinnis*	0.0	8.9	19.5	1.8	7.5	8.8	30.2	1.23
Eucinostomus sp.	0.0	3.7	2.5	0.0	1.5	1.8	6.2	0.25
Microphis lineatus Bleeker, 1853	6.4	13.0	4.2	10.0	8.4	3.9	33.6	1.37
Mugil liza Valenciennes, 1836	0.0	0.0	0.0	1.2	0.3	0.6	1.2	0.05
Sparidae	6.5	36.0	99.4	3.0	36.2	44.6	144.9	5.92
Stellifer rastrifer	0.9	5.1	13.1	1.2	5.1	5.7	20.3	0.83
Hypsoblennius invemar	0.0	0.0	0.0	3.2	0.8	1.6	3.2	0.13
Haemulidae	5.8	0.0	1.3	0.0	1.8	2.8	7.1	0.29

Table 4. (Continued)

Itapicuru River								
	Density (ind.100m^{-3})							
	I1	I2	I3	I4	Average	s	Total Density	Dominance (%)
Oligoplites sp.	1.5	0.0	0.0	0.0	0.4	0.8	1.5	0.06
Atherinopsidae	1.5	0.0	2.5	0.0	1.0	1.2	4.0	0.16
Labrizomidae	0.0	1.3	0.0	0.0	0.3	0.6	1.3	0.05
Hirundichthys sp.	0.0	1.7	0.0	0.0	0.4	0.9	1.7	0.07
Trinects sp.	3.1	0.0	2.6	0.0	1.4	1.6	5.7	0.23
Achirus lineatus	6.8	4.3	2.6	1.3	3.7	2.4	15.0	0.61
Sphoeroides sp.	0.0	9.6	1.4	31.3	10.6	14.5	42.3	1.73
Eggs	41.4	17.1	2.7	1.0	15.5	31.9	19.9	15.23

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Literature Cited

Amado, M.A.P. and C.E.F. Rocha. 1995. Três novas espécies de copépodes parasitas do gênero Ergasilius (Poecilostomatoida, Ergasilidae) coletados em filamentos branquiais de peixes Mugilídeos do Brasil. *Nauplius* 3: 33-48.

Arfi, R. and G. Patriti. 1987. Impact d'une pollution urbaine sur la partie zooplanctonique d'un systeme neritique (Marseille - Cortiou). *Hydrobiologia* 144: 11-23.

Barbier, E. and M. Cox. 2002. Economic and demographic factors affecting mangrove loss in the coastal provinces of Thailand, 1979-1996. *Ambio* 31: 351-357.

Boltovskoy, D. 2005. *Zooplankton of the South Atlantic Ocean. A taxonomic reference work with identification guides and spatial distribution patterns*. 2 ed. Amsterdam: ETI Bioinformatics, DVD ROM.

Boxshall, G.A. and S.H. Halsey. 2004. *An introduction to copepod diversity*. Ray Society Series 166. London: The Ray Society. 940 p.

Champalbert, G. and G. Patriti. 1982. Impact de la pollution sur les communautes zooplanctoniques dans la zone d'epandage de l'emissaire urbain de Marseille. *Hydrobiologia* 89: 17-27.

Falkenhaug, T., K. Tande and A. Timonin. 1997. Spatio-temporal patterns in the copepod community in Malangen, Northern Norway. *Journal of Plankton Research* 19(4): 449-468.

Feike, M., R. Heerkloss, T. Rieling and H. Schubert. 2007. Studies on the zooplankton community of a shallow lagoon of the Southern Baltic Sea: long-term trends, seasonal changes, and relations with physical and chemical parameters. *Hydrobiologia* 577: 95-106.

Fonseca, V.G. and V.L.M. Klein. 1976. Estudo sobre a composição do plâncton, no estuário do rio Jaguaribe (Ceará-Brasil). *Arquivos de Ciências do Mar* 16(1): 1-8.

Froneman, P.W. 2000. Feeding studies of selected zooplankton in the Kariega estuary, South Africa. *Estuarine, Coastal and Shelf Science* 51: 543-552.

Froneman, P.W. 2001. Seasonal changes in zooplankton biomass and grazing in a temperate estuary, South Africa. *Estuarine, Coastal and Shelf Science* 52: 543-553.

Gaughan, D.J. and I.C. Potter. 1995. Composition, distribution and seasonal abundance of zooplankton in a shallow, seasonally closed estuary in temperate Australia. *Estuarine, Coastal and Shelf Science* 41: 117-135.

Huys, R. and S. Conroy-Dalton. 2000. Generic concepts in the Clytemnestridae (Copepoda, Harpactocoida), revision and revival. *Bulletin of The Natural History Museum* 66(1): 1-48.

Islam, M.S. and M. Haque. 2004. The mangrove-based coastal and nearshore fisheries of Bangladesh: ecology, exploitation and management. *Reviews in Fish Biology and Fisheries* 14: 153-180.

Kibirige, I, R. Perissinotto and X. Thwalaet. 2006. A comparative study of zooplankton dynamics in two subtropical temporarily open/closed estuaries, South Africa. *Marine Biology* 148: 1307-1324.

Lawrence, D., I. Valiela and G. Tomasky. 2004. Estuarine calanoid copepod abundance in relation to season, salinity, and land-derived nitrogen loading, Waquoit Bay, MA. *Estuarine, Coastal and Shelf Science* 61: 547-557.

Levinton, J.S. 1995. Marine Biology: function, biodiversity, ecology. Oxford: Oxford University Press. 420 p.

Neumann-Leitão, S., L.M.O. Gusmão, T.A. Silva and D.A.N. Vieira. 1996. Variação diurna e sazonal do microzooplâncton no estuário do rio Paripe - PE - Brasil. *Arquivos de Biologia e Tecnologia* 39(2): 373-384.

Neumann-Leitão, S., M.R.M. Souza, F.F. Porto Neto, M.C.O. Moura, A.P. Silva and L.M.O. Gusmão. 1999. Zooplâncton do estuário do rio São Francisco, Nordeste do Brasil. *Trabalhos Oceanográficos da Universidade Federal do Pernambuco* 27(1): 33-54.

Park, G.S. and H.G.Marshall. 2000. Estuarine relationships between zooplankton community structure and trophic gradients. *Journal of Plankton Research* 22(1): 121-135.

Richards, W.J. 2006. *Early stages of Atlantic fishes: an identification guide for the Western Central North Atlantic*. Boca Raton: CRC Press. 2640 p.

Schulz, K. 1993. New species of Discoidae from the eastern North Atlantic (Copepoda: Calanoida). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 90: 197-207.

Singkran, N. and S. Sudara. 2005. Effects of Changing Environments of Mangrove Creeks on Fish Communities at Trat Bay, Thailand. *Environmental Management* 35(1): 45-55.

Smith, D.L. 1982. *A guide to marine coastal plankton and marine invertebrate larvae*. Mar del Plata: Inidep. 936 p.

Soetaert, K. and P. Van Rijswijk. 1993. Spatial and temporal patterns of the zooplankton in the Westerschelde estuary. *Marine ecology progress series* 97: 47-59.

Vega-Pérez, L.A. 1993. Estudo do zooplâncton da região de Ubatuba, Estado de São Paulo. *Publicação especial do Instituto Oceanográfico* 10: 65-84.

Uriarte, I. and F. Villate. 2004. Effects of pollution on zooplankton abundance and distribution in two estuaries of the Basque coast (Bay of Biscay). *Marine Pollution Bulletin* 49: 220-228.

Uriarte, I. and F. Villate. 2005. Differences in the abundance and distribution of copepods in two estuaries of the Basque coast (Bay of Biscay) in relation to pollution. *Journal of Plankton Research* 27(9): 105-122.

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