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Lists of Species

Fish composition (Teleostei) of the estuarine region of the Macaé River, southeastern Brazil

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Abstract: The first checklist of fishes of the estuary of the Macaé River (Rio de Janeiro State, Brazil) and its adjacent freshwater section is presented. A total of 24,157 specimens belonging to 110 species in 44 families and 21 orders of the Teleostei were collected based on quarterly samplings, between June 2011 and March 2012. The Sciaenidae was the most representative family in species number, whereas the Ariidae, Pristigasteridae, and the invasive Clariidae predominated numerically and/or in terms of biomass. One hundred fifty-seven species of the Teleostei are now recorded in the Macaé River, including 68 species previously reported from its upper and middle portions. More than 100 of them permanently or temporarily inhabit the lower 16 km of the river, suggesting that the estuary is relevant to the maintenance of the fish diversity of the region in spite of several human activities that have significantly altered its natural features.

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Introduction

Estuaries are relatively well-defined coastal water bodies open to the sea, where the salt content of freshwater is increased by a significant input of marine seawater (Cameron and Pritchard 1963; Pritchard 1967). Seawater intrusion and its pattern of circulation in the estuary are modulated by the amplitude of tides and variations in river discharge, among other geographic and hydrological parameters (Fairbridge 1980; Albaret *et al*. 2004). Those parameters vary along the length of the estuary, and have a strong influence on its physico-chemical properties (Drinkwater and Frank 1994; Grange and Allanson 1995). Estuaries are also highly relevant in biological terms. They are typically richer in nutrients than rivers or oceans, and thus exhibit a higher secondary production (Elliott *et al.* 2002). In addition to holding some resident species, estuaries are nursery and refuge grounds for different life-cycle stages of several marine organisms, being also relevant as migration routes for diadromous fishes (Whitfield 1990, 1998; Blaber 1997; Potter and Hyndes 1999; McLusky and Elliott 2004).

The Macaé River has approximately 130 km from its headwaters, at an altitude of about 1500 m, to its mouth in the coastal plain at the city of Macaé, northern Rio de Janeiro State (Figures 1 and 2). The lower course of the Macaé River was extensively dredged in the 1960's. The naturally meandering estuary was also reshaped into a single, relatively large, straight channel by the federal government at the time in order to drain the floodplain and, supposedly, control tropical diseases such as malaria (Figures 1C and 2C-E). As expected, most of the natural riparian vegetation of the estuary and nearby freshwater bodies was replaced by pasture and agricultural crops. Unfortunately, the fish composition of the Macaé River before that period is unknown. The city of Macaé has also experienced for the last three decades one of the highest population growth rates in Brazil. The unplanned urbanization process promoted additional alterations to the natural landscape of the estuarine region of the Macaé River, but the possible consequences of those impacts to the fish community have not been properly addressed.

The upper limit of an estuary is typically defined by a decrease followed by stability in values of diluted salts of marine origin, particularly in terms of chlorinity (*e.g.*, Pritchard 1967). However, above this relatively well-marked upper limit, a significant portion of the river is still physically influenced by the estuary, which modulates the tidal oscillation and other oceanographic features. The degree of that influence varies seasonally, interannually, or even between decades as a consequence of variations in parameters such as the rainfall regime, the pattern of circulation of oceanic currents at the opening of the estuary, or even the input of domestic or industrial wastes in highly populated estuarine areas, as in the case of the Macaé River. A substantial portion of the lower Macaé River is also located on a large, flat coastal plain (Figure 2E), a landscape feature that presumably amplifies the influence of the estuary in the region. That same feature also suggests that the upper limit of the estuary of the Macaé River is comparatively more diffuse, and that it probably varies along the year. Consequently, the structure of biological communities of a significant stretch of the lower portion of the Macaé River is under the direct or indirect influence of the estuary, and should be ideally treated as a single unity in studies aimed at the identification of its fish composition.

Sixty eight species of the Teleostei were recently recorded in the Macaé River (Brito 2007; Jaramillo-Villa 2010), but the fish composition of the estuary is still practically unknown. We therefore present the first comprehensive list of the species of the Teleostei known to temporarily or permanently inhabit the lower 16 km of the Macaé River, which includes the estuary and the freshwater region under its influence.

Materials and Methods

Study Area

The headwaters of the Macaé River are located in Pico do Tinguá, city of Nova Friburgo, Rio de Janeiro State (22°21′ – 22°28′ S, 42°27′ – 42°35′ W). The total drainage area of the basin is approximately 1765 km^2 (SEMADS 2001; Figure 1B). The riparian vegetation is highly variable and mostly related to different land uses. Stretches of relatively well-preserved Atlantic Forest are present on the upper portion of the river, whereas the lower course, where the estuary is located, is mostly characterized by pasture (Bizerril and Primo 2001).

The main channel of the lower 16 km of the Macaé River is relatively narrow and shallow, with a mean depth of approximately 3.0 m, and an average flow of 45.4 m^3.s^{-1} (Weber 2001). In the estuary, tides are usually semi-diurnal, ranging from about 1.0 m in spring and 0.5 m during neap tides. The mean annual temperature varies between 22 to 24°C, and the annual rainfall varies between 1000 to 1300 mm (Alvares *et al.* 2013), being mostly concentrated between November and April.

Sampling

Four quarterly campaigns were performed between June 2011 and March 2012 at five sampling non-equidistant stations (Figure 1C; Table 1), which include the salt wedge in the estuary (P0, P1 and P2; Figure 2A, 2B and 2C), and the freshwater section of the river under the influence of the estuary (P3 and P4; Figure 2D and 2E). Fishing equipment consisted of two sets of gill nets (mesh sizes 15, 20, 25, 30, 35, 40, and 45 mm), casting nets (mesh sizes 10, 20 and 25 mm), and a seining net (mesh size 5 mm) that was operated either with the aid of a motor boat on the deeper portions of the river, or manually at the margins of the river and at the beach. Sampling was complemented with sieves and dip nets at the vegetated banks and under macrophyte stands. Depth, salinity and temperature were recorded during sampling (Table 1). Fishes collected were fixed in a 10% solution of formalin immediately after collection, and later preserved in 70% alcohol. They were identified with the aid of several taxonomic guides and keys (*e.g.*, Figueiredo and Menezes 1978, 1980, 2000; Menezes and Figueiredo 1980, 1985), original species descriptions, and comparisons with previously identified specimens deposited in fish collections, especially those of the Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ) and of the Núcleo em Ecologia e Desenvolvimento Socioambiental de Macaé, Universidade Federal do Rio de Janeiro (NPM). Names of genera and species follow Eschmeyer (2014). Suprageneric classification follows Wiley and Johnson (2010). Biometric data of specimens, including total length (TL, cm) and total weight (TW, g) were also recorded. The most representative species were considered as those that comprised 95% and 90% of total abundance and biomass, respectively. Selected specimens representing all species recorded in the estuary were deposited in NPM (Appendix).

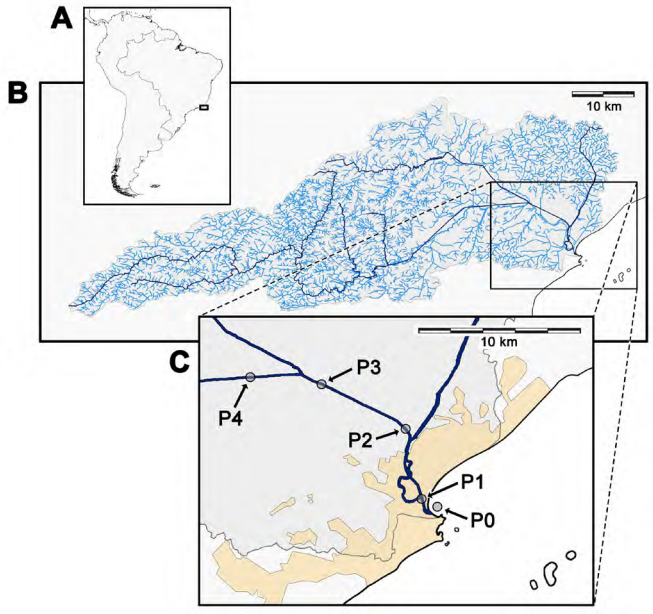

Figure 1. (A) Map of South America, study area indicated by the rectangle; (B) Macaé River drainage basin (dark grey), including the original configuration of rivers in light blue and the modern configuration of the channel of the Macaé River and some of its main tributaries in dark blue; (C) Location of sampling stations P0 - P4, with the urban portion of the city of Macaé in light brown.

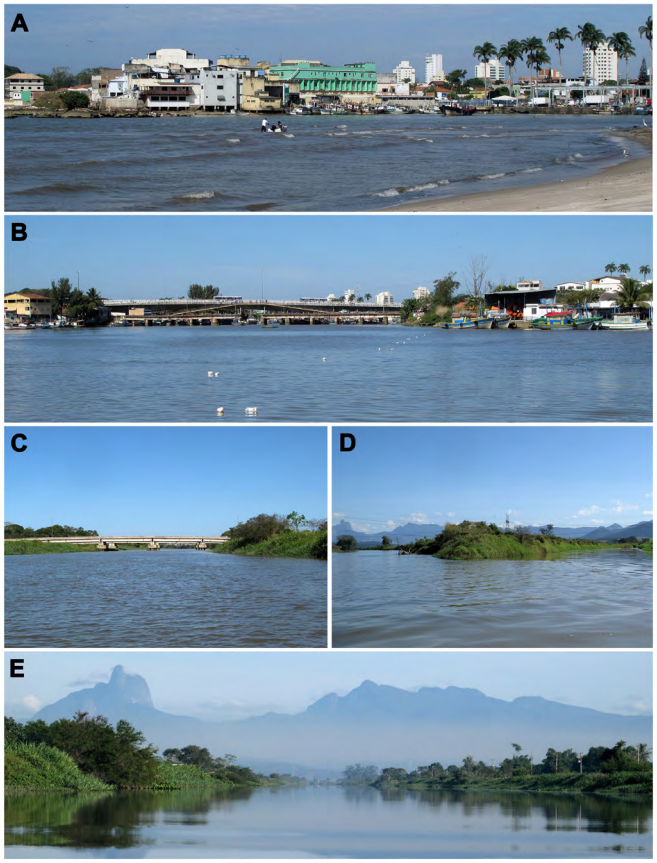

Figure 2. Sampling stations, city of Macaé, Rio de Janeiro State: (A) P0, mouth of the estuary of the Macaé River; (B) P1 and (C) P2, inside the estuary, within city limits; (D) P3, downstream the confluence of the Rivers Macaé (left) and São Pedro (right); (E) P4, lower Macaé River, Serra do Mar escarpment in the foreground.

Table 1. Geographic coordinates of sampling stations and physico-chemical parameters measured during the study, between June 2011 and March 2012. Values represent the mean ± standard deviation of the quarterly samplings.

STATIONS	COORDINATES	AREA DESCRIPTION	TEMPERATURE (°C)	SALINITY	DEPTH (M)
P0	22°22′24.50″ S, 41°46′21.56″ W	Pier Port	22.93±2.77	27.36±4.94	3.74±0.84
P1	22°22′04.79″ S, 41°46′38.68″ W	Urban area / Pier Port	23.28±2.10	17.50±9.98	2.78±0.42
P2	22°19′53.97″ S, 41°47′01.73″ W	Urban area	23.78±3.33	2.95±5.83	1.78±0.52
P3	22°17′56.03″ S, 41°50′15.43″ W	Agriculture / Pasture	23.52±3.70	0.03±0.05	0.98±0.14
P4	22°17′42.83″ S, 41°52′37.85″ W	Agriculture / Pasture / Thermoelectric plants	22.10±3.53	0.03±0.05	0.60±0.43

Results

A total of 24,157 specimens (297 kg) was collected, which corresponds to 110 species in 44 families and 21 orders of the Teleostei (Table 2). The number of species in a single locality ranged from 25 to 69. When only the region identified as the main estuary is considered (P0, P1 and P2), 22,620 specimens belonging to 78 species were collected. Forty-one specimens of 8 species were exclusively recorded in P3 and P4. Only the bluefish *Pomatomus saltatrix* (Linnaeus, 1766) was recorded both at the upper and lowermost sampling stations (P4 and P0).

Species richness varied positively with salinity, but was inversely related to the distance from the sea. There was an abrupt reduction of 50% of the species number between P1 and P2, which are inside the estuary, where the greatest differences in water salinity between consecutive sampling stations were recorded (Figure 3, Table 1). When all stations are considered, species of the Sciaenidae, Engraulidae and Ariidae represented 30.0% of the total richness, with 13.64%, 8.18% and 8.18%, respectively, of the species recorded. Lower species richness were recorded in stations P2, P3 and P4. Species in those stations belong mostly to the Characidae, Cichlidae and Poeciliidae, families that basically include fishes of the Primary and Secondary Divisions of Myers (1938). The abundance of species among the three stations located farther from the sea (P2, P3 and P4) was more equitable when compared to stations P0 and P1.

The number of species recorded was higher in stations close to the sea (P0 and P1), but those stations were also characterized by few species that numerically dominated the catches (Table 2). Dominant species were the ariids *Cathorops spixii* (Agassiz 1829) and *Genidens genidens* (Cuvier 1829), which was by far the most abundant species in those stations, the engraulids *Anchovia clupeoides* (Swainson 1839), *Anchoa tricolor* (Spix & Agassiz 1829) and *Lycengraulis grossidens* (Agassiz 1829), the pristigasterid *Pellona harroweri* (Fowler 1917), and the haemulid *Conodon nobilis* (Linnaeus 1758) (Figure 4A; Table 2). A few species of the Centropomidae, Gobiidae, Mugilidae, Engraulidae and Syngnathidae were collected in four sampling stations, but no species were recorded in all five stations (Table 2). Together, species of the Ariidae, Engraulidae, Sciaenidae and Pristigasteridae comprised 89.76 % of the total abundance. The sum of the weights of all specimens of those families combined with those of the North African catfish *Clarias gariepinus* (Burchell 1822) (Clariidae) corresponds to 74.64% of the total biomass (Figure 4B).

Discussion

Eighty-nine species of the Teleostei were herein recorded for the first time in the Macaé River. A total of 157 species of that group is now reported for the river, including species previously identified by Brito (2007) and Jaramillo-Villa (2010). Species of the Ariidae, Engraulidae, Clupeidae, Pristigasteridae, Sciaenidae, Gerreidae, Sparidae and Haemulidae, which were numerically expressive in the catches, are also well represented in fish communities of estuaries of the tropical western Atlantic (*e.g.*, Vieira and Musick 1994; Andrade-Tubino *et al.* 2008; Marceniuk *et al.* 2013). Those species are typically eurytopic and are therefore able to cope with a wide range of environmental conditions, especially salinity, which is considered as the main limiting factor regulating the occurrence of fishes in estuaries (Vieira and Musick 1993).

Species that live exclusively in tropical and temperate estuaries represent less than 13% of the total species richness of those environments (Day Jr. *et al.* 1989). As in other temperate and tropical estuaries, most species recorded in the estuary of the Macaé River might be regarded as opportunists or seasonally migrants. If that is the case, then the relevance of the estuary of the Macaé River to the maintenance of populations of several marine fishes that are probably using that environment for growth and development is reinforced.

The lower values of species richness recorded in stations P2, P3 and P4 might actually reflect the presumably smaller population sizes in the estuary and in the region under its influence of the more stenohaline freshwater species. Despite the environmental modifications that the lower Macaé River has been subjected to, rheophilic and relatively rare large species, such as the prochilodontid *Prochilodus vimboides* Kner 1859 and the anostomid *Leporinus copelandii* Steindachner 1875, were recorded. However, the region under study is now overrun by the North African catfish *C. gariepinus*, an exotic generalist predator that can reach up to 150 cm TL (Teugels 2003). That species was collected in all sampling occasions, at

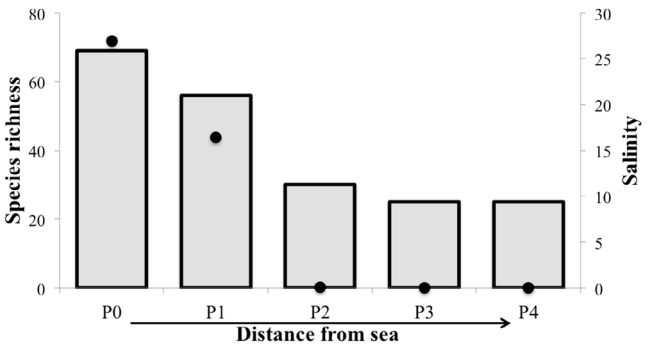

Figure 3. Variation in fish species richness (left axis, bars) and salinity (right axis, dots) in sampling stations P0 - P4 in the estuarine region of the Macaé River, Rio de Janeiro State, between June 2011 and March 2012. The distance from the sea is 0, 2, 5, 12 and 16 km for the sampling stations P0, P1, P2, P3 and P4, respectively.

least in one of the stations P2-P4. *Clarias gariepinus* is also frequently caught by local fishermen, usually in high quantities and sometimes in large sizes (Figure 5), strongly indicating that a viable population of the species is now established in the lower Macaé River. The occurrence of that highly resilient species in the region represents an additional threat to the indigenous ichthyofauna of the river, such as the fat sleeper *Dormitator maculatus* (Bloch 1792). Three juvenile specimens of that species, which exclusively inhabits the lower portion of Atlantic coastal drainages between southern North America and Uruguay (Volcan *et al*. 2010; Bastos *et al.* 2013; Duarte *et al*. 2013), were collected in one occasion in station P2 (Table 2, Appendix). *Dormitator maculatus* can be relatively abundant locally,

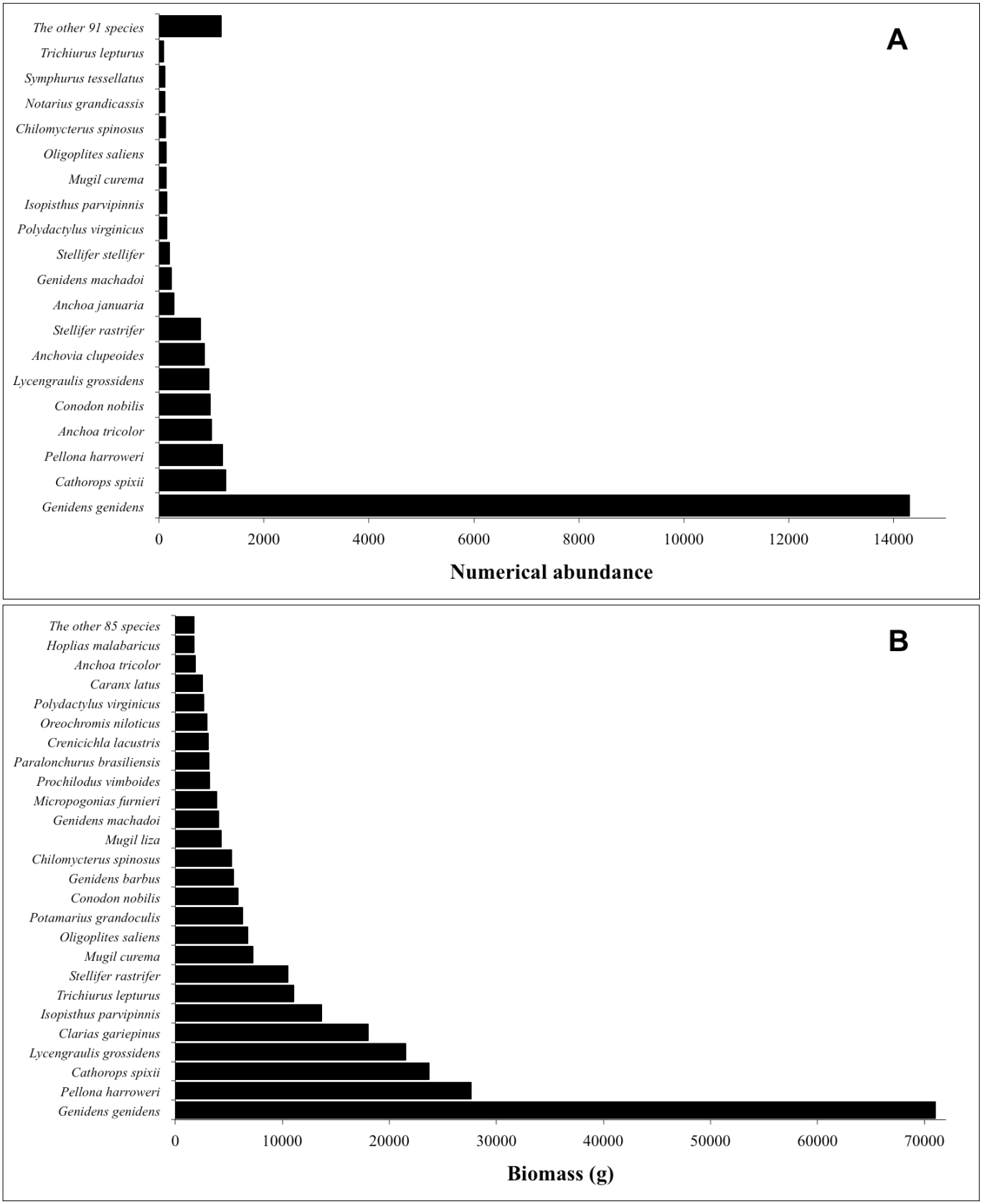

Figure 4. Species that comprise (A) 95% of the numerical abundance and (B) 90% of the biomass collected in stations P0 - P4 in the estuarine region of the Macaé River, Rio de Janeiro State, between June 2011 and March 2012.

Table 2. List of species collected in the estuarine region of the Macaé River, northern Rio de Janeiro State, between June 2011 and March 2012. New records (NR), total length (TL, in cm) of the specimens, and numerical abundance in each sampling stations are presented.

TAXON	NR	TL	SAMPLING STATIONS					
		(mean ± SD)	P0	P1	P2	P3	P4	Total
Elopiformes								
Elopidae								
Elops smithi McBride, Rocha, Ruiz-Carus & Bowen, 2010	X	29.6	1					1
Clupeiformes								
Clupeidae								
Harengula clupeola (Cuvier, 1829)	X	11.29±2.54	44	28				72
Opisthonema oglinum (Lesueur, 1818)	X	14.26±0.46	3					3
Engraulidae								
Anchoa januaria (Steindachner, 1879)	X	5.96±2. 08	272	1				273
Anchoa marinii Hildebrand, 1943	X	3.7±0.32	6					6
Anchoa tricolor (Spix & Agassiz, 1829)	X	5.96±2.08	695	303				998
Anchovia clupeoides (Swainson, 1839)	X	5.93±1.02	128	731				859
Anchoa lyolepis (Evermann & Marsh, 1900)	X	3.96±0.05		3				3
Anchoviella lepidentostole (Fowler, 1911)	X	8.8±3.19	3	1				4
Cetengraulis edentulous (Cuvier, 1829)	X	8.9±3.69	4	13				17
Engraulis anchoita Hubbs & Marini, 1935	X	13.35±0.21		2				2
Lycengraulis grossidens (Spix & Agassiz, 1829)	X	11.77±6.38	563	374	2	2		941
Pristigasteridae								
Odontognathus mucronatus Lacepède, 1800	X	7.8±3.48	26					26
Pellona harroweri (Fowler, 1917)	X	9.7±4.6	1206	1				1207
Characiformes								
Anostomidae								
Leporinus copelandii Steindachner, 1875		22.27±7.45				3	4	7
Characidae								
Astyanax aff. *bimaculatus* (Linnaeus, 1758)		10.25±3.74			8	36	15	59
Astyanax giton Eigenmann, 1908	X	11.0±0.00				1	1	2
Astyanax janeiroensis Eigenmann, 1908	X	8.74±3.74				5	2	7
Hyphessobrycon luetkenii (Boulenger, 1887)		4.04±1.69			2	12	3	17
Oligosarcus hepsetus (Cuvier, 1829)		16.9±6.46			3	4	3	10
Curimatidae								
Cyphocharax gilbert (Quoy & Gaimard, 1824)		19.25±1.98			9		3	12
Erythrinidae								
Hoplias aff. *malabaricus* (Bloch, 1794)		34.0±6.0				1	2	3
Prochilodontidae								
Prochilodus vimboides Kner, 1859		28.8±5.01			4	4	3	11
Siluriformes								
Ariidae								
Aspistor luniscutis (Valenciennes, 1840)	X	11.2	1					1
Bagre bagre (Linnaeus, 1766)	X	30.38±5.02	5	1				6
Bagre marinus (Mitchill, 1815)	X	27.6	1					1
Cathorops spixii (Agassiz, 1829)	X	11.59±3.70	567	701				1268
Genidens barbus (Lacepède, 1803)	X	23.28±3.26	46					46
Genidens genidens (Cuvier, 1829)	X	9.96±4.41	29	14249	19			14297
Genidens machadoi (Miranda Ribeiro, 1918)	X	11.13±6.65	225	3				228
Notarius grandicassis (Valenciennes, 1840)	X	8.26±1.59	111	1				112
Potamarius grandoculis (Steindachner, 1877)	X	19.85±6.84	2	37				39
Auchenipteridae								
Trachelyopterus striatulus (Steindachner, 1877)		16.25±0.54			6	2		8
Clariidae								
Clarias gariepinus (Burchell, 1822)		54.95±9.70			8	4	2	14
Heptapteridae								
Pimelodella lateristriga (Lichtenstein, 1823)		15.3±2.90			6	14	4	24
Rhamdia quelen (Quoy & Gaimard, 1824)		23.7±4.60			2	2	1	5
Loricariidae								
Hypostomus affinis (Steindachner, 1877)	X	21.38±8.59				3	4	7
Hypostomus sp.	X	15.43±10.46				2	8	10
Schizolecis guntheri (Miranda Ribeiro, 1918)		2.9±0.70			1		5	6
Gymnotiformes								
Hypopomidae								
Brachyhypopomus janeiroensis (Costa & Campos-da-Paz, 1992)	X	25.9±3.14			3	3		6

Table 2. *Continued.*

TAXON	NR	TL	SAMPLING STATIONS					
		(mean ± SD)	P0	P1	P2	P3	P4	Total
Mugiliformes								
Mugilidae								
Mugil curema Valenciennes, 1836	X	14.4±6.66	13	111	8	1		133
Mugil liza Valenciennes, 1836		36.86±9.0	7	1	1			9
Gasterosteiformes								
Syngnathidae								
Syngnathus folletti Herald, 1942	X	14.4		1				1
Microphis lineatus (Kaup, 1856)		13.11±2.66	1	1	2		2	6
Pseudophallus mindi (Meek & Hildebrand, 1923)	X	6.8				1		1
Atheriniformes								
Atherinopsidae								
Atherinella brasiliensis (Quoy & Gaimard, 1825)	X	8.46±4.10	11	4				15
Beloniformes								
Belonidae								
Strongylura marina (Walbaum, 1792)	X	35.15±2.05		2				2
Hemiramphidae								
Hemiramphus brasiliensis (Linnaeus, 1758)	X	19.0	1					1
Cyprinodontiformes								
Poeciliidae								
Phalloceros harpagos Lucinda, 2008		2.25±0.26					4	4
Poecilia vivipara Bloch & Schneider, 1801		2.1±0.78			17	7	17	41
Batrachoidiformes								
Batrachoididae								
Porichthys porosissimus (Cuvier, 1829)	X	18.95±3.46	1	1				2
Carangiformes								
Carangidae								
Carangoides bartholomaei (Cuvier, 1833)	X	11.65±2.75	2					2
Caranx latus Agassiz, 1831	X	15.37±4.01	9	35			2	46
Chloroscombrus chrysurus (Linnaeus, 1766)	X	12.75±4.95	9	3				12
Oligoplites saliens (Bloch, 1793)	X	20.0±3.71	124	4				128
Selene vomer (Linnaeus, 1758)	X	4.8±3.74	13	5				18
Trachinotus carolinus (Linnaeus, 1766)	X	4.4±4.79	20	1				21
Trachinotus falcatus (Linnaeus, 1758)	X	3.25±0.54	4					4
Dactylopteriformes								
Dactylopteridae								
Dactylopterus volitans (Linnaeus, 1758)	X	10.0		1				1
Gobiiformes								
Eleotridae								
Dormitator maculatus (Bloch, 1792)	X	3.4±0.4			3			3
Eleotris pisonis (Gmelin, 1789)		4.63±1.37			5		1	6
Gobiidae								
Awaous tajasica (Lichtenstein, 1822)		10.92±3.92		4	1	6	4	15
Bathygobius soporator (Valenciennes, 1837)	X	8.33±3.34	1	7	1			9
Gobionellus oceanicus (Pallas, 1770)	X	17.06±1.90		3				3
Labriformes								
Cichlidae								
Crenicichla lacustris (Castelnau, 1855)		21.84±7.45			2	11	7	20
Geophagus brasiliensis (Quoy & Gaimard, 1824)		11.79±3.44		1	18	1	2	22
Oreochromis niloticus (Linnaeus, 1758)	X	17.9±2.71		18	1			19
"Perciformes"								
Centropomidae								
Centropomus parallelus Poey, 1860		17.3±6.45		3	6	5	1	15
Gerreidae								
Eucinostomus melanopterus (Bleeker, 1863)	X	11.92±3.28	1	3				4
Eugerres brasilianus (Cuvier, 1830)	X	27.02±1.30	3	1	1			5
Haemulidae								
Boridia grossidens Cuvier, 1830	X	10.1	1					1
Conodon nobilis (Linnaeus, 1758)	X	7.64±2.83	961	6				967
Orthopristis ruber (Cuvier, 1830)	X	14.0±4.53	11					11
Pomadasys ramosus (Poey, 1860)	X	12.0±1.46	29	3		2		34

Table 2. *Continued.*

TAXON	NR	TL	SAMPLING STATIONS					
		(mean ± SD)	P0	P1	P2	P3	P4	Total
Polynemidae								
Polydactylus virginicus (Linnaeus, 1758)	X	9.1±4.60	77	66				143
Pomatomidae								
Pomatomus saltatrix (Linnaeus, 1766)	X	19.85±6.83	6				1	7
Sciaenidae								
Isopisthus parvipinnis (Cuvier, 1830)	X	21.0±4.35	138					138
Larimus breviceps Cuvier, 1830	X	16.14±4.97	17					17
Macrodon ancylodon (Bloch & Schneider, 1801)	X	26.77±4.46	10					10
Menticirrhus americanus (Linnaeus, 1758)	X	15.4±6.82	7					7
Menticirrhus littoralis (Holbrook, 1847)	X	12.63±2.95	3					3
Micropogonias furnieri (Desmarest, 1823)	X	15.26±7.80	19	54	1			74
Nebris microps Cuvier, 1830	X	22.76±8.42	3					3
Odontoscion dentex (Cuvier, 1830)	X	13.1		1				1
Ophioscion punctatissimus Meek & Hildebrand, 1925	X	15.8±3.93	17					17
Paralonchurus brasiliensis Meek & Hildebrand, 1925	X	17.65±5.24	50					50
Stellifer brasiliensis (Schultz, 1945)	X	10.55±4.87	24					24
Stellifer rastrifer (Jordan, 1889)	X	8.6±3.3	783	7				790
Stellifer stellifer (Bloch, 1790)	X	7.8±2.75	190	5				195
Stellifer sp.	X	9.95±2.89	18					18
Umbrina coroides Cuvier, 1830	X	8.0±1.80	8					8
Sparidae								
Archosargus probatocephalus (Walbaum, 1792)	X	16.4	1					1
Pleuronectiformes								
Achiridae								
Achirus lineatus (Quoy & Gaimard, 1824)	X	6.36±2.19		2				2
Catathyridium garmani (Jordan, 1889)	X	12.15±1.20			2			2
Trinectes microphthalmus (Chabanaud, 1928)	X	7.7±1.01		8				8
Trinectes paulistanus (Miranda Ribeiro, 1915)	X	8.05±2.20	6	27	4	1		38
Cynoglossidae								
Symphurus tessellatus (Quoy & Gaimard, 1824)	X	8.1±1.49	1	101				102
Paralichthyidae								
Citharichthys arenaceus Evermann & Marsh, 1900	X	10.72±1.86	2	63	2			67
Citharichthys macrops Dresel, 1885	X	27.2±1.76		4				4
Etropus crossotus Jordan & Gilbert, 1882	X	8.25±3.88	2					2
Paralichthys brasiliensis (Ranzani, 1842)	X	9.9±2.33		4				4
Scombriformes								
Scombridae								
Scomberomorus regalis (Bloch, 1793)	X	29.4	1					1
Trichiuridae								
Trichiurus lepturus Linnaeus, 1758	X	46.9±27.3	68	8				76
Scorpaeniformes								
Triglidae								
Prionotus punctatus (Bloch, 1793)	X	12.4	1					1
Stromateiformes								
Stromateidae								
Peprilus paru (Linnaeus, 1758)	X	16.3±2.0	4					4
Tetraodontiformes								
Diodontidae								
Chilomycteruss pinosus (Linnaeus, 1758)	X	7.63±1.62	77	45				122
Tetraodontidae								
Lagocephalus lagocephalus (Linnaeus, 1758)	X	9.46±3.57	2	7				9
Sphoeroides pachygaster (Müller & Troschel, 1848)	X	2.55±0.07	2					2
Sphoeroides spengleri (Bloch, 1785)	X	7.85±5.86		2				2
Sphoeroides testudineus (Linnaeus, 1758)	X	6.1±4.52		6				6
Total			6697	17078	148	133	101	24157

Figure 5. Local fisherman with a 65 cm SL specimen of the North African catfish *Clarias gariepinus* (NPM 1575) fished in the estuary of the Macaé River in June 2009, at station P2.

but is now considered as threatened in the Paraná State (Abilhoa and Duboc 2004) and possibly in other regions (Volcan *et al*. 2010). Further studies aimed at assessing the distribution of *C. gariepinus* and its population dynamics in the Macaé River and adjoining water bodies, such as the lagoons of Restinga de Jurubatiba National Park (Di Dario *et al.* 2013), are therefore needed in order to evaluate its potential impact on the local fish communities.

Summing up our results, the number of fish species recorded in the estuarine region of the Macaé River (110 in 44 families) is relatively high, falling within the 100 to 200 species typically recorded in tropical and subtropical estuaries (Barletta *et al*. 2005; Andrade-Tubino *et al*. 2008; Neves *et al*. 2010), including the Southeastern coast of Brazil and the Rio de Janeiro State (114-116 species in 38-45 families; Andrade-Tubino *et al*. 2008). Our results also indicate that the estuary of the Macaé River seems to be still relevant to the maintenance of the diversity of both the coastal and continental fish fauna of the region, in spite of more than 50 years of devastating human activities on the environment and misuses of its natural resources.

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Appendix 1. Selected voucher specimens collected in the estuarine region of the Macaé River, Rio de Janeiro State, between June 2011 and March 2012. The list is ordered alphabetically by family and species. Number of specimens in parentheses follows catalog number.

Achiridae: *Achirus lineatus*, NPM 1917 (1), NPM 2056 (1); *Catathyridium garmani*, NPM 2074 (2); *Trinectes microphthalmus*, NPM 2066 (1); *Trinectes paulistanus*, NPM 1937 (10), NPM 1941 (4), NPM 2095 (2), NPM 2148 (14), NPM 2149 (3), NPM 2150 (3), NPM 2234 (1), NPM 2235 (3). **Anostomidae**: *Leporinus copelandii*, NPM 2043 (1), NPM 2143 (3), NPM 2144 (2). **Ariidae**: *Aspistor luniscutis*, NPM 1675 (1); *Bagre bagre*, NPM 1676 (1), NPM 2303 (2); *Bagre marinus*, NPM 2077 (1); *Cathorops spixii*, NPM 1799 (802); *Genidens barbus*, NPM 2034 (7), NPM 2301(31); *Genidens genidens*, NPM 2305 (23), NPM 2306 (10), NPM 2307 (2); *Genidens machadoi*, NPM 2082 (1), NPM 2270 (3), NPM 2304 (98); *Notarius grandicassis*, NPM 2196 (78), NPM 2197 (27), NPM 2302 (6); *Potamarius grandoculis*, NPM 1793 (1), NPM 2083 (1), NPM 2300 (26). **Atherinopsidae**: *Atherinella brasiliensis*, NPM 2044 (4), NPM 2147 (11). **Auchenipteridae**: *Trachelyopterus striatulus*, NPM 2071 (2), NPM 2183 (6). **Batrachoididae**: *Porichthys porosissimus*, NPM 2038 (1), NPM 2264 (1). **Belonidae**: *Strongylura marina*, NPM 2073 (2). **Carangidae**: *Carangoides bartholomaei*, NPM 1959 (2); *Caranx latus*, NPM 1961 (2), NPM 1963 (4), NPM 1965 (4), NPM 2171 (5), NPM 2172 (1), NPM 2173 (3), 2174 (10); *Chloroscombrus chrysurus*, NPM 1944 (2), NPM 1960 (2), NPM 1964 (3), NPM 1984 (1), NPM 2239 (2), NPM 2240 (1); *Oligoplites saliens*, NPM 1890 (2), NPM 2152 (4), NPM 2153 (21), NPM 2154 (2); *Selene vomer*, NPM 1946 (1), NPM 1950 (2), NPM 1967 (2), NPM 1980 (6), NPM 2186 (2), NPM 2187 (1); *Trachinotus carolinus*, NPM 1939 (1), NPM 1940 (11), NPM 2280 (8), 2281 (1); *Trachinotus falcatus*, NPM 2063 (4). **Centropomidae**: *Centropomus parallelus*, NPM 1915 (2), NPM 2242 (1), NPM 2243 (2), NPM 2244 (1), NPM 2245 (1), NPM 2246 (1), NPM 2247 (1), NPM 2248 (1), NPM 2249 (1), NPM 2250 (1), NPM 2251 (2). **Characidae**: *Astyanax* aff. *bimaculatus*, NPM 1974 (10), NPM 2137 (3), NPM 2138 (20); *Astyanax giton*, NPM 2055 (1), NPM 2169 (1); *Astyanax janeiroensis*, NPM 2050 (6); *Hyphessobrycon luetkenii*, NPM 2061 (1), NPM 2277 (2), NPM 2278 (1), NPM 2279 (1); *Oligosarcus hepsetus*, NPM 2048 (4), NPM 2189 (1), NPM 2190 (1), NPM 2191 (2), NPM 2192 (1), NPM 2193 (1). **Cichlidae**: *Crenicichla lacustris*, NPM 1955 (2); NPM 1988 (1), NPM 2219 (2), NPM 2220 (2), NPM 2221(1), NPM 2226 (1), NPM 2265 (1), NPM 2284 (1); *Geophagus brasiliensis*, NPM 2065 (2), NPM 2184 (3), NPM 2185 (2), NPM 2201 (14); *Oreochromis niloticus*, NPM 2085 (1), NPM 2252 (1), NPM 2253 (1), NPM 2254 (3), NPM 2255 (2). **Clariidae**: *Clarias gariepinus*, NPM 2290 (1), NPM 2291 (3), NPM 2292 (1). **Clupeidae**: *Harengula clupeola*, NPM 1951 (8), NPM 1952 (7), NPM 1953 (2), NPM 2145 (28), NPM 2146 (25); *Opisthonema oglinum*, NPM 1926 (3). **Curimatidae**: *Cyphocharax gilbert*, NPM 1956 (4), NPM 2268 (3), NPM 2269 (2), NPM 2271 (3). **Cynoglossidae**: *Symphurus tessellatus*, NPM 1904 (47), NPM 1938 (2), NPM 1943 (52), NPM 1945 (1). **Dactylopteridae**: *Dactylopterus volitans*, NPM 1930 (1). **Diodontidae**: *Chilomycterus spinosus*, NPM 1970 (37), NPM 1990 (2), NPM 2179 (16), NPM 2180 (3), NPM 2181 (16), NPM 2182 (5). **Eleotridae**: *Dormitator maculatus*, NPM 2086 (3); *Eleotris pisonis*, NPM 1916 (1), NPM 2286 (3), NPM 2287 (2). **Elopidae**: *Elops smithi*, NPM 2030 (1). **Engraulidae**: *Anchoa januaria*, NPM 1948 (257); *Anchoa lyolepis*, NPM 1947 (3); *Anchoa marinii*, NPM 1954 (6); *Anchoa tricolor*, NPM 1927 (260), NPM 1931 (20), NPM 1958 (430), NPM 1972 (2); *Anchovia clupeoides*, NPM 1789 (533), NPM 1905 (42), NPM 1919 (600), NPM 1920 (86), NPM 2273 (1), NPM 2274 (1); *Anchoviella lepidentostole*, NPM 1962 (1), NPM 1982 (1), NPM 2222 (1), NPM 2223 (1); *Cetengraulis edentulus*, NPM 1918 (2), NPM 2275 (4); *Engraulis anchoita*, NPM 2049 (1), NPM 2166 (1); *Lycengraulis grossidens*, NPM 1921 (18), NPM 1922 (49), NPM 1923 (108), NPM 1981 (186). **Erythrinidae**: *Hoplias malabaricus*, NPM 2094 (1), NPM 2299 (2). **Gerreidae**: *Eucinostomus melanopterus*, NPM 2046 (3), NPM 2170 (1); *Eugerres brasilianus*, NPM 2076 (1), NPM 2136 (3). **Gobiidae**: *Awaous tajasica*, NPM 1933 (5), NPM 1934 (4), NPM 2211 (1), NPM 2212 (1), NPM 2213 (2), NPM 2214 (1); *Bathygobius soporator*, NPM 1900 (1), NPM 1912 (1), NPM 1913 (2), NPM 2158 (4), NPM 2159 (1); *Gobionellus oceanicus*, NPM 1925 (3). **Haemulidae**: *Boridia grossidens*, NPM 1910 (1); *Conodon nobilis*, NPM 1911 (278); *Orthopristis ruber*, NPM 2036 (1), NPM 2036 (1), NPM 2194 (7), NPM 2195 (1), NPM 2227 (3); *Pomadasys ramosus*, NPM 2058 (2), NPM 2139 (25). **Hemiramphidae**: *Hemiramphus brasiliensis*, NPM 2054 (1). **Heptapteridae**: *Pimelodella lateristriga*, NPM 2075 (15), NPM 2202 (1), NPM 2203 (1), NPM 2204 (1), NPM 2205 (1), NPM 2206 (2), NPM 2207 (1); *Rhamdia quelen*, NPM 1989 (1), NPM 2230 (1), NPM 2231 (1), NPM 2232 (1), NPM 2233 (1). **Hypopomidae**: *Brachyhypopomus janeiroensis*, NPM 1846 (2), NPM 2039 (1), NPM 2224 (1), NPM 2225 (2). **Loricariidae**: *Hypostomus affinis*, NPM 2032 (2), NPM 2078 (5); *Hypostomus* sp., NPM 1907 (2), NPM 1908 (1), NPM 1987 (1), NPM 2151 (6); *Schizolecis guntheri*, NPM 1909 (2), NPM 2156 (3), NPM 2157 (1). **Mugilidae**: *Mugil curema*, NPM 2070 (1), NPM 2175 (94), NPM 2176 (1), NPM 2177 (1), NPM 2178 (1); *Mugil liza*, NPM 2112 (2). **Paralichthyidae**: *Citharichthys arenaceus*, NPM 1903 (12), NPM 2160 (1), NPM 2161 (15), NPM 2162 (4), NPM 2163 (1), NPM 2164 (23), NPM 2165 (10); *Citharichthys macrops*, NPM 1949 (4); *Etropus crossotus*, NPM 1936 (2); *Paralichthys brasiliensis*, NPM 1973 (4). **Poeciliidae**: *Phalloceros harpagos*, NPM 2088 (3); *Poecilia vivipara*, NPM 1978 (5), NPM 1979 (4), NPM 1985 (12), NPM 2272 (6), NPM 2288 (2), NPM 2289 (10). **Polynemidae**: *Polydactylus virginicus*, NPM 1901 (7), NPM 1902 (4), NPM 2140 (1), NPM 2141 (1), NPM 2142 (57). **Pomatomidae**: *Pomatomus saltatrix*, NPM 2057 (1), NPM 2285 (5). **Pristigasteridae**: *Odontognathus mucronatus*, NPM 1957 (1), NPM 1906 (18), NPM 2188 (3); *Pellona harroweri*, NPM 1885 (166), NPM 1889 (85), NPM 1898 (69), NPM 2106 (5), NPM 2155 (103). **Prochilodontidae**: *Prochilodus vimboides*, NPM 1983 (4), NPM 2236 (2), NPM 2237 (2), NPM 2238 (3). **Sciaenidae**: *Isopisthus parvipinnis*, NPM 2041 (2), NPM 2276 (48); *Larimus breviceps*, NPM 2037 (1), NPM 2067 (3), NPM 2241 (2); *Macrodon ancylodon*, NPM 2092 (2), NPM 2282 (3); *Menticirrhus americanus*, NPM 2069 (3), NPM 2081 (1), NPM 2209 (2); *Menticirrhus littoralis*, NPM 2053 (2), NPM 2167 (1); *Micropogonias furnieri*, NPM 1576 (1), NPM 2031 (4), NPM 2115 (3), NPM 2256 (1), NPM 2257 (3), NPM 2258 (8), NPM 2259 (11), NPM 2260 (8); *Nebris microps*, NPM 2040 (1), NPM 2068 (1), NPM 2283 (1); *Odontoscion dentex*, NPM 2051 (1); *Ophioscion punctatissimus*, NPM 2080 (8), NPM 2208 (7); *Paralonchurus brasiliensis*, NPM 2042 (8), NPM 2198 (18), NPM 2199 (9), NPM 2200 (1); *Stellifer brasiliensis*, NPM 2035 (4), NPM 2052 (7), 2091 (4), NPM 2210 (5); *Stellifer rastrifer*, NPM 2033 (68), NPM 2261 (2), NPM 2262 (11), NPM 2263 (126); *Stellifer stellifer*, NPM 2059 (1), NPM 2062 (12), NPM 2064 (1), NPM 2079 (34), NPM 2090 (67); *Stellifer* sp., NPM 2047 (8), NPM 2060 (3), NPM 2215 (4); *Umbrina coroides*, NPM 364 (2). **Scombridae**: *Scomberomorus regalis*, NPM 2084 (1). **Sparidae**: *Archosargus probatocephalus*, NPM 2072 (1). **Stromateidae**: *Peprilus paru*, NPM 1914 (2), NPM 2267 (1). **Syngnathidae**: *Microphis lineatus*, NPM 1924 (1), NPM 1928 (1), NPM 1932 (1), NPM 1966 (1), NPM 2218 (1); *Pseudophallus mindi*, NPM 2089 (1); *Syngnathus folleti*, NPM 1929 (1), NPM 2093 (1). **Tetraodontidae**: *Lagocephalus lagocephalus*, NPM 1969 (4), NPM 2228 (2), NPM 2229 (2), NPM 2266 (1); *Sphoeroides pachygaster*, NPM 2087 (2); *Sphoeroides spengleri*, NPM 2045 (2); *Sphoeroides testudineus*, NPM 1971 (4), NPM 2168 (2). **Trichiuridae**: *Trichiurus lepturus*, NPM 1574 (1), NPM 2293 (4), NPM 2294 (1), NPM 2295 (9), NPM 2296 (12), NPM 2297 (24), NPM 2298 (5). **Triglidae**: *Prionotus punctatus*, NPM 1935 (1).