



# Checklist of the fish fauna of the Araçá Bay, São Sebastião Channel, northern coast of São Paulo, Brazil

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**Abstract:** This paper presents for the first time a checklist of the fish fauna of Araçá Bay, São Sebastião Channel, northern coast of São Paulo state, Brazil. Fishes were sampled in five surveys from October 2012 to February 2014 using nine different types of sampling gear during high tide. Tide pool fishes were also sampled in four surveys from March to October 2014. Geographic distribution and conservation status of each species are reported. A total of 126 species was recorded in Araçá Bay, including two non-native species and new records in the São Sebastião region for 16 species. The fish species richness found in Araçá Bay was greater than the previously recorded for the São Sebastião Channel and other adjacent areas. Most of the Araçá fish species show a wide distribution along the western Atlantic Ocean (32%). Few species are included in the international (29%) and Brazilian (3.3%) official lists of threatened species.

**Key words:** species inventory; species richness; geographic distribution; conservation status; multi-gear approach

## INTRODUCTION

Araçá Bay is a large tidal flat ecosystem located in São Sebastião Channel (SSC) on the northern coast of São Paulo state, adjacent to the São Sebastião Port (Figure 1). It harbors an exceptionally rich macrofauna, including one of the last relicts of mangrove on the São Sebastião coast (Amaral et al. 2010). The port was built in 1936, and since then, its operation, expansion and consequent surrounding urbanization have severely affected the bay's biodiversity (Migotto et al. 1993; Zanardi et al. 1999; Amaral and Nallin 2011). Furthermore, in the 1980s, a submarine sewer was built in the bay, which has caused drastic changes on its morphology and circulation (Teodoro et al. 2011; Amaral et al. 2010; Migotto et al. 1993). Currently, there is a project to expand the São

Sebastião Port toward the bay. A loss of habitat and an increase in water pollution is expected along with the port expansion, and these are expected to affect the bay's ecosystem and consequently its fish community (Consultoria Paulista de Estudos Ambientais 2011).

Several studies of the benthic fauna have been carried out at Araçá Bay (Migotto et al. 1993; Arruda and Amaral 2003; Petracco et al. 2013; Corte et al. 2014; Gorman et al. 2015), but the fish fauna of this bay is still largely unknown, despite its high importance for local fishermen. Available information of the fish fauna is restricted to bottom-trawl surveys (Muto et al. 2000; Rossi-Wongtschowski et al. 2008) and diving surveys (Gibran and Moura 2012) conducted in São Sebastião Channel and on the adjacent continental shelf.

Checklists of species are essential for effective management of ecosystems, as well as for development of conservation plans and environmental impact studies (Silveira 2011; Mace 2004; Hellman and Fowlle 1999). Additionally, comprehensive local inventories may increase our knowledge of the distribution ranges of species and thus provide support to biogeographical and macroecological studies (Silveira et al. 2010). Here, we provide a checklist of fishes from Araçá Bay. We include their geographic distributions and conservation status. The efficiency of the sampling gear used here, and the spatial and temporal variability in the species composition and abundance of the bay will be addressed in future studies.

## MATERIALS AND METHODS

Araçá Bay is composed by four sand beaches, two small islets, three small mangrove patches and a large sand-mud sediment tidal plain. It is limited northward by a rockfill and southward by rocky shores (Figure 1). The maximum depth of the bay is 10 m at its mouth, becoming shallower towards its inner part. At high tide during neap tides, the mean depth from the inner part of the bay to the islets is  $0.73 \pm 0.25$  m (SD), and from



**Figure 1.** Map of the Araçá Bay at the continental margin of the São Sebastião Channel (SSC), northern coast of São Paulo, Brazil. The arrow indicates Mãe Isabel Creek. São Sebastião Island (SSI); São Sebastião Port (SSP). A: intertidal; B: shallow sublittoral; C: outer sublittoral.

the islets to the bay's mouth is of  $1.16 \pm 0.53$  m. The bay's configuration prevents it from being directly influenced by the relatively strong SSC hydrodynamics, thus, the main abiotic driver in the bay is the tide (Amaral et al. 2010; Gubitoso et al. 2008).

For our purposes, we divided the bay into three sectors: intertidal, shallow sublittoral and outer sublittoral (Figure 1). Fishes were collected in five surveys: October 2012, March, July, October 2013 and January 2014. The nine types of gear used in each survey and the number and location of deployments are described below:

1. One cast-net (6.65 m diameter with a 10 mm monofilament mesh between adjacent knots) was used in both intertidal and shallow sublittoral sectors, with 18 random and independent deployments in each sector.
2. One otter trawl (two paired nets each with 9.5 m opening, 6.7 m cod-end, and 10 mm between adjacent knots) was operated in the shallow and outer sublittoral, performing four and three random and independent 100 m tows, respectively.
3. Two encircling gillnets were deployed; one (590 m long, 3 m high, and 30 mm stretched mesh) was used in the shallow sublittoral with two random and independent deployments; another encircling gillnet (220 m long, 2.6 m high, and 32 mm stretched mesh) was used in the intertidal, with one deployment at Mãe Isabel creek (Figure 1), and two deployments in the inner sublittoral, one near the rocky shore located south

- of the inner sublittoral and another near the port.
4. Two gillnets, with net 1 (154 m × 2.6 m with 32 mm stretched mesh) deployed between the two inlets in the intertidal, and net 2 (longer part = 154 m × 3.3 m and smaller part = 85.8 m × 3.15 m; 50 mm stretched mesh at both parts) deployed in the southern part of the inner sublittoral from the shore (Figure 1). Each net was operated over 12 hours (~ 7 p.m. to ~ 7 a.m.), being checked at each 2 hours.
  5. Six fish traps (150 cm wide × 53 cm long × 37 cm high, 15 mm monofilament line mesh) deployed over the rocky bottom in the southern part of the outer sublittoral.
  6. One beach seine (20 m long × 3 m high, with a 15 m long bag) performing 4 to 5 tows in the margins of the intertidal and 1 to 3 tows in the margins of the inner subtidal.
  7. One set of handline (15 to 20 size 6 hooks baited with sardines) used over the rocky bottom of the southern part of the outer sublittoral (Figure 1).

One night was required to operate each gear (except for the fish trap, which was continuously operated throughout the day and night over five successive days, and the handline, which was operated in the daytime from approximately 5:00 a.m. to 10:00 a.m.). After the captures, fishes were stored in ice and transported to the laboratory to be identified.

Fishes inhabiting tide pools were sampled during low tide of spring tide in four surveys: March, June, August, and October 2014. The fishes were captured (I) with hand net in the rock and rock-sand pools after dissolving a clove oil solution (4% in alcohol); and (II) with a mosquito-screen-made beach seine (2.5 m long, 3.0 mm mesh) and hand nets in soft-sediment pools (for more details on the sampling procedure, see Brenha-Nunes et al. 2016). All specimens were preserved in 70% alcohol solution and later identified in laboratory.

The taxonomic identity of the specimens was identified based on Figueiredo (1977), Figueiredo and Menezes (1978, 1980 and 2000), Menezes and Figueiredo (1980 and 1985) and on Carpenter (2002a, 2002b and 2002c). The taxonomic classification follows Eschmeyer (2014). The Chico Mendes Institute for Biodiversity Conservation granted permission for the capture and transportation of the fishes (Permit No. 5574607). Species vouchers are deposited in the Zoological Museum of the University of São Paulo. Voucher numbers are presented in the Appendix, Table A1.

The species were ranked according to the biogeographical categories proposed by Passos et al. (2012), as follow: CT – Circumtropical (throughout the tropics); TA - Trans-Atlantic (western and eastern sides of the subtropical and tropical Atlantic Ocean); WA - Western Atlantic (western side of the subtropical and tropical North and South Atlantic Ocean, with the northern

subtropical limit at South Carolina, USA); SWA - Southern West Atlantic (northern Brazil to Argentina); SSWA - Southern South West Atlantic (southeastern Brazil to Argentina); Ca – Caribbean (Florida, USA, to Venezuela); Br – Brazilian Province (between the Orinoco delta, Venezuela, and Santa Catarina, Brazil); EA – Eastern Atlantic (eastern side of the subtropical and tropical North and South Atlantic Ocean); and EP - Eastern Pacific (eastern side of the subtropical and tropical Pacific Ocean). Several species have a geographic distribution that does not fit exactly with the biogeographical categories proposed. For such cases, we combined two or three biogeographical categories in order to comply with their distribution.

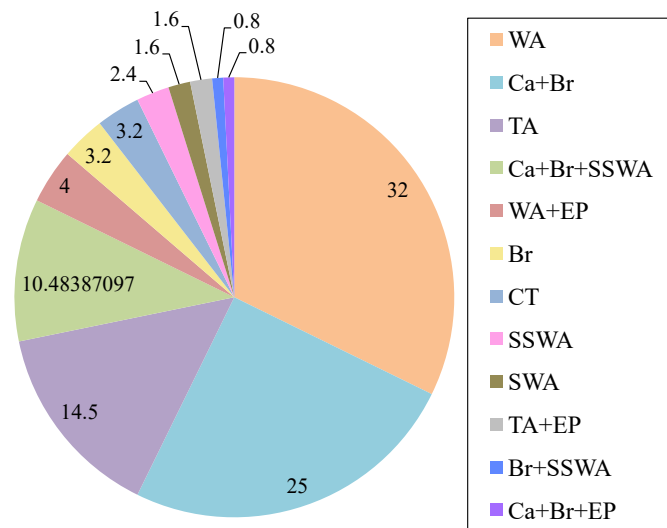
The conservation status of species was verified in the 'IUCN Red List of Threatened Species' (IUCN 2014), the Brazilian federal list for threatened species, Ordinance of the Ministry of Environment n° 445, December 17 of 2014 (Brasil 2014), and the São Paulo state list for threatened species, Decree N° 60.133 of February 7 of 2014 (Governo do Estado de São Paulo 2014).

## RESULTS

A total of 126 species were captured, including five elasmobranches (rays) and 121 teleosts belonging to 19 orders and 54 families (Table 1). Photographs of these species were already published by Rossi-Wongtschowski et al. (2015). The richest order was Perciformes (69 spp.), followed by Clupeiformes (9 spp.), and Pleuronectiformes (9 spp.). The richest families were Carangidae (11 spp.), Sciaenidae (9 spp.), Haemulidae, Gobiidae and Paralichthyidae (6 spp. each), and Engraulidae and Gerreidae (5 spp. each). Two non-native, Indo-Pacific species, *Omobranchus punctatus* (Valenciennes, 1836) (Contente et al. 2015) and *Butis koilomatodon* (Bleeker, 1849) (Contente et al. 2016), were recorded.

When compared to another comprehensive species checklist for the São Sebastião region (Lamas, 2015), 16 species captured in Araçá Bay were recorded for the first time from the region: *Achirus lineatus* (Linnaeus, 1758), *Astroscopus y-graecum* (Cuvier, 1829), *Ctenogobius smaragdus* (Valenciennes, 1837), *Elops saurus* Linnaeus, 1766, *Gobionellus stomatus* Starks, 1913, *Hemicaranx amblyrhynchus* (Cuvier, 1833), *Lutjanus cyanopterus* (Cuvier, 1828), *Microgobius meeki* Evermann & Marsh, 1899, *Mugil hospes* Jordan & Culver, 1895, *Myrophis punctatus* Lütken, 1852, *Omobranchus punctatus*, *Butis koilomatodon*, *Sphoeroides testudineus* (Linnaeus, 1758), *Strongylura marina* (Walbaum, 1792), *Trachinocephalus myops* (Forster, 1801), and *Tylosurus acus* (Lacepède, 1803).

Most of the species from Araçá Bay (32%) are largely distributed throughout the subtropical and tropical Western Atlantic Ocean, while 25% belong to the



**Figure 2.** Relative frequency of the geographic distribution categories of species recorded in Araçá Bay, São Sebastião, SP (Total richness = 126). CT: Circumtropical; TA: Trans-Atlantic; WA: Western Atlantic; SWA: Southern West Atlantic; SSWA: Southern South West Atlantic; Ca: Caribbean; Br: Brazilian Province; EA: Eastern Atlantic; EP: Eastern Pacific.

Caribbean and Brazilian Province (a combination of the Ca and Br categories). A total of 3.2% species is restricted to the Brazilian Province, and 2.4% are distributed along the southern part of the Western Atlantic (Figure 2).

The conservation status of fish species from Araçá Bay is shown in the Table 1, and the relative frequency of each category is shown in the Figure 3. Only 29% of the species are ranked within one of the IUCN Red List categories: four species are Data Deficient (DD), 26

are Least Concern (LC), two are Near Threatened (NT; *Albula vulpes* (Linnaeus, 1758) and *Rhinobatos percellens* (Walbaum, 1792)), three are Vulnerable (VU; *Gymnura altavela* (Linnaeus, 1758), *Lutjanus analis* (Cuvier, 1828) and *Lutjanus cyanopterus*), and one species is Endangered (EN; *Epinephelus marginatus* (Lowe, 1834)). According to the Brazilian federal list, only four species are assessed with a Red List category: two species are VU (*Hippocampus reidi* Ginsburg, 1933 and *Lutjanus cyanopterus*), and two species are Critically Endangered (CR; *Epinephelus marginatus* and *Gymnura altavela*). On the other hand, according to the state list, approximately 50% of species are included in some category: 38 species are ranked as DD, eight as Fisheries Management Plan Required (FMPR; *Epinephelus marginatus*, *Hippocampus reidi*, *Lutjanus analis*, *Lutjanus cyanopterus*, *Micropogonias furnieri* (Desmarest, 1823), *Mugil liza* Valenciennes, 1836, *Rhinobatos percellens* and *Sardinella brasiliensis* (Steindachner, 1879)), and nine as NT (*Anchoviella lepidentostole* (Fowler, 1911), *Centropomus parallelus* Poey, 1860, *Centropomus undecimalis* (Bloch, 1792), *Cynoscion jamaicensis* (Vaillant & Bocourt, 1883), *Menticirrhus americanus* (Linnaeus, 1758), *Opisthonema oglinum* (Linnaeus, 1758), *Orthopristis ruber* (Cuvier, 1830), *Pomatomus saltatrix* (Linnaeus, 1766) and *Selene setapinnis* (Mitchill, 1815)).

## DISCUSSION

The fish fauna of Araçá Bay is composed of the same pool of species found in other areas along the south-eastern Brazilian coast, such as Sepetiba Bay, Rio de

**Table 1.** Fish species recorded in Araçá Bay, São Sebastião Channel, northern coast of São Paulo, Brazil. Geographic distribution categories (GD); conservation status of the species: the IUCN Red List of Threatened Species (IUCN 2014), the Ordinance of the Ministry of Environment n° 445, of 17 December 2014 (BR) (Brasil 2014) and the Decree N° 60.133 of 7 February 2014 (SP) (Governo do Estado de São Paulo 2014). No geographic distribution category was attributed for *Omobranchus punctatus*, and *Butis koilomatodon* since they are originally from the Indo-Pacific. Abbreviations of geographic distribution and conservation status are in figure 2 and 3, respectively. \* Species for which vouchers are not available, due to problems in the preservation of the exemplars.

Species	Local common names	English common names	Distribution	IUCN	BR	SP
<b>ELASMOBRANCHII</b>						
<b>TORPEDINIFORMES</b>						
<b>Narcinidae</b>						
<i>Narcine brasiliensis</i> (Olfers, 1831)*	Raia-elétrica, Treme-treme	Brazilian Electric Ray	WA	DD	NE	DD
<b>RAJIFORMES</b>						
<b>Rhinobatidae</b>						
<i>Rhinobatos percellens</i> (Walbaum, 1792)	Raia-viola	Chola Guitarfish	TA	NT	NE	NFMP
<b>MYLIOBATIFORMES</b>						
<b>Dasyatidae</b>						
<i>Dasyatis guttata</i> (Bloch & Schneider, 1801)	Raia-lixo, Raia-branca	Longnose Stingray	Ca+Br	DD	NE	DD
<i>Dasyatis hypostigma</i> Santos & Carvalho, 2004	Raia-manteiga, Raia-prego	Bluntnose Stingray	SSWA	DD	NE	DD
<b>Gymnuridae</b>						
<i>Gymnura altavela</i> (Linnaeus, 1758)*	Raia-amarela, Raia-borboleta	Spiny Butterfly Ray	TA	VU	CR	DD
<b>ACTINOPTERYGII</b>						
<b>ELOPIFORMES</b>						
<b>Elopidae</b>						
<i>Elops saurus</i> Linnaeus, 1766	Ubarana	Ladyfish	Ca+Br	LC	NE	NE
<b>ALBULIFORMES</b>						
<b>Albulidae</b>						
<i>Albula vulpes</i> (Linnaeus, 1758)	Ubarana-focinho-de-rato	Bonefish	CT	NT	NE	NE

Continued

Table 1. Continued.

Species	Local common names	English common names	Distribution	IUCN	BR	SP
<b>ANGULIFORMES</b>						
<b>Muraenidae</b>						
<i>Gymnothorax ocellatus</i> Agassiz, 1831	Moréia, Moréia-pintada	Ocellated Moray	Ca+Br	NE	NE	NE
<b>Ophichthidae</b>						
<i>Myrophis punctatus</i> Lütken, 1852	Moréia, Enguia	Speckled Worm-Eel	WA	NE	NE	NE
<i>Ophichthus gomesii</i> (Castelnau, 1855)	Peixe-cobrado-mar	Shrimp Eel	WA	NE	NE	NE
<b>CLUPEIFORMES</b>						
<b>Clupeidae</b>						
<i>Harengula clupeola</i> (Cuvier, 1829)	Sardinha-cascuda	False Herring, False Pilchard	Ca+Br	NE	NE	DD
<i>Opisthonema oglinum</i> (Lesueur, 1818)	Sardinha-bandeira	Atlantic Thread Herring	Ca+Br	NE	NE	NT
<i>Sardinella brasiliensis</i> (Steindachner, 1879)	Sardinha, Sardinha-verdadeira	Brazilian Sardinella	Ca+Br+SSWA	NE	NE	NFMP
<b>Engraulidae</b>						
<i>Anchoa lyolepis</i> (Evermann & Marsh, 1900)	Manjuba	Shortfinger Anchovy	WA	NE	NE	DD
<i>Anchoa tricolor</i> (Spix & Agassiz, 1829)	Manjuba, Irico	Piquitinga Anchovy	SWA	NE	NE	DD
<i>Anchovia clupeoides</i> (Swainson, 1839)	Sardinha, Manjuba	Zabaleta Anchovy	Ca+Br	NE	NE	NE
<i>Anchoviella lepidentostole</i> (Fowler, 1911)	Manjuba	Broadband Anchovy	Br	NE	NE	NT
<i>Lycengraulis grossidens</i> (Spix & Agassiz, 1829)	Manjuba	Atlantic Sabretooth Anchovy	Ca+Br+SSWA	NE	NE	NE
<b>Pristigasteridae</b>						
<i>Pellona harroweri</i> (Fowler, 1917)	Sardinha-manteiga	American Coastal Pellona	Ca+Br	NE	NE	NE
<b>SILURIFORMES</b>						
<b>Ariidae</b>						
<i>Genidens genidens</i> (Cuvier, 1829)	Bagre	Catfish	Br	LC	NE	DD
<b>AULOPIFORMES</b>						
<b>Synodontidae</b>						
<i>Synodus foetens</i> (Linnaeus, 1758)	Peixe-lagarto	Inshore Lizardfish	WA	NE	NE	NE
<i>Trachinocephalus myops</i> (Forster, 1801)	Peixe-lagarto	Snakefish	CT	LC	NE	NE
<b>MUGILIFORMES</b>						
<b>Mugilidae</b>						
<i>Mugil curema</i> Valenciennes, 1836	Parati	White Mullet	TA+EP	NE	NE	DD
<i>Mugil hospes</i> Jordan & Culver, 1895	Parati	Hospe Mullet	Ca+Br+EP	LC	NE	DD
<i>Mugil incilis</i> Hancock, 1830	Parati	Parassi Mullet	Ca+Br	LC	NE	NE
<i>Mugil liza</i> Valenciennes, 1836	Tainha	Lebranche Mullet	Ca+Br+SSWA	NE	NE	NFMP
<b>GOBIESOCIFORMES</b>						
<b>Gobiesocidae</b>						
<i>Gobiesox barbatulus</i> Starks, 1913	Pregador	Lappetlip Clingfish	Ca+Br	NE	NE	NE
<i>Gobiesox strumosus</i> Cope, 1870	Maria-da-toca, Piramangaba	Skilletfish	WA+EP	NE	NE	NE
<b>ATHERINIFORMES</b>						
<b>Atherinopsidae</b>						
<i>Atherinella brasiliensis</i> (Quoy & Gaimard, 1825)	Peixe-rei	Brazilian Silversides	Br	NE	NE	NE
<b>CYPRINODONTIFORMES</b>						
<b>Poeciliidae</b>						
<i>Poecilia vivipara</i> Bloch & Schneider, 1801	Guarú	-	Ca+Br+SSWA	NE	NE	NE
<b>BELONIFORMES</b>						
<b>Belonidae</b>						
<i>Strongylura marina</i> (Walbaum, 1792)	Agulha	Atlantic Needlefish	WA	LC	NE	DD
<i>Strongylura timucu</i> (Walbaum, 1792)	Agulha	Timucu	Ca+Br	NE	NE	DD
<i>Tylosurus acus</i> (Lacepède, 1803)	Agulhão	Agujon Needlefish	TA	NE	NE	DD
<b>Hemiramphidae</b>						
<i>Hemiramphus brasiliensis</i> (Linnaeus, 1758)	Agulha-preta, Agulhinha	Ballyhoo Halfbeak	TA	NE	NE	DD
<i>Hyporhamphus roberti</i> (Valenciennes, 1847)	Agulha	Slender Halfbeak	Ca+Br	LC	NE	DD
<i>Hyporhamphus unifasciatus</i> (Ranzani, 1841)	Peixe-agulha	Common Halfbeak	Ca+Br+SSWA	NE	NE	DD
<b>SYNGNATHIFORMES</b>						
<b>Syngnathidae</b>						
<i>Cosmocampus elucens</i> (Poey, 1868)	Peixe-cachimbo	Shortfin Pipefish	WA	LC	NE	NE
<i>Hippocampus reidi</i> Ginsburg, 1933	Cavalo-marinho	Longsnout Seahorse	WA	DD	VU	NFMP
<b>SCORPAENIFORMES</b>						
<b>Dactylopteridae</b>						
<i>Dactylopterus volitans</i> (Linnaeus, 1758)	Coió, Voador	Flying Gurnard	TA	NE	NE	NE
<b>Scorpaenidae</b>						
<i>Scorpaena brasiliensis</i> Cuvier, 1829	Mangangá, Beatinha	Barbfish	WA	NE	NE	NE
<i>Scorpaena plumieri</i> Bloch, 1789	Peixe-pedra, Mangangá	Spotted Scorpionfish	TA	NE	NE	NE

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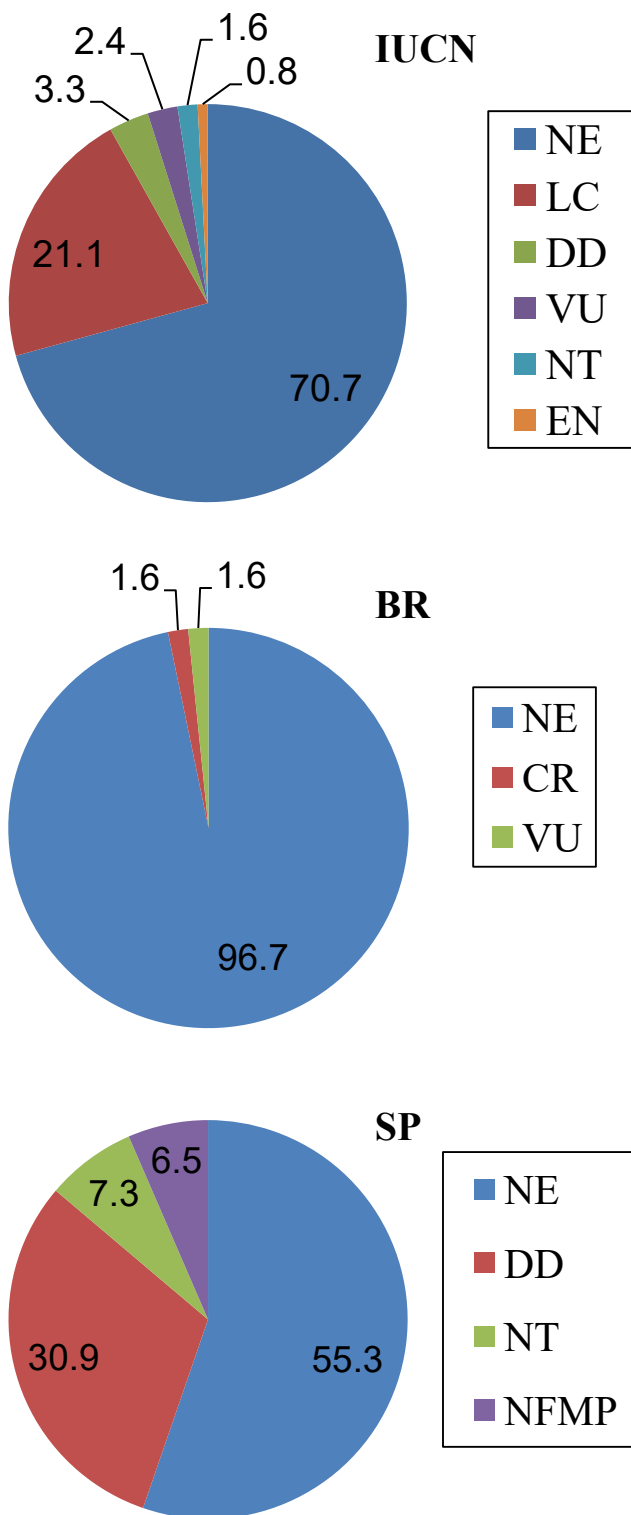
Table 1. Continued.

Species	Local common names	English common names	Distribution	IUCN	BR	SP
<b>Triglidae</b>						
<i>Prionotus punctatus</i> (Bloch, 1793)	Peixe-cabra, Cabrinha	Bluewing Searobin	Ca+Br+SSWA	NE	NE	NE
<b>PERCIFORMES</b>						
<b>Centropomidae</b>						
<i>Centropomus parallelus</i> Poey, 1860	Robalo-peva	Fat Snook	Ca+Br	NE	NE	NT
<i>Centropomus undecimalis</i> (Bloch, 1792)	Robalo-flecha	Common Snook	WA	NE	NE	NT
<b>Serranidae</b>						
<i>Dipllectrum formosum</i> (Linnaeus, 1766)	Michole-da-areia	Sand Perch	WA	NE	NE	NE
<i>Dipllectrum radiale</i> (Quoy & Gaimard, 1824)	Michole-da-areia, Jacundá	Pond Perch	Ca+Br+SSWA	NE	NE	NE
<i>Epinephelus marginatus</i> (Lowe, 1834)	Garoupa, Garoupa-verdadeira	Dusky Grouper	TA	EN	CR	NFMP
<i>Mycteroperca acutirostris</i> (Valenciennes, 1828)	Badejo-mira	Comb Grouper	Ca+Br	LC	NE	NE
<b>Pomatomidae</b>						
<i>Pomatomus saltatrix</i> (Linnaeus, 1766)	Anchova	Bluefish	CT	NE	NE	NT
<b>Carangidae</b>						
<i>Caranx hippos</i> (Linnaeus, 1766)*	Xaréu, Aracimbora	Common Jack, Crevalle Jack	TA	NE	NE	NE
<i>Caranx latus</i> Agassiz, 1831	Xerelete	Horse-eye Jack	TA	NE	NE	NE
<i>Chloroscombrus chrysurus</i> (Linnaeus, 1766)	Palombeta, Carapau	Atlantic Bumper	TA	NE	NE	NE
<i>Hemicaranx amblyrhynchus</i> (Cuvier, 1833)	Cabeça dura, Vento-leste	Bluntnose Jack	WA	NE	NE	NE
<i>Oligoplites saliens</i> (Bloch, 1793)	Guaivira	Castin Leatherjacket	Ca+Br+SSWA	NE	NE	NE
<i>Oligoplites saurus</i> (Bloch & Schneider, 1801)	Tibiro de couro	Leatherjacket	WA+EP	NE	NE	NE
<i>Selene setapinnis</i> (Mitchill, 1815)	Galo	Atlantic Moonfish	WA	NE	NE	NT
<i>Selene vomer</i> (Linnaeus, 1758)	Galo de penacho	Lookdown	WA	NE	NE	NE
<i>Trachinotus carolinus</i> (Linnaeus, 1766)	Pampo	Florida Pompano	WA	NE	NE	NE
<i>Trachinotus falcatus</i> (Linnaeus, 1758)	Sernambiguara	Permit	WA	NE	NE	NE
<i>Trachinotus goodei</i> Jordan & Evermann, 1896	Pampo-galhudo	Great Pompano	WA	LC	NE	NE
<b>Lutjanidae</b>						
<i>Lutjanus analis</i> (Cuvier, 1828)	Caranho-vermelho	Mutton Snapper	WA	VU	NE	NFMP
<i>Lutjanus cyanopterus</i> (Cuvier, 1828)	Caranha	Cubera Snapper	WA	VU	VU	NFMP
<i>Lutjanus synagris</i> (Linnaeus, 1758)	Ariocó, Vermelho-ariocó	Lane Snapper	WA	NE	NE	NE
<b>Gerreidae</b>						
<i>Diapterus rhombeus</i> (Cuvier, 1829)	Carapeba	Caitipa Mojarra	Ca+Br	NE	NE	NE
<i>Eucinostomus argenteus</i> Baird & Girard, 1855	Carapicu	Silver Mojarra	WA+EP	NE	NE	NE
<i>Eucinostomus gula</i> (Quoy & Gaimard, 1824)	Carapicu	Jenny Mojarra	WA	NE	NE	DD
<i>Eucinostomus melanopterus</i> (Bleeker, 1863)	Carapicu	Flagfin Mojarra	TA	NE	NE	NE
<i>Eugerres brasillianus</i> (Cuvier, 1830)	Caratinga	Brazilian Mojarra	WA	NE	NE	DD
<b>Haemulidae</b>						
<i>Anisotremus surinamensis</i> (Bloch, 1791)	Sargo-beiçudo, Sargo-de-beiço	Black Margate	Ca+Br	NE	NE	NE
<i>Anisotremus virginicus</i> (Linnaeus, 1758)	Salema	Porkfish	Ca+Br	NE	NE	NE
<i>Conodon nobilis</i> (Linnaeus, 1758)*	Roncador	Barred Grunt	Ca+Br	NE	NE	DD
<i>Haemulon steindachneri</i> (Jordan & Gilbert, 1882)	Corcoroca-boca-larga, Macasso	Chere-chere Grunt	WA+EP	LC	NE	NE
<i>Haemulopsis corvinaeformis</i> (Steindachner, 1868)	Corcoroca legitima, coró-branco	Roughneck Grunt	Ca+Br	NE	NE	NE
<i>Orthopristis ruber</i> (Cuvier, 1830)	Corcoroca jurumirim, Canguito	Corocoro Grunt	Ca+Br	NE	NE	NT
<b>Sparidae</b>						
<i>Archosargus rhomboidalis</i> (Linnaeus, 1758)	Canhanha, Salema	Sea Bream	WA	LC	NE	NE
<i>Calamus penna</i> (Valenciennes, 1830)	Peixe-pena	Sheepshead Porgy	Ca+Br	LC	NE	NE
<i>Diplodus argenteus</i> (Valenciennes, 1830)	Pargo-branco	Silver Porgy	Ca+Br+SSWA	LC	NE	NE
<b>Polynemidae</b>						
<i>Polydactylus virginicus</i> (Linnaeus, 1758)	Barbudo, Parati-barbudo	Barbu	WA	NE	NE	NE
<b>Sciaenidae</b>						
<i>Ctenosciaena gracilicirrus</i> (Metzelaar, 1919)	Pescada cascuda, Goretê	Barbel Drum	Ca+Br	NE	NE	NE
<i>Cynoscion jamaicensis</i> (Vaillant & Bocourt, 1883)	Goete	Jamaica Weakfish	Ca+Br+SSWA	NE	NE	NT
<i>Cynoscion leiarchus</i> (Cuvier, 1830)	Pescada-branca	Smooth Weakfish	Ca+Br	NE	NE	DD
<i>Isopisthus parvipinnis</i> (Cuvier, 1830)*	Corvina manteiga, Pescada-mole	Bigtooth Corvina	Ca+Br	NE	NE	NE
<i>Larimus breviceps</i> Cuvier, 1830	Oveva	Shorthead Drum	Ca+Br	NE	NE	NE
<i>Menticirrus americanus</i> (Linnaeus, 1758)	Papa-terra, Judeu	Southern Kingcroaker	WA	NE	NE	NT
<i>Micropogonias furnieri</i> (Desmarest, 1823)	Corvina	Whitemouth Croaker	Ca+Br+SSWA	NE	NE	NFMP
<i>Odontoscia dentex</i> (Cuvier, 1830)	Pescada	Reef Croaker	Ca+Br	NE	NE	DD
<i>Umbrina coroides</i> Cuvier, 1830	Castanha-riscada, Corvina-riscada	Sand Drum	Ca+Br	NE	NE	NE
<b>Mullidae</b>						
<i>Upeneus parvus</i> Poey, 1852	Trilha	Dwarf Goatfish	WA	NE	NE	DD

Continued

Table 1. Continued.

Species	Local common names	English common names	Distribution	IUCN	BR	SP
<b>Chaetodontidae</b>						
<i>Chaetodon striatus</i> Linnaeus, 1758	Peixe-borboleta	Banded Butterflyfish	WA	LC	NE	NE
<b>Kyphosidae</b>						
<i>Kyphosus incisor</i> (Cuvier, 1831)	Pirajica	Yellow Sea Chub	TA	NE	NE	NE
<i>Kyphosus sectatrix</i> (Linnaeus, 1758)	Pirajica	Bermuda Sea Chub	TA	NE	NE	NE
<b>Pomacentridae</b>						
<i>Abudefduf saxatilis</i> (Linnaeus, 1758)	Sargentinho, Sinhá-rosa	Sergeant-Major	TA	NE	NE	NE
<b>Scaridae</b>						
<i>Nicholsina usta usta</i> (Valenciennes, 1840)	Budião	Emerald Parrotfish	WA	LC	NE	NE
<b>Uranoscopidae</b>						
<i>Astroscopus y-graecum</i> (Cuvier, 1829)	Miracéu	Southern Stargazer	WA	NE	NE	DD
<b>Labrisomidae</b>						
<i>Labrisomus nuchipinnis</i> (Quoy & Gaimard, 1824)	Guavina, Macaco	Hairy Blenny	TA	LC	NE	NE
<i>Malacoctenus delalandii</i> (Valenciennes, 1836)	Macaquino	Brazilian Blenny	Ca+Br	LC	NE	NE
<b>Blenniidae</b>						
<i>Hypleurochilus fissicornis</i> (Quoy & Gaimard, 1824)	Maria-da-toca	-	SWA	LC	NE	NE
<i>Omobranchus punctatus</i> (Valenciennes, 1836)	-	Muzzled Blenny	-	NE	NE	NE
<i>Parablennius pilicornis</i> (Cuvier, 1829)	Maria-da-toca	Ringneck Blenny	TA	LC	NE	NE
<i>Scartella cristata</i> (Linnaeus, 1758)	Peixe macaco	Molly Miller	TA	LC	NE	NE
<b>Gobiidae</b>						
<i>Bathygobius soporator</i> (Valenciennes, 1837)	Amboré	Frillfin Goby	TA+EP	NE	NE	NE
<i>Ctenogobius boleosoma</i> (Jordan & Gilbert, 1882)	Amboré, Rondon	Darter Goby	WA	NE	NE	NE
<i>Ctenogobius smaragdus</i> (Valenciennes, 1837)	Amboré, Maria-da-toca	Emerald Goby	WA	NE	NE	NE
<i>Gobionellus stomatus</i> Starks, 1913*	Amoré	-	Br	NE	NE	NE
<i>Gobionellus oceanicus</i> (Pallas, 1770)	Amoré	Highfin Goby	WA	NE	NE	NE
<i>Microgobius meeki</i> Evermann & Marsh, 1899*	Amboré	-	Ca+Br	NE	NE	NE
<b>Eleotridae</b>						
<i>Butis koilomatodon</i> (Bleeker, 1849)	Barrigudo, Dorminhoco	Mud Sleeper	-	NE	NE	NE
<b>Ephippidae</b>						
<i>Chaetodipterus faber</i> (Broussonet, 1782)	Paru, Enxada	Atlantic Spadefish	WA	NE	NE	NE
<b>Sphyaenidae</b>						
<i>Sphyaena tome</i> Fowler, 1903*	Bicuda, Barracuda	-	SSWA	NE	NE	DD
<b>Trichiuridae</b>						
<i>Trichiurus lepturus</i> Linnaeus, 1758	Peixe-espada	Largehead Hairtail	CT	NE	NE	NE
<b>Scombridae</b>						
<i>Scomberomorus brasiliensis</i> Collette, Russo & Zavala-Camin, 1978	Sororoca	Serra Spanish Mackerel	Ca+Br	LC	NE	DD
<b>PLEURONECTIFORMES</b>						
<b>Paralichthyidae</b>						
<i>Citharichthys arenaceus</i> Evermann & Marsh, 1900	Linguado	Sand Whiff	Ca+Br	NE	NE	DD
<i>Citharichthys macrops</i> Dresel, 1885	Linguado	Spotted Whiff	WA	NE	NE	DD
<i>Citharichthys spilopterus</i> Günther, 1862	Linguado, Solha-linguada	Bay Whiff	WA	NE	NE	DD
<i>Etropus crossotus</i> Jordan & Gilbert, 1882	Linguado, Solha	Fringed Flounder	WA+EP	NE	NE	DD
<i>Etropus longimanus</i> Norman, 1933	Linguado	-	SSWA	NE	NE	DD
<i>Syacium papillosum</i> (Linnaeus, 1758)	Linguado	Dusky Flounder	WA	NE	NE	DD
<b>Bothidae</b>						
<i>Bothus ocellatus</i> (Agassiz, 1831)	Linguado	Eyed Flounder	WA	NE	NE	DD
<b>Achiridae</b>						
<i>Achirus lineatus</i> (Linnaeus, 1758)	Linguado, Solha	Lined Sole	Ca+Br+SSWA	NE	NE	DD
<b>Cynoglossidae</b>						
<i>Symphurus tessellatus</i> (Quoy & Gaimard, 1824)	Língua-de-mulata	Tessellated Tonguefish	Ca+Br+SSWA	NE	NE	DD
<b>TETRAODONTIFORMES</b>						
<b>Monacanthidae</b>						
<i>Stephanolepis hispidus</i> (Linnaeus, 1766)	Peixe-porco	Planehead Filefish	TA	NE	NE	NE
<b>Tetraodontidae</b>						
<i>Lagocephalus laevigatus</i> (Linnaeus, 1766)	Baiacu	Smooth Puffer	WA	LC	NE	DD
<i>Sphoeroides greeleyi</i> Gilbert, 1900	Baiacu	Green Puffer	Ca+Br	LC	NE	DD
<i>Sphoeroides spengleri</i> (Bloch, 1785)	Baiacu	Bandtail Puffer	WA	LC	NE	DD
<i>Sphoeroides testudineus</i> (Linnaeus, 1758)	Baiacu	Checkered Puffer	WA	LC	NE	DD
<b>Diodontidae</b>						
<i>Chilomycterus spinosus</i> (Linnaeus, 1758)	Baiacu, Baiacu-de-espinho	Brown Burrfish	Br+SSWA	NE	NE	DD



**Figure 3.** Relative frequency of the conservation status of species recorded in Araçá Bay (total richness = 126) in the IUCN Red List (IUCN 2014), in the federal list (BR; Brasil 2014), and in the state list (SP; Governo do Estado de São Paulo 2014). IUCN: NE – Not Evaluated; LC – Least Concern; DD – Data Deficient; VU – Vulnerable; NT – Near Threatened; EN – Endangered. BR: NE – Not Evaluated; VU – Vulnerable; CR – Critically Endangered. SP: NE – Not Evaluated; DD – Data Deficient; NT – Near Threatened; NFMP – Needed Fisheries Management Plan. For the IUCN classification criteria see ‘The IUCN Red List of Threatened Species’ (IUCN 2014), for the federal classification criteria see the Ordinance of the Ministry of Environment nº 445, of 17 December 2014 (Brasil 2014) and for the state classification criteria see the Decree Nº 60.133 of 7 February 2014 (Governo do Estado de São Paulo 2014).

Janeiro (Araújo et al. 2002), and Flamengo Cove, Ubatuba (Mattox et al. 2014). In Araçá Bay, as in those areas, the richest families in terms of species were Sciaenidae, Haemulidae, Paralichthyidae, and Carangidae. In fact, such families, especially Carangidae and Sciaenidae, are commonly found throughout the Brazilian coast (Vazzoler et al. 1999).

Although potential differences in fish species composition may be due to differences in the sampling processes and protocols, a comparison of the Araçá Bay species composition to other southeastern Brazilian coastal ecosystems might be informative. The richness of Araçá Bay (126 spp.) is greater than on the Ubatuba shelf, where a total of 79 and 111 species were reported by Rocha and Rossi-Wongtschowski (1998), and Costa (2014), respectively. A lesser richness than in Araçá Bay was also found in adjacent regions of the SSC by Rossi-Wongtschowski et al. (2008), and Gibran and Moura (2012), who found 65 and 68 species, respectively. The high species richness encountered in the present study may be due to the varied (nine) gear types used, while the other studies used only one. These comparisons emphasize the importance of combining different sampling methods to attain a more complete picture of the species composition in fish assemblages (Olin and Malinen 2003). It is worth pointing out that Araçá Bay shares approximately half of its fish fauna with the SSC (43%, Lamas 2015), which suggests a considerable connectivity of species.

A bottom trawl survey carried out 20 years ago in the outer sublittoral of the Araçá Bay recorded the following species not recorded in the present study: *Chirocentron bleekermanus* (Poey, 1867), *Cyclosetta chittendeni* Bean, 1895, *Dules auriga* Cuvier, 1829, *Epinephelus morio* (Valenciennes, 1828), *Hyporthodus nigritus* (Holbrook, 1855), *Ogcocephalus verpertilio* (Linnaeus, 1758), *Porichthys porosissimus* (Cuvier, 1829), *Sphoeroides tyleri* Shipp, 1972 and *Trinectes paulistanus* (Miranda Ribeiro, 1915) (Muto et al. 2000). The absence of these species in our samples may be due to sampling effort but also potential differences in fish community between 1994 and 2016. For this reason, these species have not been included in the present checklist.

Most of the fish fauna of Araçá Bay is either widely distributed throughout the subtropical and tropical Western Atlantic, or more restricted to the tropical region (i.e., occurring in both Caribbean and Brazilian Province), and there are also species more related to the temperate region (i.e., southern South West Atlantic). The geographic distribution pattern of Araçá fishes reflects the bay’s location in the Argentinian zoogeographic province, which extends from Cabo Frio, Rio de Janeiro, to the Valdés Peninsula, Argentina (Caires 2014). The Argentinian zoogeographic province is a large faunistic transition zone, where tropical and



temperate fauna meets, but also has many endemic species (Caires 2014). Three of the endemic fish species, *Dasyatis hypostigma* Santos & Carvalho, 2004, *Sardinella brasiliensis*, and *Sphyræna tome* Fowler, 1903, were recorded in Araçá Bay.

With the expansion of the São Sebastião Port, habitat will be lost within the bay and a substantial increase in pollution from oil spills and sewage may be expected. These are threats to fish populations within the bay. We found legally endangered species, such as *Epinephelus marginatus* and *Gymnura altavela*, in Araçá Bay, which means that measures should be taken to protect their populations during and after the port expansion, as determined by federal legislation (Brasil 2014). Our results also found species in need of fishery management, such as *Hippocampus reidi*, *Lutjanus analis*, *Lutjanus cyanopterus*, *Micropogonias furnieri*, *Mugil liza*, *Rhinobatos percellens* and *Sardinella brasiliensis*, which emphasizes the inclusion of the bay in the regional fisheries planning.

Also important is the presence of two non-native species, *O. punctatus* and *B. koilomatodon*. These species were likely introduced into the bay with ballast water and as part of the biofouling communities on cargo ships that dock in the São Sebastião Port. With the port expansion, a substantial increase in ship traffic is expected, which increases the probability of new introductions. Non-native species pose a threat to native species by out-competing for habitat and resources (Contente et al. 2015; Contente et al. 2016).

Our study also determined that the conservation status of many species found in Araçá Bay, and elsewhere along the Brazilian coast, remains unevaluated. This may be a consequence of the paucity of biological and ecological data on these species, which are needed for ranking status. We found that species often received a different ranking in the state and federal lists, and that the state list classifies many more species as threatened than the federal one. This highlights the disparity of methods and criteria used (Gärdenfors 2001; Possingham et al. 2002).

This study provides the first checklist of the fish species of the Araçá Bay, with remarks on their distribution and conservation, which can be an important tool for future environmental impact, biogeographical and macroecological studies.

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**APPENDIX**

**Table A1.** Voucher number of specimens deposited in the Zoological Museum of the University of São Paulo. Species are in alphabetic order.

Voucher number	Species	Voucher number	Species	Voucher number	Species
MZUSP 118862	<i>Abudefduf saxatilis</i>	MZUSP 118901	<i>Epinephelus marginatus</i>	MZUSP 118940	<i>Nicholsina usta usta</i>
MZUSP 118863	<i>Achirus lineatus</i>	MZUSP 118902	<i>Etropus crossotus</i>	MZUSP 118941	<i>Odontoscion dentex</i>
MZUSP 118864	<i>Albula vulpes</i>	MZUSP 118903	<i>Etropus longimanus</i>	MZUSP 118942	<i>Oligoplites saliens</i>
MZUSP 118865	<i>Anchovia clupeioides</i>	MZUSP 118904	<i>Eucinostomus argenteus</i>	MZUSP 118943	<i>Oligoplites saurus</i>
MZUSP 118866	<i>Anchoviella lepidentostole</i>	MZUSP 118905	<i>Eugerres brasiliensis</i>	MZUSP 118944	<i>Ophichthus gomesii</i>
MZUSP 118867	<i>Anchoa lyoleps</i>	MZUSP 118906	<i>Eucinostomus gula</i>	MZUSP 118945	<i>Opisthonema ogliunum</i>
MZUSP 118868	<i>Anisotremus surinamensis</i>	MZUSP 118907	<i>Eucinostomus melanopterus</i>	MZUSP 118946	<i>Orthopristis ruber</i>
MZUSP 118869	<i>Anchoa tricolor</i>	MZUSP 118908	<i>Genidens genidens</i>	MZUSP 118947	<i>Parablennius pilicornis</i>
MZUSP 118870	<i>Anisotremus virginicus</i>	MZUSP 118909	<i>Gobiesox barbatus</i>	MZUSP 118948	<i>Pellona harroweri</i>
MZUSP 118871	<i>Archosargus rhomboidalis</i>	MZUSP 118910	<i>Gobionellus oceanicus</i>	MZUSP 118949	<i>Pomatomus saltatrix</i>
MZUSP 118872	<i>Astroscopus y-graecum</i>	MZUSP 118911	<i>Gobiesox strumosus</i>	MZUSP 118950	<i>Polydactylus virginicus</i>
MZUSP 118873	<i>Atherinella brasiliensis</i>	MZUSP 118912	<i>Gymnothorax ocellatus</i>	MZUSP 118951	<i>Poecilia vivipara</i>
MZUSP 118874	<i>Bathygobius soporator</i>	MZUSP 118913	<i>Harengula clupeiola</i>	MZUSP 118952	<i>Prionotus punctatus</i>
MZUSP 118875	<i>Bothus ocellatus</i>	MZUSP 118914	<i>Haemulopsis corvinaeformis</i>	MZUSP 118953	<i>Rhinobatos percellens</i>
MZUSP 118876	<i>Caranx latus</i>	MZUSP 118915	<i>Haemulon steindachneri</i>	MZUSP 118954	<i>Sardinella brasiliensis</i>
MZUSP 118877	<i>Calamus penna</i>	MZUSP 118916	<i>Hemicaranx amblyrhynchus</i>	MZUSP 118955	<i>Scomberomorus brasiliensis</i>
MZUSP 118878	<i>Centropomus parallelus</i>	MZUSP 118917	<i>Hemiramphus brasiliensis</i>	MZUSP 118956	<i>Scartella cristata</i>
MZUSP 118879	<i>Centropomus undecimalis</i>	MZUSP 118918	<i>Hippocampus reidi</i>	MZUSP 118957	<i>Scorpaena brasiliensis</i>
MZUSP 118880	<i>Chloroscombrus chrysurus</i>	MZUSP 118919	<i>Hypoleurochilus fissicornis</i>	MZUSP 118958	<i>Scorpaena plumieri</i>
MZUSP 118881	<i>Chaetodipterus faber</i>	MZUSP 118920	<i>Hyporhamphus roberti</i>	MZUSP 118959	<i>Selene setapinnis</i>
MZUSP 118882	<i>Chilomycterus spinosus</i>	MZUSP 118921	<i>Hyporhamphus unifasciatus</i>	MZUSP 118960	<i>Selene vomer</i>
MZUSP 118883	<i>Chaetodon striatus</i>	MZUSP 118922	<i>Kyphosus incisor</i>	MZUSP 118961	<i>Sphoeroides greeleyi</i>
MZUSP 118884	<i>Citharichthys arenaceus</i>	MZUSP 118923	<i>Kyphosus sectatrix</i>	MZUSP 118962	<i>Sphoeroides spengleri</i>
MZUSP 118885	<i>Citharichthys macrops</i>	MZUSP 118924	<i>Larimus breviceps</i>	MZUSP 118963	<i>Sphoeroides testudineus</i>
MZUSP 118886	<i>Citharichthys spilopterus</i>	MZUSP 118925	<i>Lagocephalus laevigatus</i>	MZUSP 118964	<i>Stephanolepis hispidus</i>
MZUSP 118887	<i>Cosmocampus elucens</i>	MZUSP 118926	<i>Labrisomus nuchipinnis</i>	MZUSP 118965	<i>Strongylura marina</i>
MZUSP 118888	<i>Ctenogobius boleosoma</i>	MZUSP 118927	<i>Lutjanus analis</i>	MZUSP 118966	<i>Strongylura sp</i>
MZUSP 118889	<i>Ctenosciaena gracilicirrhus</i>	MZUSP 118928	<i>Lutjanus cyanopterus</i>	MZUSP 118967	<i>Strongylura timucu</i>
MZUSP 118890	<i>Ctenogobius smaragdus</i>	MZUSP 118929	<i>Lutjanus synagris</i>	MZUSP 118968	<i>Synodus foetens</i>
MZUSP 118891	<i>Cynoscion jamaicensis</i>	MZUSP 118930	<i>Lycengraulis grossidens</i>	MZUSP 118969	<i>Syacium papillosum</i>
MZUSP 118892	<i>Cynoscion leiarchus</i>	MZUSP 118931	<i>Malacotenus delalandii</i>	MZUSP 118970	<i>Symphurus tessellatus</i>
MZUSP 118893	<i>Dasyatis guttata</i>	MZUSP 118932	<i>Menticirrhus americanus</i>	MZUSP 118971	<i>Trachinotus carolinus</i>
MZUSP 118894	<i>Dasyatis hypostigma</i>	MZUSP 118933	<i>Micropogonias furnieri</i>	MZUSP 118972	<i>Trachinotus falcatus</i>
MZUSP 118895	<i>Dactylopterus volitans</i>	MZUSP 118934	<i>Mugil curema</i>	MZUSP 118973	<i>Trachinotus goodei</i>
MZUSP 118896	<i>Diplodus argenteus</i>	MZUSP 118935	<i>Mugil hospes</i>	MZUSP 118974	<i>Trichiurus lepturus</i>
MZUSP 118897	<i>Diplectrum formosum</i>	MZUSP 118936	<i>Mugil incilis</i>	MZUSP 118975	<i>Trachinocephalus myops</i>
MZUSP 118898	<i>Diplectrum radiale</i>	MZUSP 118937	<i>Mugil liza</i>	MZUSP 118976	<i>Tylosurus acus</i>
MZUSP 118899	<i>Diapterus rhombeus</i>	MZUSP 118938	<i>Mycteroperca acutirostris</i>	MZUSP 118977	<i>Umbrina coroides</i>
MZUSP 118900	<i>Elops saurus</i>	MZUSP 118939	<i>Myrophis punctatus</i>	MZUSP 118978	<i>Upeneus parvus</i>