Fishes of Paranaguá Estuarine Complex, South West Atlantic

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Abstract: The objective of this work was to present an updated checklist of the currently known fishes in the Paranaguá Estuarine Complex (PEC) and provides comments on conservation status for the treated species. We used a large dataset derived from a pool of studies which have been conducted within there along the last 30 years. Each study was based on monthly samplings and conducted in several estuarine habitat; thus, the pool covers practically all estuarine habitats and takes into account the seasonal cycle in the system. The PEC ichthyofauna represents a mixture between that fauna typical from the tropical Brazilian coast and that with affinities of temperate Argentinean and Uruguayan zones. The PEC harbors a rich fish fauna of 213 species, inserted in the families that are common along the Brazilian coast. Only a minor part (8%) of the PEC fish fauna was evaluated as regards the conservation status, mostly because of the lack of basic biological and ecological information for most species. Despite part of the among-estuaries differences are due to different and incomplete sampling efforts, the richness in the PEC is surprisingly higher than other systems in Brazil and around world, which emphasize the importance of the region for global biodiversity conservation.
Keywords: *ichthyofauna, species list, Paraná, West Atlantic.*

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Resumo: O objetivo deste trabalho é apresentar uma lista de espécies atualizada a partir do conhecimento atual dos peixes no Complexo Estuarino de Paranaguá (CEP), com comentários sobre o status de conservação das espécies. Nós utilizamos um grande conjunto de dados derivados de diversos estudos conduzidos na região ao longo dos últimos 30 anos. Cada estudo foi baseado em amostragens mensais realizadas em diferentes habitats estuarinos. Dessa forma, os dados abrangem praticamente todos os habitats estuarinos e leva em conta o ciclo sazonal no sistema. A ictiofauna do CEP representa uma mistura entre a fauna típica da costa tropical brasileira e da fauna com afinidade com as zonas temperadas argentinas e uruguaias. O CEP abriga 213 espécies, inseridas em famílias que são comuns ao longo da costa brasileira. Apenas uma pequena parte (8%) das espécies foi avaliada quanto ao status de conservação, principalmente por causa da falta de informações biológicas e ecológicas básicas para a maioria das espécies. Apesar de parte das diferenças entre estuários ser devido a diferentes e incompletos esforços amostrais, a riqueza do CEP é surpreendentemente elevada em comparação com outros sistemas do Brasil e ao redor do mundo, o que enfatiza a importância da região para a conservação da biodiversidade global.
Palavras-chave: *ictiofauna, lista de espécies, Paraná, Atlântico Oeste.*

Introduction

The Paranaguá Estuarine Complex (PEC), situated on the coast of Paraná state (Brazil) (25° 16' and 25° 34' S and 48° 17' and 48° 42' W), represents the southern sector of one of the last and least impacted, large Brazilian coastal ecosystems, the subtropical Iguape-Cananéia-Paranaguá estuarine system. This system harbors an important biodiversity, as it is inserted in a global biodiversity hotspot, the southern sector of Brazil's Atlantic Forest Biosphere Reserve (Diegues 1995), and an abundance of socio-economically important fishery stocks (Lana et al. 2001). Several surveys and ecological studies on the fish fauna, most of which based on a monthly sampling design including a diversity of estuarine habitats, have been conducted in the PEC along the last 30 years (e.g. Corrêa et al. 1986, Spach et al. 2003, Félix et al. 2007, Queiroz et al. 2007, Schwarz Junior. et al. 2007, Barletta et al. 2008, Contente et al. 2011). Sampling several areas within several temporal scales increases the species detectability and, thus, our ability to estimate the species richness of a given system (Magurran 2003); thus, such robust spatio-temporal information included in the data derived from the pool of these studies provide a unique opportunity to produce a full list of fish species for this system. A compilation of this nature has twofold: (I) helping to improve our understanding on the geographical distribution and macro-ecological traits of the SW Atlantic estuarine fishes (Barletta & Blaber 2007); and (II) supporting conservation efforts (Barletta et al. 2010). Particular concern must be placed to the region's fish biodiversity that is faced to serious treats, notably due to overfishing, introduction of non-native species, and habitat loss (Lana et al. 2001, Vitule et al. 2006, Caires et al. 2007), and a full check-list of species may be an important tool in impact assessments. For instance, dredgings and buildings of ports result in large impact and an ecosystem scale check-list may serve as a parameter against which the potentially affected pattern of the fish fauna may be compared, thus helping to assess the strength of impact (Sheaves 2006, Barletta et al. 2010). The objective of the present work is, therefore, to present an updated checklist of the currently known fishes in the PEC. Additionally, we provided comments on conservation status for the treated species.

Materials and Methods

1. Study area

The PEC (Figure 1) has an area of 612 km^2 (see map in Lana et al. 2001) characterized by distinct areas and densities of drainage, tidal flats and mean depths (Noernberg et al. 2004). The system has a diversity of habitats, like tidal flats, channels, mangroves (mainly composed by *Rhizophora mangle*, *Avicennia schaueriana*, *Laguncularia racemosa*, and *Conocarpus erectus*; Lana et al. 2001) fringed by *Spartina alterniflora* bank salt-marshes, tidal creeks, estuarine beaches, rivers, and rock shores near the mouth of the

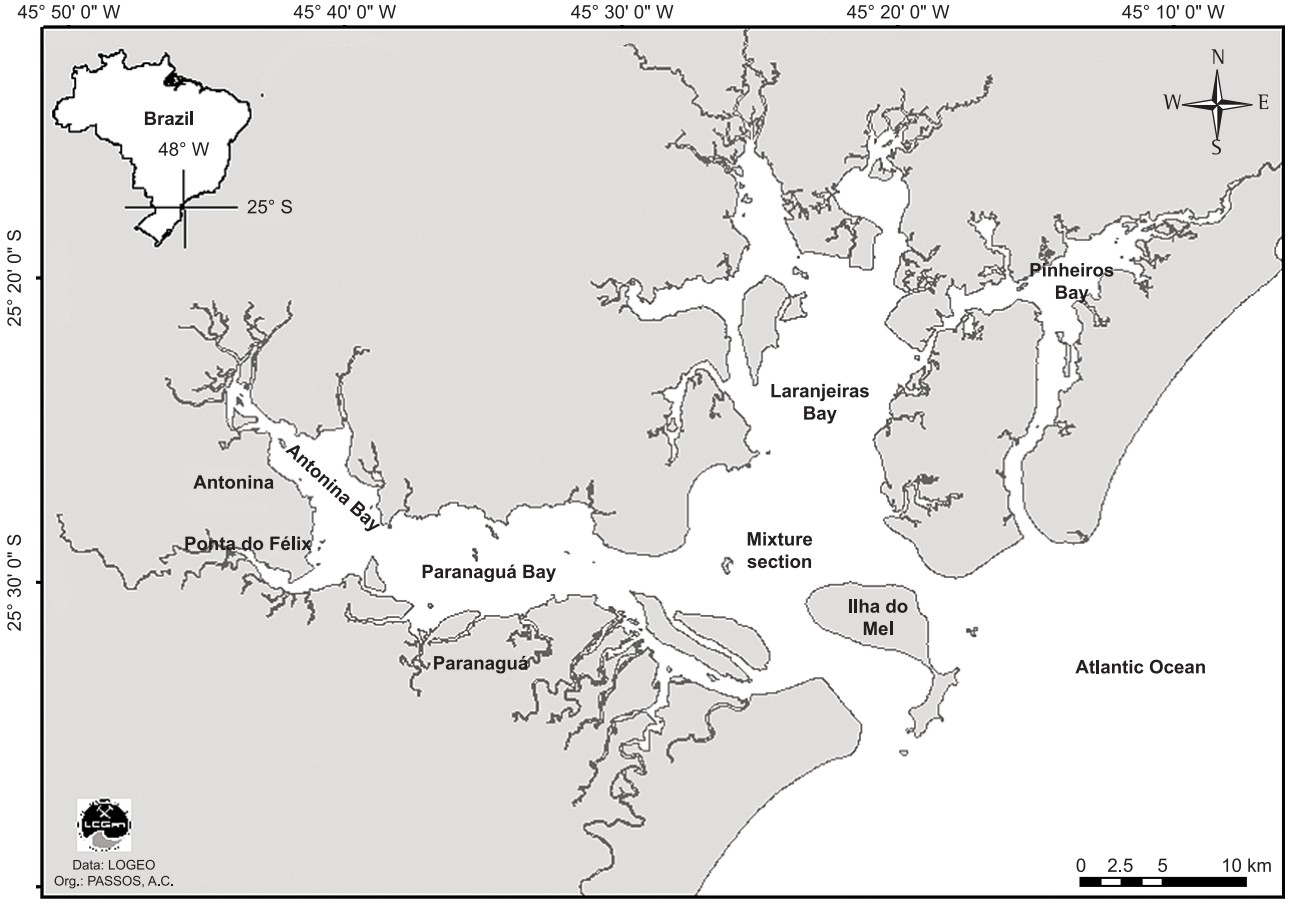

Figure 1. Map of Paranaguá Estuarine Complex, showing the five central sectors (Antonina, Paranaguá, Laranjeiras, mixing zone and Pinheiros); and the position of port areas (ports of Paranaguá, Antonina and Ponta do Félix).

Figura 1. Mapa do Complexo Estuarino de Paranaguá, mostrando as Baías de Antonina, Paranaguá, das Laranjeiras, Pinheiros e setor de mistura; e a localização dos Portos de Paranaguá, Antonina e Ponta do Félix.

estuary. The PEC, a partially mixed estuary with semidiurnal tides and diurnal inequality (Knoppers et al. 1987), is connected to the Cananéia Estuarine Complex, in the north, by the Ararapira Channel and to the Atlantic Ocean, in the east, by Sueste Channel and Galheta Channel. The climate of the region is tropical (transition), with a mean annual rainfall of 2500 mm (maximum 3500 mm). The rainy season typically starts at the end of spring and lasts until nearly the end of summer. The dry season lasts from the end of autumn to the end of winter, but is interrupted by a short low-intensity rainy period that occurs at the beginning of winter (Lana et al. 2001). To further details on the system, see Lana et al. (2001) and Marone et al. (2005).

2. *Data collection and treatment of the data*

This work is based on the compilation of data from unpublished PhD thesis and master dissertations (i.e. Abilhôa 1998, Pinheiro 1999, Fávaro 2004, Nakayama 2004, Stefanoni 2007, Pichler 2009) and from the literature dealing with the PEC fish community (e.g. Corrêa et al. 1986, Godefroid et al. 1997, 1999, Santos et al. 2002, Vendel et al. 2002, Spach et al. 2003, Vendel et al. 2003, Spach et al. 2004a, b, 2006, Félix et al. 2007, Queiroz et al. 2007, Schwarz Junior et al. 2007, Barletta et al. 2008, Oliveira Neto et al. 2008, Pichler et al. 2008, Cortellete et al. 2009, Hackradt et al. 2009, Ignácio & Spach 2009, Contente et al. 2011). It is important to highlight that this study is representative of most habitats (e.g. tidal flats, channels, vegetated wetlands, tidal creeks, estuarine beaches, rivers) and the extension of the system, i.e., from the representative, upper tidal freshwater reaches (like upper Antonina Bay Estuary and upper Guaragaçu River Estuary) to the mouths of the estuary (like Pontal do Sul and Ilha das Peças beaches). Practically all studies were took place with monthly samplings along the seasonal cycle. The species in this study were reviewed as regards the taxonomic classification and the nomenclature based on Marceniuk (2005), Craig & Hastings (2007), Smith & Craig (2007), Eschmeyer (2010), Carvalho-Filho et al. (2010), Figueiredo et al. (2010), and Menezes et al. (2010). *Mugil* sp. was used for the species usually identified under the invalid name *Mugil gaimardianus* (Menezes et al. 2003). The orders and families were listed in phylogenetic order according to Eschmeyer (2010) and the species were organized within each family in alphabetical order. To analyze zoogeographic affinities, the distribution of each species was verified from the literature and then inserted into the adapted categories based on Floeter et al. (2008) and Luiz Junior et al. (2008) as follows: CT = Circumtropical, TA = Trans-Atlantic (western and eastern Atlantic Ocean), WA = Western Atlantic (northern and southern Atlantic Ocean), SWA = Southern West Atlantic (from northern Brazil to Argentina), SSWA = Southern South West Atlantic (species with temperate affinities occurring from Argentina and Uruguay to the south and southeast of Brazil), Ca = Caribbean (from Florida state to Venezuela), Br = Brazilian Province (area between the Orinoco Delta in Venezuela and Santa Catarina in Brazil), EA = Eastern Atlantic and EP = Eastern Pacific. The status of species conservation was based both on the International Union for Conservation of Nature list (International... 2012) and the Ministry of the Environment list for endangered fauna (Brasil 2004, 2008).

Results and Discussion

The ichthyofauna of the PEC consists of 213 species, distributed in 21 orders and 65 families (Table 1). A total of 97% (208 spp.) are Actinopterygii and 3% (5), Elasmobranchii. Twenty species (i.e. *H. robertii*, *O. vespertilio*, *A. clupeoides*, *A. januaria*, *G. ocellatus*, *S. brasiliensis*, *S. plumieri*, *A. brasilianus*, *M. bonaci*, *L. synagris*, *A. probatocephalus*, *C. penna*, *P. cromis*, *U. parvus*, *G. brasiliensis*, *E. pisonis*, *S. picudilla*, *A. solandri*, *P. patagonicus* and *T. microphthalmus*) were recorded for the first time for the PEC. Perciformes (116) dominated in number of species, followed by Clupeiformes (20), Pleuronectiformes (17), and Syngnathiformes (8). The most speciose family was Sciaenidae (23), followed by Carangidae (17), Engraulidae (12), Gobiidae (9), Haemulidae (9), and Paralichthyidae (9). This is supported by Andrade-Tubino et al. (2008) that state such families among the most important in Brazilian coast, and by Vieira & Musick (1994), which reveal them as the most conspicuous in SW Atlantic estuarine fish assemblages. Carangidae and Sciaenidae were also the two most speciose families in the two large estuaries near the PEC, the Guaratuba Bay, located just south of the PEC, and the Babitonga Bay, located 70 Km south of the PEC (Chaves & Corrêa 1998, Chaves & Vendel 2001, Vilar et al. 2011). *Anchoa* and *Cynoscion* had six species each and were the richest genera in the PEC. The following were *Mugil*, with five species, and *Ctenogobius*, *Paralichthys*, *Sphoeroides*, *Sphyraena* and *Trachinotus*, with four species each. This pattern was not found in such nearby estuaries, as *Ctenogobius*, followed by *Eucinostomus* and *Oligoplites* were the richest genera in Guaratuba (Chaves & Corrêa 1998, Chaves & Vendel 2001), and *Mycteroperca*, *Mugil*, *Anchoa*, *Cynoscion*, *Eucinostomus* and *Sphoeroides* were those most rich in Babitonga (Vilar et al. 2011). Comparing the species composition of PEC with that of Babitonga and Guaratuba estuaries reveals a relatively low number shared (just 35%) and relatively a high number of exclusive species (about 40%) of the PEC. This is unexpected because the distribution for most species occurring in all such estuaries overlaps. Such taxonomic differences are most likely due to differences in number of fish survey as well as in fish sampling gear and strategies (see discussion below).

In terms of number of species, the total species richness in the PEC is higher than those reported for large estuaries in Western Atlantic [Guaratuba Bay, southern Brazil (87 spp.; Chaves & Corrêa 1998, Chaves & Vendel 2001); Río de la Plata estuary, northern Argentina (60 spp.; Jaureguizar et al. 2004); Caeté River estuary, northern Brazil (82spp.; Barletta et al. 2005), Sergipe River estuary (136 spp.; Alcântara 2006), Curuçá estuary (98 spp.; Hercos 2006, Giarrizzo & Krumme 2007, Sarpedonti et al. 2008), Babitonga Bay (152 spp.; Vilar et al. 2011), Estuary of Mataripe area (36 spp.; Dias et al. 2011) and Paraguaçu River estuary (124 spp.; Reis-Filho et al. 2010)] as well as for other large, permanently open, tropical estuaries around world (number of species ranging from 81 to 197, Blaber 2002), including those of estuaries from the species-rich Indo Pacific biogeographical zones. Moreover, the PEC has a comparable fauna to large coastal ecosystems, like Gulf of Carpentaria (237 spp.) (Blaber et al. 1990) and Embley estuary (203 spp.) (Barletta & Blaber 2007), which has a large diversity of estuarine habitats, similar to that of PEC. These differences in richness and taxonomic composition may be difficult to explain. Multiple area specific synergic factors act in determining fish fauna patterns, including diversity of estuarine habits, rainfall pattern, hydrograph, oceanographic patterns, and historic dispersion pattern of taxa and so on. These operate in different intensity and scale, producing very distinct fish fauna patterns. For example, in a continental scale, the estuarine area may be critical to determine the fish richness in accordance with the species-area theory. This theory states that, the larger a given system, the larger the number of species, because the number of habitat tend to increase with the area. In fact, the PEC is larger (612 km^2) than the Guaratuba Bay (48 km^2), Babitonga Bay (130 km^2), Sergipe River estuary (47.1 km^2) and Paraguaçu River estuary (127.9 km^2) and this may explain, at least in part, the higher richness in PEC. However, a considerable part of such differences among tropical fish faunas can be attributed to the incomplete effort of surveys on all range of estuarine habitats

Table 1. Taxonomic classification of the ichthyofauna recorded in the Paranaguá Estuarine Complex, Southwest Atlantic.

Tabela 1. Classificação taxonômica da ictiofauna encontrada no Complexo Estuarino de Paranaguá, Atlântico Sul Oeste.

Orders/Families/Species	Geographic distribution	Source
Torpediniformes		
Narcinidae		
Narcine brasiliensis (Olfers 1831)	WA	Spach et al. (2004a)
Rajiformes		
Rhinobatidae		
Rhinobatos horkelii Müller & Henle 1841†	SWA	Barletta et al. (2008)
R. percellens (Walbaum 1792)	TA	Pichler et al. (2008)
Dasyatidae		
Dasyatis guttata (Bloch & Schneider 1801)	Ca+Br	Schwarz Junior et al. (2007)
Gymnuridae		
Gymnura altavela (Linnaeus 1758)	TA	Schwarz Junior et al. (2007)
Elopiformes		
Elopidae		
Elops saurus Linnaeus 1766	WA	Pichler et al. (2008)
Albuliformes		
Albulidae		
Albula vulpes (Linnaeus 1758)	WA	Pichler et al. (2008)
Anguilliformes		
Muraenidae		
Gymnothorax ocellatus Agassiz 1831	Ca+SWA	Nakayama (2004)
Ophichthidae		
Echiophis intertinctus (Richardson 1848)	WA	Spach et al. (2004a)
Myrophis punctatus Lütken 1852	WA	Spach et al. (2004a)
Ophichthus gomesii (Castelnau 1855)	WA	Oliveira Neto et al. (2008)
Congridae		
Conger orbignianus Valenciennes 1837	SSWA	Spach et al. (2004a)
Muraenesocidae		
Cynoponticus savanna (Bancroft 1831)	Ca+Br	Spach et al. (2004a)
Nettastomatidae		
Hoplunnis tenuis Ginsburg 1951	WA	Spach et al. (2004a)
Clupeiformes		
Clupeidae		
Brevoortia sp.	?	Godefroid et al. (1999)
Chirocentrodon bleekerianus (Poey 1867)	Ca+Br	Oliveira Neto et al. (2008)
Harengula clupeola (Cuvier 1829)	WA	Pichler et al. (2008)
H. jaguana Poey 1865	WA	Godefroid et al. (1997)
Opisthonema oglinum (Lesueur 1818)	WA	Pichler et al. (2008)
Platanichthys platana (Regan 1917)	SSWA	Pichler et al. (2008)
Sardinella brasiliensis (Steindachner 1879) ††	SSWA	Pichler et al. (2008)
Engraulidae		
Anchoa filifera (Fowler 1915)	Ca+Br	Godefroid et al. (1997)
A. hepsetus (Linnaeus 1758)	WA	Barletta et al. (2008)
A. januaria (Steindachner 1879)	Br	Pichler (2009)
A. lyolepis (Evermann & Marsh 1900)	WA	Pichler et al. (2008)
A. spinifer (Valenciennes 1848)	Ca+Br+EP	Barletta et al. (2008)
A. tricolor (Spix & Agassiz 1829)	SWA	Pichler et al. (2008)
Anchovia clupeoides (Swainson 1839)	Ca+Br	Nakayama (2004)
Anchoviella brevirostris (Günther 1868)	Br	Barletta et al. (2008)

Geographic distribution: CT = circuntropical, 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 and ? = not found. National conservation status according to Brasil (2004, 2008): †† = overexploited, † = endangered. Global conservation status according to IUCN (2012): § = least concern, ‡ = data deficient, • = vulnerable, * = critically endangered, # = near threatened. (Distribuição Geográfica: CT = circuntropical, 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 and ? = not found. Status de conservação segundo Brasil (2004, 2008): †† = sobreexplotada, † = em perigo. Status de conservação segundo IUCN (2012): § = menos preocupante, ‡ = dados deficientes, • = vulnerável, * = criticamente em perigo, # = próxima ao perigo).

Table 1. Continued...

Orders/Families/Species	Geographic distribution	Source
A. lepidentostole (Fowler 1911)	Br	Vendel et al. (2002)
Cetengraulis edentulus (Cuvier 1829)	Ca+Br	Pichler et al. (2008)
Engraulis anchoita Hubbs & Marini 1935	SSWA	Ignácio & Spach (2009)
Lycengraulis grossidens (Agassiz 1829)	Br+SWA	Pichler et al. (2008)
Pristigasteridae		
Pellona harroweri (Fowler 1917)	Ca+Br	Spach et al. (2004a)
Siluriformes		
Ariidae		
Bagre bagre (Linnaeus 1766)	Ca+Br	Schwarz Junior et al. (2007)
Cathorops spixii (Agassiz 1829)	Ca+Br	Pichler et al. (2008)
Genidens barbus (Lacepède 1803) ††	SSWA	Queiroz et al. (2007)
G. genidens (Cuvier 1829)	SSWA	Pichler et al. (2008)
Notarius luniscutis (Valenciennes 1840)	Br	Schwarz Junior et al. (2007)
Osmeriformes		
Argentinidae		
Glossanodon pygmaeus Cohen 1958	WA	Godefroid et al. (1999)
Aulopiformes		
Synodontidae		
Synodus foetens (Linnaeus 1766)	WA	Pichler et al. (2008)
Gadiformes		
Phycidae		
Urophycis brasiliensis (Kaup 1858)	SSWA	Barletta et al. (2008)
Batrachoidiformes		
Batrachoididae		
Batrachoides sp.	?	Barletta et al. (2008)
Opsanus beta (Goode & Bean 1880)	Ca	Ignácio & Spach (2009)
Porichthys porosissimus (Cuvier 1829)	SSWA	Oliveira Neto et al. (2008)
Lophiiformes		
Ogcocephalidae		
Ogcocephalus vespertilio (Linnaeus 1758)	Ca+SWA	Pinheiro (1999)
Gobiesociformes		
Gobiesocidae		
Gobiesox strumosus Cope 1870	WA	Godefroid et al. (1997)
Atheriniformes		
Atherinopsidae		
Atherinella brasiliensis (Quoy & Gaimard 1825)	Ca+Br	Pichler et al. (2008)
Membras dissimilis (Carvalho 1956)	SSWA	Godefroid et al. (1999)
Odontesthes bonariensis (Valenciennes 1835)	SSWA	Spach et al. (2004a)
O. incisa (Jenyns 1841)	SSWA	Spach et al. (2004a)
Cyprinodontiformes		
Poeciliidae		
Poecilia vivipara Bloch & Schneider 1801	Br+SWA	Spach et al. (2004a)
Beloniformes		
Belonidae		
Strongylura marina (Walbaum 1792)	WA	Pichler et al. (2008)
S. timucu (Walbaum 1792)	WA	Pichler et al. (2008)
Hemiramphidae		
Hemiramphus brasiliensis (Linnaeus 1758)	TA	Oliveira Neto et al. (2008)
Hyporhamphus roberti (Valenciennes 1847)	WA+EP	Pichler (2009)

Geographic distribution: CT = circuntropical, 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 and ? = not found. National conservation status according to Brasil (2004, 2008): †† = overexploited, † = endangered. Global conservation status according to IUCN (2012): § = least concern, ‡ = data deficient, • = vulnerable, * = critically endangered, # = near threatened. (Distribuição Geográfica: CT = circuntropical, 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 and ? = not found. Status de conservação segundo Brasil (2004, 2008): †† = sobreexplotada, † = em perigo. Status de conservação segundo IUCN (2012): § = menos preocupante, ‡ = dados deficientes, • = vulnerável, * = criticamente em perigo, # = próxima ao perigo).

Table 1. Continued...

Orders/Families/Species	Geographic distribution	Source
H. unifasciatus (Ranzani 1841)	WA+EP	Pichler et al. (2008)
Exocoetidae		
Parexocoetus brachypterus (Richardson 1846)	TA+EP	Spach et al. (2004a)
Syngnathiformes		
Fistulariidae		
Fistularia petimba Lacepède 1803	TA	Pichler et al. (2008)
F. tabacaria Linnaeus 1758	TA	Spach et al. (2004a)
Syngnathidae		
Bryx dunckeri (Metzelaar 1919)	WA	Spach et al. (2004a)
Cosmocampus elucens (Poey 1868)	WA	Spach et al. (2004a)
Hippocampus reidi Ginsburg 1933 ††/‡	WA	Spach et al. (2004a)
Pseudophallus mindii (Meek & Hildebrand 1923)	Ca+Br	Spach et al. (2004a)
Syngnathus folletti Herald 1942	SWA	Spach et al. (2004a)
S. pelagicus Linnaeus 1758	WA	Pichler et al. (2008)
Scorpaeniformes		
Scorpaenidae		
Pontinus rathbuni Goode & Bean 1896	WA	Spach et al. (2004a)
Scorpaena brasiliensis Cuvier 1829	WA	Nakayama (2004)
S. isthmensis Meek & Hildebrand 1928	WA	Spach et al. (2007)
S.plumieri Bloch 1789	WA	Pinheiro (1999)
Dactylopteridae		
Dactylopterus volitans (Linnaeus 1758)	TA	Spach et al. (2004a)
Triglidae		
Prionotus nudigula Ginsburg 1950	SSWA	Queiroz et al. (2007)
P. punctatus (Bloch 1793)	Ca+SWA	Spach et al. (2004a)
Perciformes		
Centropomidae		
Centropomus parallelus Poey 1860	WA	Pichler et al. (2008)
C.undecimalis (Bloch 1792)	WA	Spach et al. (2004a)
Acropomatidae		
Synagrops bellus (Goode & Bean 1896)	TA	Spach et al. (2004a)
Serranidae		
Acanthistius brasilianus (Cuvier 1828)	SSWA	Fávaro (2004)
Alphestes afer (Bloch 1793) §	TA	Spach et al. (2004a)
Diplectrum radiale (Quoy & Gaimard 1824)	WA	Spach et al. (2004a)
Epinephelus itajara (Lichtenstein 1822) ††/*	WA	Barletta et al. (2008)
Hyporthodus nigritus (Holbrook 1855) *	WA	Godefroid et al. (1997)
Mycteroperca bonaci (Poey 1860) ††/#	WA	Fávaro (2004)
M. rubra (Bloch 1793) §	TA	Spach et al. (2004a)
Rypticus randalli Courtenay 1967	Ca+Br	Spach et al. (2004a)
Pomatomidae		
Pomatomus saltatrix (Linnaeus 1766) ††	CT	Spach et al. (2004a)
Carangidae		
Carangoides bartholomaei Cuvier 1833	WA	Barletta et al. (2008)
Caranx hippos (Linnaeus 1766)	TA	Oliveira Neto et al. (2008)
C. latus Agassiz 1831	TA	Pichler et al. (2008)
C. ruber (Bloch 1793)	WA	Spach et al. (2004a)
Chloroscombrus chrysurus (Linnaeus 1766)	TA	Pichler et al. (2008)

Geographic distribution: CT = circuntropical, 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 and ? = not found. National conservation status according to Brasil (2004, 2008): †† = overexploited, † = endangered. Global conservation status according to IUCN (2012): § = least concern, ‡ = data deficient, • = vulnerable, * = critically endangered, # = near threatened. (Distribuição Geográfica: CT = circuntropical, 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 and ? = not found. Status de conservação segundo Brasil (2004, 2008): †† = sobreexplotada, † = em perigo. Status de conservação segundo IUCN (2012): § = menos preocupante, ‡ = dados deficientes, • = vulnerável, * = criticamente em perigo, # = próxima ao perigo).

Table 1. Continued...

Orders/Families/Species	Geographic distribution	Source
Hemicaranx amblyrhynchus (Cuvier 1833)	WA	Corrêa et al. (1986)
Oligoplites palometa (Cuvier 1832)	Ca+Br	Barletta et al. (2008)
O. saliens (Bloch 1793)	Ca+SWA	Pichler et al. (2008)
O. saurus (Bloch & Schneider 1801)	WA	Spach et al. (2004a)
Selene setapinnis (Mitchill 1815)	WA	Spach et al. (2004a)
S. vomer (Linnaeus 1758)	WA	Pichler et al. (2008)
Seriola lalandi Valenciennes 1833	CT	Spach et al. (2004a)
Trachinotus carolinus (Linnaeus 1766)	WA	Pichler et al. (2008)
T. falcatus (Linnaeus 1758)	WA	Pichler et al. (2008)
T. goodei Jordan & Evermann 1896	WA	Spach et al. (2004a)
T. marginatus Cuvier 1832	SSWA	Spach et al. (2004a)
Uraspis secunda (Poey 1860)	CT	Godefroid et al. (1997)
Lutjanidae		
Lutjanus analis (Cuvier 1828) ††/•	WA	Spach et al. (2004a)
L. griseus (Linnaeus 1758)	WA	Spach et al. (2003)
L. synagris (Linnaeus 1758)	WA	Pinheiro (1999)
Lobotidae		
Lobotes surinamensis (Bloch 1790)	CT	Godefroid et al. (1997)
Gerreidae		
Diapterus auratus Ranzani 1842	WA	Ignácio & Spach (2009)
Diapterus rhombeus (Cuvier 1829)	Ca+Br	Pichler et al. (2008)
Eucinostomus argenteus Baird & Girard 1855	WA+EP	Pichler et al. (2008)
E. gula (Quoy & Gaimard 1824)	WA	Pichler et al. (2008)
E. melanopterus (Bleeker 1863)	TA	Pichler et al. (2008)
Eugerres brasilianus (Cuvier 1830)	WA	Oliveira Neto et al. (2008)
Ulaema lefroyi (Goode 1874)	Ca+Br	Spach et al. (2003)
Haemulidae		
Anisotremus surinamensis (Bloch 1791)	WA	Pichler et al. (2008)
A. virginicus (Linnaeus 1758)	WA	Spach et al. (2004a)
Boridia grossidens Cuvier 1830	SSWA	Spach et al. (2006)
Conodon nobilis (Linnaeus 1758)	WA	Spach et al. (2004a)
Genyatremus luteus (Bloch 1790)	Ca+Br	Spach et al. (2004a)
Haemulon steindachneri (Jordan & Gilbert 1882)	Ca+SWA	Godefroid et al. (1997)
Orthopristis ruber (Cuvier 1830)	Ca+SWA	Pichler et al. (2008)
Pomadasys corvinaeformis (Steindachner 1868)	Ca+SWA	Spach et al. (2004a)
P. ramosus (Poey 1860)	Ca+Br	Hackradt et al. (2009)
Sparidae		
Archosargus probatocephalus (Walbaum 1792)	WA	Pichler (2009)
Archosargus rhomboidalis (Linnaeus 1758)	WA	Godefroid et al. (1997)
Calamus penna (Valenciennes 1830)	WA	Pinheiro (1999)
Diplodus argenteus (Valenciennes 1830)	SWA	Spach et al. (2004a)
Sciaenidae		
Bairdiella ronchus (Cuvier 1830)	Ca+Br	Pichler et al. (2008)
Ctenosciaena gracilicirrhus (Metzelaar 1919)	Ca+Br	Spach et al. (2004a)
Cynoscion acoupa (Lacepède 1801)	Ca+SWA	Oliveira Neto et al. (2008)

Geographic distribution: CT = circuntropical, 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 and ? = not found. National conservation status according to Brasil (2004, 2008): †† = overexploited, † = endangered. Global conservation status according to IUCN (2012): § = least concern, ‡ = data deficient, • = vulnerable, * = critically endangered, # = near threatened. (Distribuição Geográfica: CT = circuntropical, 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 and ? = not found. Status de conservação segundo Brasil (2004, 2008): †† = sobreexplotada, † = em perigo. Status de conservação segundo IUCN (2012): § = menos preocupante, ‡ = dados deficientes, • = vulnerável, * = criticamente em perigo, # = próxima ao perigo).

Table 1. Continued...

Orders/Families/Species	Geographic distribution	Source
C. jamaicensis (Vaillant & Bocourt 1883)	Ca+SWA	Schwarz Junior et al. (2007)
C. leiarchus (Cuvier 1830)	Ca+Br	Spach et al. (2004a)
C. microlepidotus (Cuvier 1830)	Br	Spach et al. (2004a)
C. striatus (Cuvier 1829)	SSWA	Ignácio & Spach (2009)
C. virescens (Cuvier 1830)	Ca+Br	Schwarz Junior et al. (2007)
Isopisthus parvipinnis (Cuvier 1830)	Ca+Br	Spach et al. (2004a)
Larimus breviceps Cuvier 1830	Ca+Br	Spach et al. (2004a)
Macrodon atricauda (Bloch & Schneider 1801) ††	Br+SWA	Schwarz Junior et al. (2007)
Menticirrhus americanus (Linnaeus 1758)	WA	Pichler et al. (2008)
M. littoralis (Holbrook 1847)	WA	Spach et al. (2004a)
Micropogonias furnieri (Desmarest 1823) ††	Ca+SWA	Pichler et al. (2008)
Nebris microps Cuvier 1830	Br	Schwarz Junior et al. (2007)
Ophioscion punctatissimus Meek & Hildebrand 1925	Ca+Br	Spach et al. (2004a)
Paralonchurus brasiliensis (Steindachner 1875)	Ca+SWA	Schwarz Junior et al. (2007)
Pogonias cromis (Linnaeus 1766)	WA	Pichler (2009)
Stellifer brasiliensis (Schultz 1945)	Br	Spach et al. (2004a)
S. rastrifer (Jordan 1889)	Br+SSWA	Ignácio & Spach (2009)
S. stellifer (Bloch 1790)	Br	Spach et al. (2004a)
Umbrina canosai Berg 1895 ††	SSWA	Spach et al. (2004a)
U. coroides Cuvier 1830	WA	Ignácio & Spach (2009)
Polynemidae		
Polydactylus oligodon (Günther 1860)	WA	Godefroid et al. (1999)
P. virginicus (Linnaeus 1758)	WA	Spach et al. (2004a)
Mullidae		
Mullus auratus Jordan & Gilbert 1882	WA	Barletta et al. (2008)
Pseudupeneus maculatus (Bloch 1793)	WA	Spach et al. (2004a)
Upeneus parvus Poey 1852	WA	Pinheiro (1999)
Mugilidae		
M. curema Valenciennes 1836	TA+EP	Pichler et al. (2008)
M. curvidens Valenciennes 1836	Ca+Br	Spach et al. (2004a)
M. incilis Hancock 1830	Ca+Br	Spach et al. (2004a)
M. liza Valenciennes 1836 ††	WA	Pichler et al. (2008)
Mugil sp.	?	Spach et al. (2004a)
Cichlidae		
Geophagus brasiliensis (Quoy & Gaimard 1824)	SSWA	Pichler (2009)
Oreochromis niloticus (Linnaeus 1758)	EA	Contente et al.(2010)
Uranoscopidae		
Astroscopus sexspinosus (Steindachner 1876)	SSWA	Spach et al. (2004a)
A. y-graecum (Cuvier 1829)	WA	Pichler et al. (2008)
Pinguipedidae		
Pinguipes brasilianus Cuvier 1829	SSWA	Spach et al. (2004a)
Clinidae		
Ribeiroclinus eigenmanni (Jordan 1888)	SSWA	Spach et al. (2004a)
Blenniidae		
Hypleurochilus sp.	?	Corrêa et al. (1986)
Parablennius pilicornis (Cuvier 1829)	TA	Spach et al. (2004b)
Eleotridae		
Dormitator maculatus (Bloch 1792)	WA	Queiroz et al. (2007)

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Table 1. Continued...

Orders/Families/Species	Geographic distribution	Source
Eleotris pisonis (Gmelin 1789)	WA	Fávaro (2004)
Guavina guavina (Valenciennes 1837)	WA	Pichler et al. (2008)
Gobiidae		
Awaous tajasica (Lichtenstein 1822)	WA	Vendel et al. (2002)
Bathygobius soporator (Valenciennes 1837)	TA	Pichler et al. (2008)
Ctenogobius boleosoma (Jordan & Gilbert 1882)	WA	Pichler et al. (2008)
C. shufeldti (Jordan & Eigenmann 1887)	WA	Pichler et al. (2008)
C. smaragdus (Valenciennes 1837)	WA	Pichler et al. (2008)
C. stigmaticus (Poey 1860)	WA	Vendel et al. (2002)
Gobioides broussonnetii Lacepède 1800	WA	Cortellete et al. (2009)
Gobionellus oceanicus (Pallas 1770)	WA	Pichler et al. (2008)
Microgobius meeki Evermann & Marsh 1899	Ca+Br	Pichler et al. (2008)
Ephippidae		
Chaetodipterus faber (Broussonet 1782)	WA	Pichler et al. (2008)
Sphyraenidae		
Sphyraena barracuda (Edwards 1771)	CT	Spach et al. (2004a)
S. guachancho Cuvier 1829	TA	Spach et al. (2004a)
S. picudilla Poey 1860	WA	Abilhôa (1998)
S. tome Fowler 1903	SSWA	Vendel et al. (2003)
Trichiuridae		
Trichiurus lepturus Linnaeus 1758	CT	Spach et al. (2004a)
Scombridae		
Acanthocybium solandri (Cuvier 1832) §	CT	Fávaro (2004)
Scomberomorus brasiliensis Collette, Russo & Zavala-Camin 1978 §	Ca+Br	Pichler et al. (2008)
S. cavalla (Cuvier 1829) §	WA	Spach et al. (2004a)
Stromateidae		
Peprilus paru (Linnaeus 1758)	WA	Spach et al. (2004a)
Pleuronectiformes		
Paralichthyidae		
Citharichthys arenaceus Evermann & Marsh 1900	WA	Pichler et al. (2008)
C. macrops Dresel 1885	WA	Félix et al. (2007)
C. spilopterus Günther 1862	WA	Pichler et al. (2008)
Etropus crossotus Jordan & Gilbert 1882	WA+EP	Pichler et al. (2008)
Paralichthys brasiliensis (Ranzani 1842)	SWA	Pichler et al. (2008)
P. orbignyanus (Valenciennes 1839)	SSWA	Pichler et al. (2008)
P. patagonicus Jordan 1889	SSWA+EP	Stefanoni (2007)
P. tropicus Ginsburg 1933	WA	Santos et al. (2002)
Syacium papillosum (Linnaeus 1758)	WA	Félix et al. (2007)
Pleuronectidae		
Oncopterus darwinii Steindachner 1874	SSWA	Godefroid et al. (1997)
Pleuronectes sp.	?	Barletta et al. (2008)
Achiridae		
Achirus declivis Chabanaud 1940	WA	Ignácio & Spach (2009)
A. lineatus (Linnaeus 1758)	WA	Pichler et al. (2008)

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Table 1. Continued...

Orders/Families/Species	Geographic distribution	Source
Trinectes microphthalmus (Chabanaud 1928)	Ca+Br	Fávaro (2004)
T. paulistanus (Miranda Ribeiro 1915)	Ca+Br	Spach et al. (2004a)
Cynoglossidae		
Symphurus plagusia (Bloch & Schneider 1801)	Ca+Br	Spach et al. (2004a)
S. tesselatus (Quoy & Gaimard 1824)	Ca+Br+SSWA	Spach et al. (2004a)
Tetraodontiformes		
Monacanthidae		
Stephanolepis hispidus (Linnaeus 1766)	TA	Spach et al. (2004a)
Tetraodontidae		
Lagocephalus laevigatus (Linnaeus 1766)	TA	Pichler et al. (2008)
Sphoeroides greeleyi Gilbert 1900	Ca+Br	Spach et al. (2004a)
S. spengleri (Bloch 1785)	TA	Schwarz Junior et al. (2007)
S. testudineus (Linnaeus 1758)	WA	Pichler et al. (2008)
S. tyleri Shipp 1972	Br	Vendel et al. (2002)
Diodontidae		
Chilomycterus spinosus (Linnaeus 1758)	SWA	Pichler et al. (2008)

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and/or the use of different sampling gears across tropical estuaries around the world (Blaber 2002).

The species' classification into the geographical categories used in this study present here, which were adapted from Floeter et al. (2008) and Luiz Junior et al. (2008), fits well with the species' distribution described on the literature. This is an indicative of utility of such a classification for future studies aiming to classify SW Atlantic estuarine fishes. Most species in the PEC are widely distributed throughout the Western Atlantic (40%), followed by those that are restricted to (and occur both in) the Caribbean and Brazilian (15%), and South-West Atlantic (11%) provinces (Figure 2). Thus, the PEC fish fauna can be regarded as a mixture between the fish fauna typical from the tropical Brazilian coast and those with affinities of temperate Argentinean and Uruguayan zones.

Our results suggest an expansion of the geographical distribution for *G. pygmaeus* and *M. auratus*. *G. pygmaeus*, recorded in Godefroid et al. (1997, 1999), which was previously reported only for the tropical Western Atlantic, from South Carolina state to the tropical coast of Brazil, near the equator (Eschmeyer 2010), and *Mullus auratus*, recorded by Barletta et al. (2008), previously reported from North Carolina, USA, to the Caribbean (Floeter et al. 2008).

Only a minor part (8%) of the PEC fish fauna was evaluated as regards the conservation status: ten are on the IUCN Red List (International... 2012), 12 on the ME list (Brasil 2004, 2008), and four are on both. Of the ten species on the IUCN Red List (International... 2012), two (*Epinephelus itajara* and *Hyporthodus nigritus*) are critically endangered, one (*Mycteroperca bonaci*) is near threatened, one (*Lutjanus analis*) is vulnerable, five (*Alphestes afer*, *Mycteroperca rubra*, *Acanthocybium solandri*, *Scomberomorus brasiliensis* and *S. cavalla*) are least concern and one (*Hippocampus reidi*) is data deficient. Among the 12 species on the Ministry of the Environment List, 11 are overexploited and one is endangered (*Rhinobatus horkelii*). Many fishery species in PEC are found to be classified as threatened on the list for endangered fauna of the adjacent state of São Paulo (São Paulo 2010). It is supposed that many species in PEC have similar conservation status 'threatened' as face similar threats to those of São Paulo state coast, where the fishing pressure is similar to that of Paraná state. Such a setting reinforces the urgent need for critical, basic information for fish species to support their conservation effort through IUCN classification in this important estuary.

Particular concern must be place to introduction in the PEC of the species *Opsanus beta*, from the North Atlantic (Eschmeyer 2010), and *Oreochromis niloticus* from Africa. Although the impact of *O. beta* on the native fish fauna is still unknown (Caires et al. 2007), it is supposed to be serious, as it is a voracious, generalized predator (Gray & Winn 1961). Moreover, recent field observations have already reported *O. beta* as a very common by-catch in long-line inside estuary, thus affecting local fisheries. *O. niloticus* is classified as a pest and has been reported to adversely impact ecosystem after its introduction (Froese & Pauly 2010). Future studies assessing the degree of establishment success of such species and their impact on the local fish biodiversity are strongly recommended.

This study provides a full list of fish species of the Paranaguá Estuarine Complex based on a robust dataset, which takes into account a wide and representative spatio temporal variability, largely improving the species detectability. The ichthyofauna of the PEC contains taxa with affinities from the tropical Brazilian coast and those with affinities of temperate Argentinean and Uruguayan waters. The fish richness of the system of 213 species is surprisingly higher than other systems in Brazil and around world, which emphasize the importance of the region for global biodiversity conservation. Once we have knowledge of the species and the richness of PEC, we suggest a fauna monitoring for a regional analysis of conservation status and more details about impacts of exotic species for the creation of management and conservation proposals.

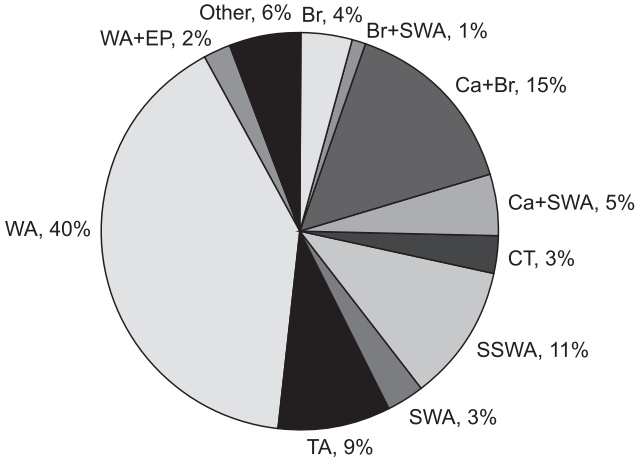

Figure 2. Geographic distribution of the ichthyofauna recorded in the Paranaguá Estuarine Complex, Southwest Atlantic (CT = circuntropical, TA = Trans-Atlantic, WA = Western Atlantic, SWA = Southern West Atlantic, SSWA = Southern South West Atlantic, Ca = Caribbean, Br = Brazilian Province, EA = Eastern Atlantic, EP = Eastern Pacific and Other = categories (Trans-Atlantic + Eastern Pacific, Brazilian Province + southern South-West Atlantic, Caribbean, Caribbean + Brazilian Province + Eastern Pacific, Caribbean + Brazilian Province + southern South-West Atlantic, southern South-West Atlantic + Eastern Pacific, Eastern Atlantic) that represent less than 1% each).

Figura 2. Distribuição Geográfica da ictiofauna encontrada no Complexo Estuarino de Paranaguá, Atlântico Sul (CT = circuntropical, 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 e Outros = categorias (Trans-Atlantic + Eastern Pacific, Brazilian Province + southern South-West Atlantic, Caribbean, Caribbean + Brazilian Province + Eastern Pacific, Caribbean + Brazilian Province + southern South-West Atlantic, southern South-West Atlantic + Eastern Pacific, Eastern Atlantic) que representam menos de 1% cada.

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