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Original article

The bony fishes (Teleostei) caught by industrial trawlers off the Brazilian North coast, with insights into its conservation

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The Brazilian North coast is one of the world's most important shrimp fishery grounds, with a total area of approximately 223,000 km^2. However, the available data on the diversity of fish caught by the region's industrial trawler fleet are limited to the commercially-valuable species. This lacuna in the data on the region's marine fish fauna is worrying, both for the management of stocks and the conservation of the local biodiversity. The present study was based on a comprehensive inventory of the teleost fishes captured by the industrial outrigger trawling operations off the North coast of Brazil. This inventory recorded 201 species belonging to 64 families and 20 orders, and revealed a unique fauna, characterized by 17 endemic species, and a mixture of estuarine-dependent and marine species, mainly associated with coral reefs. The Kernel density analysis indicated that the industrial trawling fleet operates within an important ecotone, which encompasses the transition zones of different fish communities found off the Brazilian North coast.

Keywords: Biodiversity, Bycatch, Fishes discarded, Inventory, Marine fish, Outrigger trawling.

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A costa Norte do Brasil é um dos pesqueiros de camarão mais importantes do mundo, com uma área total de aproximadamente 223.000 km^2. No entanto, dados disponíveis sobre a diversidade de peixes capturados pela frota industrial de arrasto de portas na região são limitados às espécies com valor comercial. Essa lacuna no conhecimento sobre a fauna de peixes marinhos da região é preocupante, tanto para o manejo dos estoques quanto para a conservação da biodiversidade local. O presente estudo é baseado num inventário abrangente dos peixes teleósteos capturados por operações de arrasto de portas da frota industrial que opera na costa Norte do Brasil. Este inventário registrou 201 espécies pertencentes a 64 famílias e 20 ordens, e revelou uma fauna única, caracterizada por 17 espécies endêmicas, e uma mistura de espécies estuarino-dependentes e espécies marinhas, principalmente associadas a recifes de corais. A análise da densidade Kernel indicou que a frota industrial de arrasto de portas opera dentro de um importante ecótono, que abrange uma zona de transição de diferentes comunidades de peixes encontrados na costa Norte do Brasil.

Palavras-chave: Biodiversidade, Fauna acompanhante, Inventário, Peixes descartados, Peixes marinhos, Pesca de arrasto de portas.

Introduction

Different fishery techniques are used to target determined species, although all types of industrial fishery operation result in the harvesting of bycatch, that is, species captured unintentionally (Eayrs, 2007; Davies *et al*., 2009). The amount and diversity of this bycatch may vary significantly among different fishery operation (Clucas, 1997), and among fishing grounds and seasons (Paiva *et al*., 2009; Maia *et al*., 2016). Outrigger trawling, in particular, is known for its reduced selectivity and high proportion of incidental catch (Perez, Pezzuto, 1998; Diamond *et al*., 2000). The bycatch generated by outrigger trawling operations is typically made up of both commercially-valuable species and other species that are discarded, either because they have a low market value or because of the lack of adequate technology for the processing of the catch (Saila, 1983; Alverson *et al*., 1994; Clucas, 1998).

In addition to the large volume of bycatch, which may often exceed the amount of shrimp harvested (Paiva *et al*., 2009; Aragão *et al*., 2015), industrial shrimp outrigger trawling operations cause profound impacts on the environment (Stobutzki *et al*., 2001) through the destruction of bottom substrates and the elimination of benthic organisms such as coral reefs. The discarding of low-value species may have a significant impact on the local biodiversity (Clucas, 1997), altering the structure of fish assemblages (Wassenberg, Hill, 1989; Anderson *et al*., 2013), and vanishing species that may significantly impairthe the trophic web. This makes the effective management of outrigger trawling operations a major challenge (Davies *et al*., 2009).

The North coast of Brazil is one of the world's most important shrimp fishery grounds, which extends from the border with French Guiana to the state line between the Brazilian states of Maranhão and Piauí, with a total area of approximately 223,000 km^2 (Corrêa, Martinelli, 2009). This area is characterized primarily by the enormous input of nutrients and sediment from the Amazon River and coastal drainage basins, which contribute to the region's abundance of fish and crustaceans (Isaac *et al*., 1992), being that, the hydrological regime has a great influence on the life cycle of the species found in the region (Aragão *et al*., 2015; Isaac, Braga, 1999). However, the influence of the region's coral reefs on the fauna exploited by the industrial fisheries of the north coast of Brazil is still unclear (Moura *et al*., 2016; Francini-Filho *et al*., 2018). Some species from this coral reef guild are considerable valuable in fisheries, as groupers and snappers, but the real impact of fisheries on these specific populations along north coast of Brazil is not clear.

A number of recent studies have described the region's industrial fishing fleet (Silva *et al*., 2014; Aragão *et al*., 2015), its productivity, fishery statistics, and marketing network (Pinheiro, Frédou, 2004; Isaac *et al*., 2008; Frédou *et al*., 2009; Pinheiro *et al*., 2013). Other studies, such as those of Isaac, Braga (1999), Pinheiro, Frédou (2004), Paiva *et al*. (2009), and Aragão *et al*. (2015) have attempted to determine the volume of the bycatch harvested by industrial fisheries off the North coast of Brazil, although the data available on the composition of the bycatch is limited to the commercially-valuable species (Paiva *et al*., 2009; Aragão *et al*., 2015; Maia *et al*., 2016). This situation is a major cause for concern given the considerable lacuna in the understanding of the diversity of the teleost fish fauna of the Brazilian North coast (Marceniuk *et al*., 2013, 2017).

The reliable identifications of this fauna is fundamentally important for studies of the quality of the environment, and the establishment of criteria for the zoning of fishing grounds, which must be based not only on the number of species, but also the diversity of the environments and communities affected by fisheries (*sensu* Manthey, Fridley, 2009). In this sense, the incomplete knowledge, or the absence of data on the bony fish species captured by outrigger trawlers represent potential limitations for the development of effective measures for the protection of this fauna, and the management of the ecosystems exploited by the fisheries (Thrush *et al*., 1998; Greenstreet, Rogers, 2004; Juan, Demestres, 2012).

In this context, the present study is based on a comprehensive inventory of the teleost fishes harvested by the industrial trawling operations of the North coast of Brazil, including outriggers that target pink-shrimp, *Penaeus* spp., and pair trawlers that target number of fish species, with additional data obtained from published studies. Based on data obtained from the industrial trawling operations in coast of the Pará and Amapá states, we try to characterize the diversity of the teleost fish harvested by the region's industrial outrigger trawling operations, defining

distinct communities of fish, according to the habitats they occupy, and determine which areas are occupied more intensively occupied by these communities, using a Kernel Density Estimation (KDE) approach. The zones with the greatest species richness are identified as a baseline for the implementation of effective conservation policies.

Material and Methods

Study area. The North coast of Brazil refers to the region between the mouth of the rio Oiapoque (04°23' N), which forms the border between Brazil and French Guiana, and the mouth of the rio Parnaíba (02°53' S), which forms the state line between Maranhão and Piauí (Fig. 1). This area forms part of a vast shrimping ground, which extends north to the area adjacent to the mouth of the rio Orinoco, in Venezuela (IBAMA, 1997). The Brazilian North coast is divided into three sectors (Studart-Gomes, 1988): (i) the coast of Maranhão, between the rio Parnaíba (02°53' S) and Cape Gurupi (00°53' S), where the bottom substrates are a mixture of mud and sand, and the fishing grounds are close to the coast, (ii) the coast of Pará, between 02°30' N and 00°50' S, with predominantly muddy bottoms, and (iii) the coast of Amapá, between 04°23' N and 02°30' N (Cape Orange), which is dominated by hard and rocky substrates. The present study focused on the continental shelf of this region, in the two northern most sectors (Pará and Amapá), where the industrial outrigger trawling fleet based in Belém (Pará) concentrates its operations (Fig. 1).

Material examined. The inventory of the teleost fishes harvested by trawlers off the Brazilian states of Amapá and Pará, was based on the observations conducted by observers of the Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha da Costa Norte do Brasil at Belém, Pará State (CEPNOR), embarked on trawlers in 2016 and 2018, when they monitored 29 trawling operations off Amapá and Pará, between 03°37'32.7" N and 00°11'75.4" S (Fig. 1). A total of 517 trawls were monitored during the study period, corresponding to 1.644 operational hours and 273 days at sea, including 160 days during the shrimping season and 103 during the off season (Fig. 2A). Complementary data were obtained through a literature search (Pinheiro, Frédou, 2004; Oliveira *et al*., 2004; Maia *et al*., 2016).

The specimens collected during this monitoring were processed at sea and specimens deposited in the ichthyological collection of the Museu Paraense Emílio Goeldi at Belém, Pará State (MPEG), the zoological collection of the Universidade Santa Cecília at Santos, São Paulo State (AZUSC), and the Laboratório de Biologia e Genética de Peixes (LBP) of the Universidade Estadual Paulista Júlio de Mesquita at Botucatu, São Paulo State. Published papers on the teleost fish species harvested as bycatch by the industrial outrigger trawling fleet of the North coast do Brazil (Oliveira *et al*., 2004; Pinheiro, Frédou, 2004; Maia *et al*., 2016) were used as a secondary source of data. Additional data were obtained from publications on the bycatch of the industrial outrigger trawling fleet operating off the southeastern coast of Brazil (Graça-Lopes *et al*., 2002; Vianna, Almeida, 2005; Severino-Rodrigues, 2007; Quirino-Duarte *et al*., 2009).

Species were identified using the descriptions and collection keys provided by Figueiredo, Menezes (1978, 1980, 2000), Menezes, Figueiredo (1980, 1985), Cervigón *et al.* (1992) Carpenter (2003a,b,c), Marceniuk (2005), Menezes *et al.* (2015), Marceniuk *et al.* (2017), as well as by comparison with specimens deposited in the ichthyological collections of the Museu de Zoologia da Universidade de São Paulo at São Paulo (MZUSP), AZUSC and LBP, and through consultations with specialists.

Taxonomic procedures. The species recorded in the inventory were grouped by order and family, following Eschmeyer's Catalog of Fishes (Fricke *et al*., 2019), with the genera and species of each family being presented in alphabetical order. The table is annotated with a range of information on each species, including the source of the record, its regional status (endemic, first report), habitat preferences and use (pelagic, demersal, benthic), shoaling behavior, IUCN conservation status, fishery value, and abundance. The data on endemism and the existence of specimens in scientific collections were obtained from the Neodat (http://www.mnrj.ufrj.br/search.htm), SpeciesLink (http://www.splink.org.br/), and FishNet2 (http://www.fishnet2.net) online databases.

The species labelled as "sp." are new species currently being described by our research team: *Bairdiella goeldi* (Marceniuk *et al.*, 2019), *Haemulon* sp. (Oliveira *et al*., in preparation), and *Neoconger* sp. (Marceniuk *et al*., in preparation).

Life history traits and conservation status. Habitat categorization was adapted from Gaither *et al*. (2016) and we employed herein four basic habitat categories: (i) estuarine, including species found in areas influenced by freshwater; (ii) marine, species found in over coral reefs or rocky bottoms; (iii) marine, not associated with reefs or rocky bottoms (for most of their lives), and (iv) species associated with rocky reefs, but found in estuaries during some life stage. The data on habitat preferences were obtained from recent literature of each species, cited in the Eschmeyer's Catalog of Fishes (Fricke *et al*., 2019).

Habitat use was classified as (i) pelagic (upper portion of the water column), (ii) benthic (on the sea floor), and (iii) demersal (lower portion of the water column). This classification and the shoaling habits of the species were derived from the information available in the FishBase (http://www.fishbase.org/search.php) online database. The conservation status of each species was obtained from the IUCN Red List of Threatened Species (http://www.iucnredlist.org), and the inclusion of each species in the Red Book of the Brazilian Fauna Threatened with Extinction (http://www.icmbio.gov.br) was also confirmed.

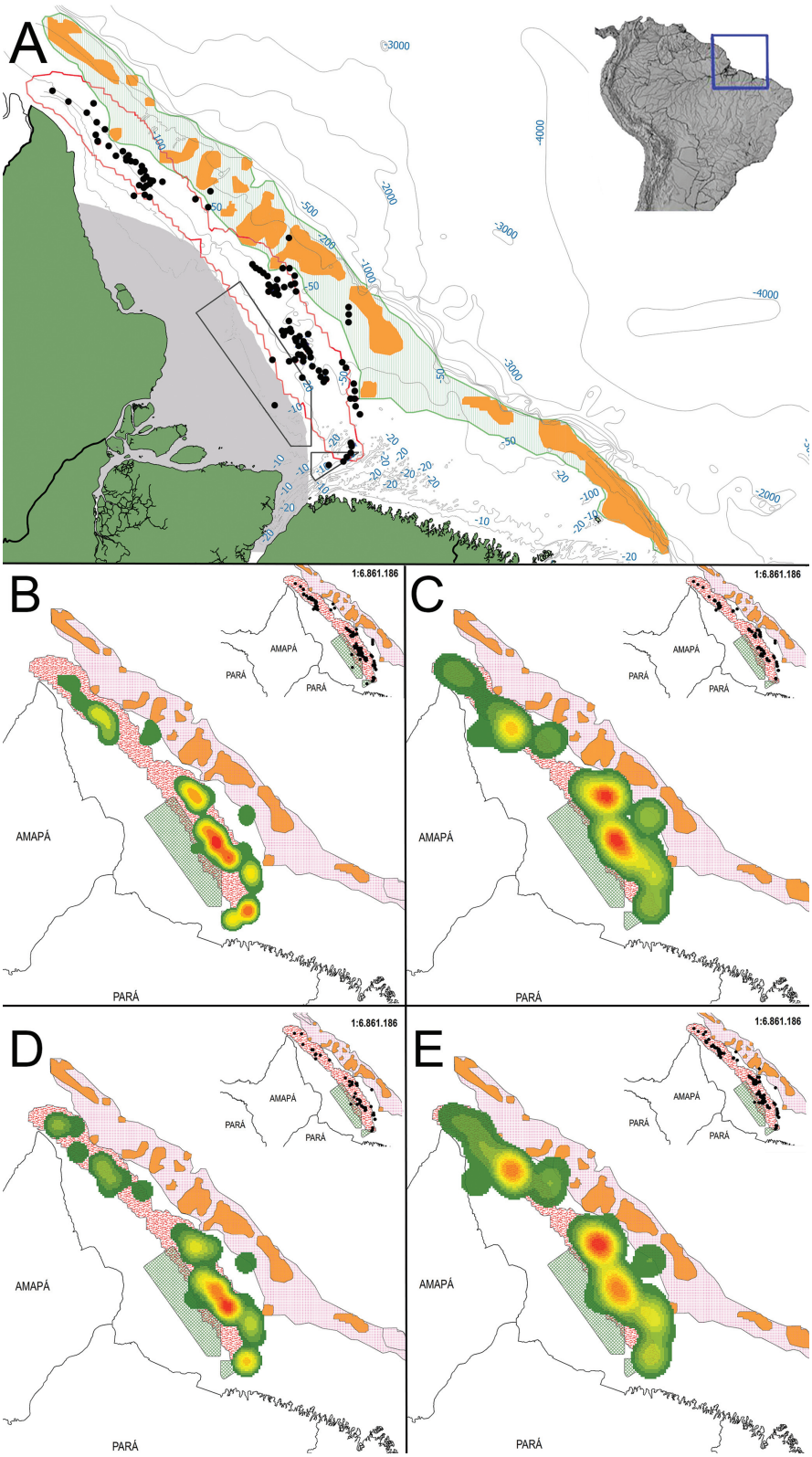

Fig. 1. (A) Industrial trawling zone off the North coast of Brazil (modified from Aragão *et al*., 2001 and Brasil, 2011). Outriggers that target pink-shrimp (red outline) and pair trawlers that target a number of fish species (black dots in the main image and green shading in C-E). The Amazon River plume is shaded gray. The Great Amazon Reef System, as defined by Moura *et al*. (2016), is shaded orange in all images (A-E), while the system defined by Francini-Filho *et al*. (2018) is shaded green here, and red in all other images (B-E); (B-E) Kernel density plots of (B) estuarine species; (C) estuarine species also associated with coral reefs; (D) species associated with coral reefs or rock bottom; (E) marine species, not associated with coral reefs.

Fig. 2. Collection conducted by observers of the Centro de Pesquisa e Gestão de Recursos Pesqueiros do Litoral Norte do Brasil (CEPNOR), embarked on trawlers.

Distribution and density. The distribution of the different fish species off the northern coast of Brazil was evaluated based on the species life-habitat as defined above. The occurrence of the species in the four categories was mapped, and an exploratory interpolation statistical technique, based on Kernel Density Estimation (KDE), was used to generate a density plot from the distribution points, which permitted the visualization of the areas with more intense occurrence. We estimate bandwidth (influence radius) and K (Kernel) functions for each species community (Hart, Zandbergen, 2013). The KDE analyses included only the species that had specimens in zoological collection with the coordinates of the catch locality.

Results

Based on the specimens observed (photographed and measured) on board the fishing vessels, and the 2.323 specimens examined in the laboratory, a total of 201 species were identified (Tab. 1, column A), and a further 15 species recorded in previous studies (Oliveira *et al*., 2004; Pinheiro, Frédou, 2004; Maia *et al*., 2016), not observed during the present study (Tab. 1, column A). So, the total number of species, based on the present inventory of the fish harvested by the industrial trawling operations and the published data was 216 species. These species represent 64 fish families and 20 orders (Tab. 1). Voucher specimens were deposited in zoological collections, with the exception of the species that were only examined on board the fishing vessels (Tab. 1, column A).

Considering the complete data set (present study plus published data), the most diverse families are the Sciaenidae (21 spp.), Carangidae (21 spp.), Engraulidae (10 spp.), Serranidae (12 spp.), Haemulidae (10 spp.), and Lutjanidae with nine species (Tab. 1). Overall, 17 (7.9%) of the 216 species are endemic to the Orinoco-Amazon plume (Tab. 1, column B), 64 (29.6%) are found throughout the entire Atlantic coast of the Americas, 65 (30.1%) are distributed between the Caribbean and the Atlantic South America (not found in Golf of Mexico), and 111 species (51.4%) range between the Caribbean and Brazilian southeast coast (not found in Argentina Province). Overall, 42 (19.4%) of the 216 species were recorded from the North coast of Brazil (in zoological collections) for the first time (Tab. 1, column C), and five species (*Pythonichthys sanguineus*, *Aplatophis chauliodus*, *Lonchopisthus higmani*, *Caulolatilus guppyi*, and *Ogcocephalus pumilus*) had not previously been recorded in Brazil (Menezes *et al*., 2003).

Just over half (n = 114, 52.8%) of the species recorded here are found exclusively in marine habitats (Tab. 1, column F and G), of which, 72 (33.3%) are associated with coral reefs or rocky bottoms (Tab. 1, column G). The remaining 102 species (47.2%) have some association with estuaries or freshwater habitats (Tab. 1, column D), although 21 are also found on coral reefs during at least one stage of their life history (Tab. 1, column D and G). Over half (n = 117, 54.2%) of the species are also demersal and just under a third (n = 63, 29.2%) are pelagic, while the remaining 38 species (17.6%) are benthic (Tab. 1, column E). Most (143 species, 66.2%) species form shoals, and 49 of form major shoals (Tab. 1, column H).

Nineteen species (8.3%) are listed as threatened or endangered (Tab. 1, column I). With the exception of three species, *Epinephelus itajara* (Lichtenstein, 1822) (CR), which is very common in the estuaries of the North coast (Marceniuk *et al*., 2017), *Lutjanus synagris* (Linnaeus, 1758) (NT) and *Pomatomus saltatrix* (Linnaeus, 1766) (VU), all these listed taxa were few common in the trawls (Tab. 1, column K).

Density estimates. Kernel density maps were generated for 68 estuarine species (Fig. 1B), 39 marine species not associated with coral reef (Fig. 1E), 49 species associated with reefs and/or rocky bottoms (Fig. 1D), and 20 estuarine species that are also found in coral reefs (Fig. 1C). The Kernel density map of the estuarine species shows three areas of high species concentration south of the shrimp fishery zone, primarily on the coast of Pará, with no overlap with the area of coral reef. The marine species also presented three focal areas, distributed in a north-south orientation, off the coasts of both Amapá and Pará, and overlapping the area of coral reef. The species associated with reefs and/or rocky bottoms also had three focal points, one off Amapá and two off Pará, with the latter being more concentrated and overlapping more with the coral reef. The estuarine species associated with reefs had the smallest bandwidth, with only one area of high concentration, off the coast of Pará, but with no overlap with the coral reef.

Discussion

The bony fish diversity and bycatch caught by industrial trawlers off the Brazilian North coast. The present study revealed the presence of a unique fish fauna that is caught by bottom trawlers off the northern coast of Brazil, which includes 17 endemic species (7.9%) to the Orinoco-Amazon plume, and a mixture of estuarine (102 spp., 47.2%) and exclusively marine species (114 spp., 52.8%), of which 72 are associated with coral reefs. The greater species richness recorded in northern Brazil is likely related to the environmental characteristics of this region, in particular, the enormous input of nutrients and sediment from the Amazon River and coastal drainage basins, which favor the occurrence in the region of estuarine fish. The region's diversity may be further reinforced by the local mangroves, including the world's largest continuous tract of mangrove forest (Schaffer-Novelli *et al*., 2000), and the Great Amazon Reef System (Moura *et al*., 2016; Francini-Filho *et al*., 2018), given that a third of the species recorded here are associated with reefs. Overall, the results of the Kernel density analysis indicate that the industrial trawling fleet off the North Coast of Brazil operates within an important ecotone, which encompasses the transition zones of different fish communities.

The biological diversity of the region is further reinforced when the findings are compared with the trawl bycatch data from southeastern Brazil, the most comprehensive of any Brazilian region (Graça-Lopes *et al*., 2002; Vianna, Almeida, 2005; Severino-Rodrigues, 2007; Quirino-Duarte *et al*., 2009), which include only 156 species, in comparison with the 216 recorded here. While on the North coast, for example, just under half (102 spp., 47.2%) of the species are tolerant of brackish waters, little more than a third (55 spp., 36.2%) of the species from the southeastern coast of Brazil fall into this category, while 63.8% are found exclusively in marine habitats (*vs*. 114 spp, 52.8% in Brazilian North coast). Species associated with reefs or rocky bottoms, including 72. (33.3%) from the North coast, and 50 (32.9%) on the southeastern coast. By contrast, pelagic fish were almost half as common again in northern Brazil (63 spp., 29.2%) as they are on the southeastern coast (32 spp., 20.5%). There was much less difference, however, in the proportions of demersal (60.9% southeast *vs*. 53.2% north) and benthic species (19.2% southeast *vs*. 17.6% north). Differences in the ecological diversity of the two fish faunas affected by trawler bycatch may be related to the variation in the characteristics of the continental shelf, the type of sediment, oceanographic conditions, historical events, and temperature (Lowe-McConnell, 1987, Longhurst, Pauly, 2007, Mora *et al*., 2007).

The conservation of bycatch fish species in northern Brazil. The recognition of distinct communities affected by industrial trawling operations is fundamental to the effective management of local stocks and the biota impacted by the industrial fisheries of northern Brazil. One important aspect of these communities that requires further investigation is the possible temporal variation in the distribution of these communities are influenced differentially by the region's marked seasonal fluctuations in precipitation levels. Breeding patterns in most coastal and estuarine species tend to be synchromized with the rainy season, for example, which lasts from December to May on the Amazon coast, whereas marine species associated with coral reefs typically reproduce during the dry season, when precipitation rates are lower, that is, between June and November.

One other important question is that, while most species have wide geographic distribution, a considerable proportion of the fishes recorded here are endemic to the Amazon-Orinoco plume. These species are thus restricted to an area that is trawled intensively, and in many cases, nothing is known of their life cycles.

Tab. 1. The bone fishes of the Brazilian North coast. Asterisk corresponds to figures presented in Marceniuk *et al*. (2017). **A.** Source of information: Z = Zoological Collections (present study); O = onboard observers; L = literature. **B.** Endemic species. **C.** First record for the Brazilian North coast. **D**. Occurs in estuaries and areas influenced by freshwater. **E.** Life habits: P = pelagic, D = demersal, B = benthonic. **F.** Marine species not associated with coral reefs. **G**. Occurs in reefs or over rocky bottoms. **H.** Formation of shoals: (0) does not form shoals, (1) may form shoals, (2) forms major shoals. **I**. IUCN conservation status (IUCN, 2018) and species included in the Brazilian List of Endangered Fauna (ICMBio, 2018) are marked with an asterisk. CR = Critically Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; X = not evaluated. **J**. Market value: (0) no value, (1) edible, (2) high commercial value. **K**. Abundance: (0) rare, (1) common, (2) very common.

ORDEM	FAMILY	SPECIE		A	B	C	D	E	F	G	H	I	J	K
Elopiformes	Megalopidae	*Megalops atlanticus* Valenciennes, 1847	*fig. 2b.	Z,L			x	P		x	1	VU	2	0
Albuliformes	Albulidae	*Albula vulpes* (Linnaeus, 1758)	Fig. 3.	Z			x	D		x	0	NT	1	0
Anguilliformes	Heterenchelyidae	*Pythonichthys sanguineus* Poey, 1868	Fig. 4a.	Z		x		D		x	0	LC	0	0
Anguilliformes	Moringuidae	*Neoconger* sp.	Fig. 4b.	Z		x		B	x		0	LC	0	0
Anguilliformes	Muraenidae	*Enchelycore nigricans* (Bonnaterre, 1788)	Fig. 4c.	Z		x		B		x	0	LC	0	0
Anguilliformes	Muraenidae	*Gymnothorax conspersus* Poey, 1867	Fig. 4d.	Z				B	x		0	X	0	0
Anguilliformes	Muraenidae	*Gymnothorax ocellatus* Agassiz, 1831	Fig. 4e.	Z				B		x	0	LC	1	1
Anguilliformes	Ophichthidae	*Aplatophis chauliodus* Böhlke, 1956	Fig. 4f.	Z		x	x	B		x	0	LC	0	0
Anguilliformes	Ophichthidae	*Echiophis punctifer* (Kaup, 1859)	Fig. 4g.	Z		x		B		x	0	LC	0	1
Anguilliformes	Ophichthidae	*Ophichthus cylindroideus* (Ranzani, 1839)	Fig. 4h.	Z				B	x		0	LC	0	1
Anguilliformes	Ophichthidae	*Ophichthus ophis* (Linnaeus, 1758)	Fig. 4i.	Z		x		B		x	0	LC	0	0
Anguilliformes	Muraenesocidae	*Cynoponticus savanna* (Bancroft, 1831)	Fig. 5a.	Z			x	B			0	LC	1	1
Anguilliformes	Congridae	*Paraconger guianensis* Kanazawa, 1961	Fig. 5b.	Z	x			B	x		0	X	0	0
Anguilliformes	Congridae	*Rhynchoconger flavus* (Goode, Bean, 1896)	Fig. 5c.	Z				B	x		0	LC	0	1
Anguilliformes	Nettastomatidae	*Hoplunnis macrura* Ginsburg, 1951	Fig. 5d.	Z				B	x		0	LC	0	0
Clupeiformes	Clupeidae	*Lile piquitinga* (Schreiner, Miranda-Ribeiro, 1903)	Fig. 6a.	Z,L		x	x	P			2	LC	2	1
Clupeiformes	Clupeidae	*Opisthonema oglinum* (Lesueur, 1818)	*fig. 4a.	Z,L			x	P			1	LC	2	2
Clupeiformes	Engraulidae	*Anchoa filifera* (Fowler, 1915)	Fig. 6b.	Z		x	x	P			2	LC	0	1
Clupeiformes	Engraulidae	*Anchoa pectoralis* Hildebrand, 1943	Fig. 6c.	O			x	P			2	X	0	1
Clupeiformes	Engraulidae	*Anchoa spinifera* (Valenciennes, 1848)	*fig. 4c.	Z			x	P			2	LC	2	1
Clupeiformes	Engraulidae	*Anchovia clupeoides* (Swainson, 1839)	Fig. 6d.	Z,L			x	P			2	LC	2	1
Clupeiformes	Engraulidae	*Anchovia surinamensis* (Bleeker, 1865)	*fig. 4d.	L	x		x	P			1	LC	2	1
Clupeiformes	Engraulidae	*Anchoviella lepidentostole* (Fowler, 1911)	Fig. 6e.	Z,L			x	P			1	LC	2	0
Clupeiformes	Engraulidae	*Cetengraulis edentulus* (Cuvier, 1829)	*fig. 4f.	Z,L			x	P			2	LC	1	1
Clupeiformes	Engraulidae	*Lycengraulis batesii* (Günther, 1868)	*fig. 4g.	L	x		x	P			1	LC	2	1
Clupeiformes	Engraulidae	*Lycengraulis grossidens* (Spix, Agassiz, 1829)	*fig. 4h.	L			x	P			1	LC	2	1
Clupeiformes	Engraulidae	*Pterengraulis atherinoides* (Linnaeus, 1766)	*fig. 4i.	L	x		x	P			1	LC	1	1
Clupeiformes	Pristigasteridae	*Chirocentrodon bleekerianus* (Poey, 1867)	Fig. 6f.	Z			x	P			1	LC	0	0
Clupeiformes	Pristigasteridae	*Odontognathus mucronatus* Lacepède, 1800	Fig. 6g.	Z			x	P			2	LC	0	1
Clupeiformes	Pristigasteridae	*Pellona flavipinnis* (Valenciennes, 1837)	*fig. 4k.	Z	x		x	P			1	X	1	1
Clupeiformes	Pristigasteridae	*Pellona harroweri* (Fowler, 1917)	Fig. 6h.	Z,L			x	P			2	LC	1	2

Tab. 1. (Continued)

ORDEM	FAMILY	SPECIE		A	B	C	D	E	F	G	H	I	J	K
Siluriformes	Ariidae	*Amphiarius phrygiatus* (Valenciennes, 1840)	Fig. 6i.	Z,L	x		x	D			0	LC	1	0
Siluriformes	Ariidae	*Aspistor quadriscutis* (Valenciennes, 1840)	*fig. 6b.	Z,L	x		x	D			1	LC	1	0
Siluriformes	Ariidae	*Bagre bagre* (Linnaeus, 1766)	*fig. 6c.	Z,L			x	D			1	LC	2	2
Siluriformes	Ariidae	*Cathorops spixii* (Agassiz, 1829)	*fig. 6f.	Z,L			x	D			1	X	1	0
Siluriformes	Ariidae	*Notarius grandicassis* (Valenciennes, 1840)	Fig. 6j.	Z,L	x			D	x		0	LC	1	1
Siluriformes	Ariidae	*Sciades couma* (Valenciennes, 1840)	Fig. 6h.	Z,L	x		x	D			0	LC	1	0
Siluriformes	Ariidae	*Sciades parkeri* (Traill, 1832)	*fig. 6i.	Z,L	x		x	D			0	VU	1	0
Siluriformes	Ariidae	*Sciades proops* (Valenciennes 1840)	*fig. 6k.	Z,L			x	D			0	X	1	0
Siluriformes	Aspredinidae	*Aspredo aspredo* (Linnaeus, 1758)	*fig. 7f.	Z	x		x	D			1	X	0	1
Aulopiformes	Synodontidae	*Saurida caribbaea* Breder, 1927	Fig. 7a.	Z		x		D	x		1	LC	0	0
Aulopiformes	Synodontidae	*Synodus bondi* Fowler, 1939	Fig. 7b.	Z		x		D	x		1	LC	1	1
Aulopiformes	Synodontidae	*Synodus poeyi* Jordan, 1887	Fig. 7c.	O		x		D	x		0	LC	1	0
Aulopiformes	Synodontidae	*Trachinocephalus myops* (Forster, 1801)	*fig. 5a.	O				D		x	0	LC	1	0
Holocentriformes	Holocentridae	*Holocentrus adscensionis* (Osbeck, 1765)	Fig. 7d.	Z				D		x	1	LC	1	0
Holocentriformes	Holocentridae	*Myripristis jacobus* Cuvier, 1829	Fig. 7e.	Z				D		x	1	LC	1	0
Ophidiiformes	Ophidiidae	*Brotula barbata* (Bloch, Schneider, 1801)	Fig. 7f.	Z		x		D		x	0	LC	0	0
Ophidiiformes	Ophidiidae	*Lepophidium brevibarbe* (Cuvier, 1829)	Fig. 7g.	Z				D	x		0	LC	1	0
Lophiiformes	Antennariidae	*Antennarius striatus* (Shaw, 1794)	Fig. 7h.	Z			x	B		x	0	LC	0	1
Lophiiformes	Ogcocephalidae	*Halieutichthys aculeatus* (Mitchill, 1818)	Fig. 7i.	Z				B		x	0	LC	0	1
Lophiiformes	Ogcocephalidae	*Ogcocephalus nasutus* (Cuvier, 1837)	Fig. 7j.	Z				B		x	0	LC	0	0
Lophiiformes	Ogcocephalidae	*Ogcocephalus notatus* (Valenciennes, 1829)	Fig. 7k.	Z				B		x	0	LC	0	1
Lophiiformes	Ogcocephalidae	*Ogcocephalus pumilus* Bradbury, 1980	Fig. 7l.	Z		x		B		x	0	LC	0	0
Lophiiformes	Ogcocephalidae	*Ogcocephalus vespertilio* (Linnaeus, 1758)	*fig. 9d.	Z			x	B		x	0	X	0	1
Mugiliformes	Mugilidae	*Mugil brevirostris* Miranda-Ribeiro, 1915	*fig. 16c.	Z			x	P			1	X	2	1
Mugiliformes	Mugilidae	*Mugil curema* Valenciennes, 1830	*fig. 16d.	Z,L			x	P		x	2	LC	2	1
Mugiliformes	Mugilidae	*Mugil incilis* Hancock, 1830	*fig. 16e.	Z			x	P			1	LC	2	1
Mugiliformes	Mugilidae	*Mugil rubrioculus* Harrison *et al*., 2007	*fig. 16f.	Z			x	P			1	LC	2	1
Beloniformes	Exocoetidae	*Cheilopogon melanurus* (Valenciennes, 1847)	*fig. 10c.	Z		x		P	x		1	LC	0	1
Beloniformes	Exocoetidae	*Exocoetus volitans* Linnaeus, 1758	Literature	L				P	x		1	LC	0	0
Beloniformes	Exocoetidae	*Parexocoetus hillianus* (Gosse, 1851)	Fig. 7m.	Z				P	x		*1*	LC	0	1
Beloniformes	Hemiramphidae	*Hyporhamphus roberti* (Valenciennes, 1847)	*fig. 10b.	L			x	P			1	LC	1	0
Gasterosteiformes	Fistulariidae	*Fistularia petimba* Lacepède, 1803	Fig. 7n.	Z		x	x	D		x	1	LC	1	0
Gasterosteiformes	Fistulariidae	*Fistularia tabacaria* Linnaeus, 1758	Fig. 7o.	Z			x	D		x	1	LC	1	0
Scorpaeniformes	Dactylopteridae	*Dactylopterus volitans* (Linnaeus, 1758)	*fig. 10e.	Z			x	D		x	2	LC	1	1
Scorpaeniformes	Scorpaenidae	*Scorpaena brasiliensis* Cuvier, 1829	Fig. 7p.	Z				D		x	1	LC	0	1
Scorpaeniformes	Scorpaenidae	*Scorpaena isthmensis* Meek, Hildebrand, 1928	Fig. 7q.	Z				D		x	1	LC	0	1
Scorpaeniformes	Triglidae	*Prionotus punctatus* (Bloch, 1793)	*fig. 10f.	Z			x	B		x	1	LC	1	1

Tab. 1. (Continued)

ORDEM	FAMILY	SPECIE		A	B	C	D	E	F	G	H	I	J	K
Perciformes	Centropomidae	*Centropomus ensiferus* Poey, 1860	Fig. 8a.	Z,L		x		D	x		1	LC	2	0
Perciformes	Centropomidae	*Centropomus undecimalis* (Bloch, 1792)	*fig. 11b.	L			x	D		x	1	LC	2	0
Perciformes	Serranidae	*Alphestes afer* (Bloch, 1793)	Fig. 8b.	Z		x		D		x	0	LC	1	0
Perciformes	Serranidae	*Cephalopholis fulva* (Linnaeus, 1758)	Fig. 8c.	O,L				D		x	0	LC	2	0
Perciformes	Serranidae	*Diplectrum radiale* (Quoy, Gaimard, 1824)	Fig. 8d.	Z				D		x	0	LC	2	1
Perciformes	Serranidae	*Epinephelus itajara* (Lichtenstein, 1822)	*fig. 11c.	Z,L			x	D		x	0	CR*	2	1
Perciformes	Serranidae	*Epinephelus morio* (Valenciennes, 1828)	Fig. 8e.	Z				D		x	0	NT*	2	0
Perciformes	Serranidae	*Hyporthodus nigritus* (Holbrook, 1855)	Fig. 8f.	Z		x		D		x	0	CR*	2	0
Perciformes	Serranidae	*Hyporthodus niveatus* (Valenciennes, 1828)	Fig. 8g.	Z,L				D		x	0	VU*	2	0
Perciformes	Serranidae	*Mycteroperca bonaci* (Poey, 1860)	Fig. 8h.	O,L				D		x	0	NT*	2	0
Perciformes	Serranidae	*Paralabrax dewegeri* (Metzelaar, 1919)	Fig. 8i.	Z		x		D		x	0	LC	0	0
Perciformes	Serranidae	*Paranthias furcifer* (Valenciennes, 1828)	Fig. 8j.	O		x		D		x	1	LC	2	0
Perciformes	Serranidae	*Serranus flaviventris* (Cuvier, 1829)	Fig. 8k.	Z				D		x	0	LC	0	0
Perciformes	Serranidae	*Serranus phoebe* Poey, 1851	Fig. 8l.	Z				D		x	0	LC	0	0
Perciformes	Opistognathidae	*Lonchopisthus higmani* Mead, 1959	Fig. 8m.	Z	x	x		D	x		0	LC	0	0
Perciformes	Priacanthidae	*Priacanthus arenatus* Cuvier, 1829	Fig. 8n.	Z,L				D		x	2	LC	1	0
Perciformes	Malacanthidae	*Caulolatilus guppyi* Beebe, Tee-Van 1937	Fig. 8o.	Z	x	x		D	x		1	LC	1	0
Perciformes	Malacanthidae	*Malacanthus plumieri* (Bloch, 1786)	Fig. 8p.	O		x		D		x	1	LC	2	0
Perciformes	Pomatomidae	*Pomatomus saltatrix* (Linnaeus, 1766)	Fig. 8q.	Z,L			x	D			2	VU	2	1
Perciformes	Echeneidae	*Echeneis naucrates* Linnaeus, 1758	Fig. 8r.	Z			x	P		x	0	LC	1	1
Perciformes	Rachycentridae	*Rachycentron canadum* (Linnaeus, 1766)	*fig. 11d.	Z,L			x	P		x	1	LC	2	0
Perciformes	Carangidae	*Alectis ciliaris* (Bloch, 1787)	Fig. 9a.	Z,L				P		x	1	LC	2	0
Perciformes	Carangidae	*Caranx bartholomaei* Cuvier, 1833	Fig. 9b.	Z,L				P		x	1	LC	2	1
Perciformes	Carangidae	*Caranx crysos* (Mitchill, 1815)	Fig. 9c.	Z,L			x	P		x	2	LC	2	1
Perciformes	Carangidae	*Caranx hippos* (Linnaeus, 1766)	*fig. 12a.	Z,L			x	P			2	LC	1	1
Perciformes	Carangidae	*Caranx latus* Agassiz, 1831	*fig. 12b.	Z,L				P		x	2	LC	1	1
Perciformes	Carangidae	*Chloroscombrus chrysurus* (Linnaeus, 1766)	*fig. 12c.	Z,L			x	P			2	LC	1	1
Perciformes	Carangidae	*Decapterus macarellus* (Cuvier, 1833)	Fig. 9d.	O,L		x	x	P			2	LC	1	0
Perciformes	Carangidae	*Decapterus punctatus* (Cuvier, 1829)	Fig. 9e.	Z,L			x	P			2	LC	1	0
Perciformes	Carangidae	*Decapterus tabl* Berry, 1968	Fig. 9f.	Z		x	x	P			1	LC	1	0
Perciformes	Carangidae	*Hemicaranx amblyrhynchus* (Cuvier, 1833)	*fig. 12d.	Z,L			x	P			2	LC	1	1
Perciformes	Carangidae	*Oligoplites palometa* (Cuvier, 1832)	*fig. 12e.	Z,L			x	P			2	LC	1	1
Perciformes	Carangidae	*Oligoplites saliens* (Bloch, 1793)	Fig. 9g.	Z			x	P			2	LC	2	1
Perciformes	Carangidae	*Oligoplites saurus* (Bloch, Schneider, 1801)	*fig. 12f.	Z,L			x	P			2	X	1	1
Perciformes	Carangidae	*Selar crumenophthalmus* (Bloch, 1793)	Fig. 9h.	Z,L				P	x		2	LC	1	1
Perciformes	Carangidae	*Selene setapinnis* (Mitchill, 1815)	Fig. 9i.	Z,L				P	x		2	LC	1	2
Perciformes	Carangidae	*Selene vomer* (Linnaeus, 1758)	*fig. 12g.	Z,L			x	P			2	LC	1	0

Tab. 1. (Continued)

ORDEM	FAMILY	SPECIE		A	B	C	D	E	F	G	H	I	J	K
Perciformes	Carangidae	*Seriola dumerili* (Risso, 1810)	Fig. 9j.	Z,L		x		P		x	1	LC	1	1
Perciformes	Carangidae	*Trachinotus carolinus* (Linnaeus, 1766)	*fig. 12h.	Z			x	P			2	LC	1	0
Perciformes	Carangidae	*Trachinotus cayennensis* Cuvier, 1832	Fig. 9k.	Z,L	x		x	P			2	LC	2	1
Perciformes	Carangidae	*Trachinotus falcatus* (Linnaeus, 1758)	*fig. 12i.	Z,L				P		x	2	LC	1	1
Perciformes	Carangidae	*Trachurus trachurus* (Linnaeus, 1758)	Literature	L				P	x		2	VU	1	0
Perciformes	Chaetodontidae	*Chaetodon ocellatus* Bloch, 1787	Fig. 10a.	Z				D		x	0	LC	0	1
Perciformes	Chaetodontidae	*Chaetodon sedentarius* Poey, 1860	Fig. 10b.	Z				D		x	0	LC	0	0
Perciformes	Ephippidae	*Chaetodipterus faber* (Broussonet, 1782)	*fig. 17c.	Z,L			x	P		x	2	LC	1	1
Perciformes	Lutjanidae	*Lutjanus apodus* (Walbaum, 1792)	Fig. 10c.	Z		x		D		x	1	LC	1	0
Perciformes	Lutjanidae	*Lutjanus campechanus* (Poey 1860)	Fig. 10d.	Z,L				D		x	2	VU*	2	0
Perciformes	Lutjanidae	*Lutjanus cyanopterus* (Cuvier 1828)	Fig. 10e.	O			x	D		x	0	VU*	2	0
Perciformes	Lutjanidae	*Lutjanus jocu* (Bloch, Schneider, 1801)	*fig. 13ab.	Z,L			x	D		x	1	DD	1	1
Perciformes	Lutjanidae	*Lutjanus synagris* (Linnaeus, 1758)	*fig. 13c.	Z,L				D		x	1	NT	2	1
Perciformes	Lutjanidae	*Lutjanus vivanus* (Cuvier, 1828)	Fig. 10f.	Z				D		x	1	LC	2	0
Perciformes	Lutjanidae	*Ocyurus chrysurus* (Bloch, 1791)	Fig. 10g.	O,L				P		x	2	DD	1	0
Perciformes	Lutjanidae	*Pristipomoides aquilonaris* (Goode, Bean, 1896)	Fig. 10h.	Z		x		D		x	1	LC	1	0
Perciformes	Lutjanidae	*Rhomboplites aurorubens* (Cuvier, 1828)	Fig. 10i.	Z,L				P		x	1	VU	1	0
Perciformes	Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	*fig. 13d.	L			x	D		x	1	LC	1	0
Perciformes	Gerreidae	*Diapterus auratus* Ranzani, 1840	*fig. 13e.	Z			x	D			2	LC	1	1
Perciformes	Gerreidae	*Diapterus rhombeus* (Valenciennes, 1830)	Fig. 10j.	Z			x	D			2	LC	1	1
Perciformes	Gerreidae	*Eucinostomus argenteus* Baird, Girard, 1855	*fig. 13f.	Z			x	D			1	LC	1	0
Perciformes	Gerreidae	*Eucinostomus gula* (Quoy, Gaimard, 1824)	*fig. 13g.	Z			x	D			1	LC	1	0
Perciformes	Haemulidae	*Anisotremus surinamensis* (Bloch, 1791)	*fig. 14a.	Z				D		x	1	DD	1	0
Perciformes	Haemulidae	*Anisotremus virginicus* (Linnaeus, 1758)	*fig. 14b.	Z				D		x	2	LC	1	1
Perciformes	Haemulidae	*Conodon nobilis* (Linnaeus, 1758)	*fig. 14c.	Z,L				D		x	1	LC	1	2
Perciformes	Haemulidae	*Genyatremus cavifrons* (Cuvier, 1830)	*fig. 14d.	Z,L			x	D			1	LC	1	1
Perciformes	Haemulidae	*Haemulon aurolineatum* Cuvier, 1830	Fig. 10k	O				D		x	1	LC	1	0
Perciformes	Haemulidae	*Haemulon carbonarium* Poey, 1860	Fig. 10l.	O,L		x		D		x	1	LC	1	0
Perciformes	Haemulidae	*Haemulon parra* (Desmarest, 1823)	*fig. 14e.	Z				D		x	1	LC	1	0
Perciformes	Haemulidae	*Haemulon* sp.	Fig. 10m.	Z				D		x	1	LC	1	1
Perciformes	Haemulidae	*Haemulopsis corvinaeformis* (Steindachner, 1868)	*fig. 14g.	Z,L			x	D		x	2	LC	1	2
Perciformes	Haemulidae	*Orthopristis scapularis* Fowler, 1915	Fig. 10n.	Z			x	D			1	LC	1	2
Perciformes	Pomacanthidae	*Holacanthus ciliaris* (Linnaeus, 1758)	Fig. 11a.	Z				D		x	0	LC	0	0
Perciformes	Pomacanthidae	*Pomacanthus paru* (Bloch, 1787)	*fig. 16b.	Z				D		x	0	LC	1	0
Perciformes	Polynemidae	*Polydactylus virginicus* (Linnaeus, 1758)	Fig. 11b.	Z,L			x	D			1	LC	1	2
Perciformes	Scaridae	*Sparisoma axillare* (Steindachner, 1878)	Fig. 11c.	O				D		x	1	DD	1	0
Perciformes	Scaridae	*Sparisoma frondosum* (Agassiz, 1831)	Fig. 11d.	Z				D		x	1	DD	1	0

Tab. 1. (Continued)

ORDEM	FAMILY	SPECIE		A	B	C	D	E	F	G	H	I	J	K
Perciformes	Sparidae	*Calamus penna* (Valenciennes, 1830)	Fig. 11e.	Z				D		x	1	LC	1	0
Perciformes	Sparidae	*Calamus pennatula* Guichenot, 1868	Fig. 11f.	Z		x		D		x	1	LC	1	0
Perciformes	Sciaenidae	*Bairdiella goeldi* Marceniuk *et al*., 2019	*fig. 15a.	Z			x	D			1	LC	1	0
Perciformes	Sciaenidae	*Ctenosciaena gracilicirrhus* (Metzelaar, 1919)	Fig. 12a.	Z				D	x		1	LC	1	2
Perciformes	Sciaenidae	*Cynoscion acoupa* (Lacepède, 1801)	Fig. 12b.	Z,L			x	D			1	LC	2	2
Perciformes	Sciaenidae	*Cynoscion jamaicensis* (Vaillant, Bocourt, 1883)	Fig. 12c.	Z,L			x	D			1	LC	2	2
Perciformes	Sciaenidae	*Cynoscion leiarchus* (Cuvier, 1830)	Fig. 12d.	Z,L				D	x		1	LC	2	1
Perciformes	Sciaenidae	*Cynoscion microlepidotus* (Cuvier, 1830)	Fig. 12e.	Z			x	D			1	LC	2	1
Perciformes	Sciaenidae	*Cynoscion similis* Randall, Cervigón, 1968	Fig. 12f.	Z,L	x			D	x		1	LC	2	2
Perciformes	Sciaenidae	*Cynoscion steindachneri* (Jordan, 1889)	Fig. 12g.	Z			x	D			1	LC	1	0
Perciformes	Sciaenidae	*Cynoscion virescens* (Cuvier, 1830)	Fig. 12h.	Z,L			x	D			1	LC	2	1
Perciformes	Sciaenidae	*Isopisthus parvipinnis* (Cuvier, 1830)	Fig. 12i.	Z			x	D			1	LC	2	2
Perciformes	Sciaenidae	*Larimus breviceps* Cuvier, 1830	Fig. 12j.	Z,L			x	D			1	LC	1	2
Perciformes	Sciaenidae	*Macrodon ancylodon* (Bloch, Schneider, 1801)	Fig. 12k.	Z,L			x	D			1	LC	2	2
Perciformes	Sciaenidae	*Menticirrhus americanus* (Linnaeus, 1758)	*fig. 15j.	Z,L			x	D			1	LC	2	2
Perciformes	Sciaenidae	*Micropogonias furnieri* (Desmarest, 1823)	*fig. 15l.	Z,L			x	D			2	LC	2	2
Perciformes	Sciaenidae	*Nebris microps* Cuvier, 1830	*fig. 15m.	Z,L			x	D			1	LC	2	1
Perciformes	Sciaenidae	*Ophioscion punctatissimus* Meek, Hildebrand, 1925	Fig. 12l.	Z			x	D			1	LC	1	1
Perciformes	Sciaenidae	*Paralonchurus brasiliensis* (Steindachner, 1875)	*fig. 15n.	Z			x	D			1	LC	1	2
Perciformes	Sciaenidae	*Pareques acuminatus* (Bloch, Schneider, 1801)	Literature	L				D		x	0	LC	1	0
Perciformes	Sciaenidae	*Plagioscion magdalenae* (Steindachner, 1878)	Literature	L	x		x	D			1	X	1	0
Perciformes	Sciaenidae	*Stellifer rastrifer* (Jordan, 1889)	*fig. 15q.	Z,L			x	D			2	LC	1	2
Perciformes	Sciaenidae	*Stellifer stellifer* (Bloch, 1790)	*fig. 15r.	Z			x	D			2	DD	1	2
Perciformes	Mullidae	*Upeneus parvus* Poey, 1852	Fig. 13a.	Z				D	x		1	LC	2	0
Perciformes	Kyphosidae	*Kyphosus vaigiensis* (Quoy, Gaimard, 1825)	Fig. 13b.	Z		x		D		x	1	LC	2	0
Perciformes	Gobiidae	*Priolepis dawsoni* Greenfield, 1989	Fig. 13c.	Z				B		x	0	LC	0	0
Perciformes	Acanthuridae	*Acanthurus chirurgus* (Bloch, 1787)	Fig. 13d.	Z				D		x	2	LC	0	1
Perciformes	Sphyraenidae	*Sphyraena guachancho* Cuvier, 1829	Fig. 13e.	Z			x	D			1	LC	1	1
Pleuronectiformes	Paralichthyidae	*Citharichthys arenaceus* Evermann, Marsh, 1900	Fig. 14a.	Z			x	B			0	LC	0	2
Pleuronectiformes	Paralichthyidae	*Citharichthys macrops* Dresel, 1885	Fig. 14b.	Z		x		B		x	0	LC	0	1
Pleuronectiformes	Paralichthyidae	*Citharichthys spilopterus* Günther, 1862	*fig. 18a.	Z,L			x	B			0	LC	0	2
Pleuronectiformes	Paralichthyidae	*Cyclopsetta chittendeni* Bean, 1895	Fig. 14c.	Z				B	x		0	LC	1	1
Pleuronectiformes	Paralichthyidae	*Etropus crossotus* Jordan, Gilbert, 1882	Fig. 14d.	Z				B	x		0	LC	0	1
Pleuronectiformes	Paralichthyidae	*Syacium papillosum* (Linnaeus, 1758)	Fig. 14e.	Z				B	x		0	LC	1	1
Pleuronectiformes	Achiridae	*Achirus achirus* (Linnaeus, 1758)	*fig. 18b.	Z			x	B			0	LC	1	1
Pleuronectiformes	Achiridae	*Achirus declivis* Chabanaud, 1940	Fig. 14f.	Z			x	B			0	LC	1	1
Pleuronectiformes	Achiridae	*Achirus lineatus* (Linnaeus, 1758)	Fig. 14g.	Z			x	B			0	LC	1	1

Tab. 1. (Continued)

ORDEM	FAMILY	SPECIE		A	B	C	D	E	F	G	H	I	J	K
Pleuronectiformes	Achiridae	*Gymnachirus nudus* Kaup, 1858	Fig. 14h.	Z		x		B	x		0	LC	0	0
Pleuronectiformes	Achiridae	*Trinectes paulistanus* (Miranda-Ribeiro, 1915)	Fig. 14i.	Z			x	B			0	LC	0	1
Pleuronectiformes	Cynoglossidae	*Symphurus oculellus* Munroe, 1991	Fig. 14j.	Z	x			B	x		0	LC	0	0
Pleuronectiformes	Cynoglossidae	*Symphurus tesselatus* (Quoy, Gaimard, 1824)	Fig. 15k.	Z				B	x		0	LC	0	2
Istiophoriformes	Istiophoridae	*Makaira nigricans* Lacepède, 1802	Literature	L				P	x		1	VU*	2	0
Istiophoriformes	Istiophoridae	*Kajikia albida* (Poey, 1860)	Literature	L				P	x		0	VU	2	0
Istiophoriformes	Xiphiidae	*Xiphias gladius* Linnaeus, 1758	Literature	L				P	x		1	LC	2	0
Batrachoidiformes	Batrachoididae	*Amphichthys cryptocentrus* (Valenciennes, 1837)	Fig. 15a.	O				B		x	0	LC	1	0
Batrachoidiformes	Batrachoididae	*Batrachoides surinamensis* (Bloch, Schneider, 1801)	*fig. 9a.	Z			x	B			0	LC	2	1
Batrachoidiformes	Batrachoididae	*Porichthys plectrodon* Jordan, Gilbert, 1882	Fig. 15b	Z				B	x		0	LC	0	0
Batrachoidiformes	Batrachoididae	*Thalassophryne nattereri* Steindachner, 1876	Fig. 15c.	Z			x	B			0	LC	0	0
Scombriformes	Scombridae	*Acanthocybium solandri* (Cuvier, 1832)	Fig. 15d.	O,L		x		P	x		1	LC	2	0
Scombriformes	Scombridae	*Euthynnus alletteratus* (Rafinesque, 1810)	Fig. 15e.	Z		x		P	x		2	LC	2	0
Scombriformes	Scombridae	*Sarda sarda* (Bloch, 1793)	Literature	L			x	P			1	LC	1	0
Scombriformes	Scombridae	*Scomberomorus brasiliensis* Collette *et al.,* 1978	Fig. 15f.	Z,L				P	x		2	LC	2	2
Scombriformes	Scombridae	*Scomberomorus cavalla* (Cuvier, 1829)	Fig. 15g.	Z				P		x	1	LC	2	1
Scombriformes	Scombridae	*Thunnus atlanticus* (Lesson, 1831)	Fig. 15h.	Z,L		x		P	x		2	LC	2	0
Scombriformes	Trichiuridae	*Trichiurus lepturus* Linnaeus, 1758	*fig. 17d.	Z			x	D			2	LC	1	1
Scombriformes	Stromateidae	*Peprilus crenulatus* Cuvier, 1829	*fig. 17f.	Z,L			x	P			1	LC	2	2
Scombriformes	Stromateidae	*Peprilus xanthurus* (Quoy, Gaimard, 1825)	*fig. 17g.	Z,L				P	x		2	LC	2	0
Syngnathiformes	Syngnathidae	*Hippocampus reidi* Ginsburg, 1933	Fig. 15i.	Z			x	B		x	1	VU*	0	0
Tetraodontiformes	Balistidae	*Balistes capriscus* Gmelin, 1789	Fig. 16a.	O,L				D		x	2	VU	2	0
Tetraodontiformes	Balistidae	*Balistes vetula* Linnaeus, 1758	Fig. 16b.	Z				D		x	1	NT	2	0
Tetraodontiformes	Monacanthidae	*Aluterus heudelotii* Hollard, 1855	Fig. 16c.	Z		x		D	x		1	LC	0	0
Tetraodontiformes	Monacanthidae	*Aluterus monoceros* (Linnaeus, 1758)	Fig. 16d.	Z				D	x		2	LC	0	0
Tetraodontiformes	Monacanthidae	*Aluterus scriptus* (Osbeck, 1765)	Fig. 16e.	Z		x		D		x	0	LC	0	0
Tetraodontiformes	Monacanthidae	*Cantherhines macrocerus* (Hollard, 1853)	Fig. 16f.	O		x		D		x	0	LC	0	0
Tetraodontiformes	Ostraciidae	*Acanthostracion polygonius* Poey, 1876	Fig. 16g.	Z				D		x	1	LC	1	1
Tetraodontiformes	Ostraciidae	*Acanthostracion quadricornis* (Linnaeus, 1758)	Fig. 16h.	Z				D		x	1	LC	1	1
Tetraodontiformes	Ostraciidae	*Lactophrys trigonus* (Linnaeus, 1758)	Fig. 16i.	Z		x		D		x	0	LC	1	0
Tetraodontiformes	Tetraodontidae	*Colomesus psittacus* (Bloch, Schneider, 1801)	*fig. 19a.	Z,L			x	D			1	LC	0	2
Tetraodontiformes	Tetraodontidae	*Lagocephalus laevigatus* (Linnaeus, 1766)	Fig. 16j.	Z,L			x	D			2	LC	2	1
Tetraodontiformes	Tetraodontidae	*Sphoeroides dorsalis* Longley, 1934	Fig. 16k.	O,L				D	x		0	LC	0	0
Tetraodontiformes	Tetraodontidae	*Sphoeroides testudineus* (Linnaeus, 1758)	*fig. 19c,d.	Z,L			x	D			1	LC	0	1
Tetraodontiformes	Diodontidae	*Chilomycterus reticulatus* (Linnaeus, 1758)	Fig. 16l.	Z		x		D		x	1	LC	0	1
Tetraodontiformes	Diodontidae	*Chilomycterus spinosus* (Linnaeus, 1758)	Fig. 16m.	Z				D		x	2	LC	0	1
Tetraodontiformes	Diodontidae	*Chilomycterus antillarum* (Jordan, Rutter, 1897)	Fig. 16n.	Z		x		D		x	1	LC	0	1

Fig. 3. Species of the order Elopiformes, family Albulidae, *Albula vulpes*, MPEG 35222, 308 mm TL.

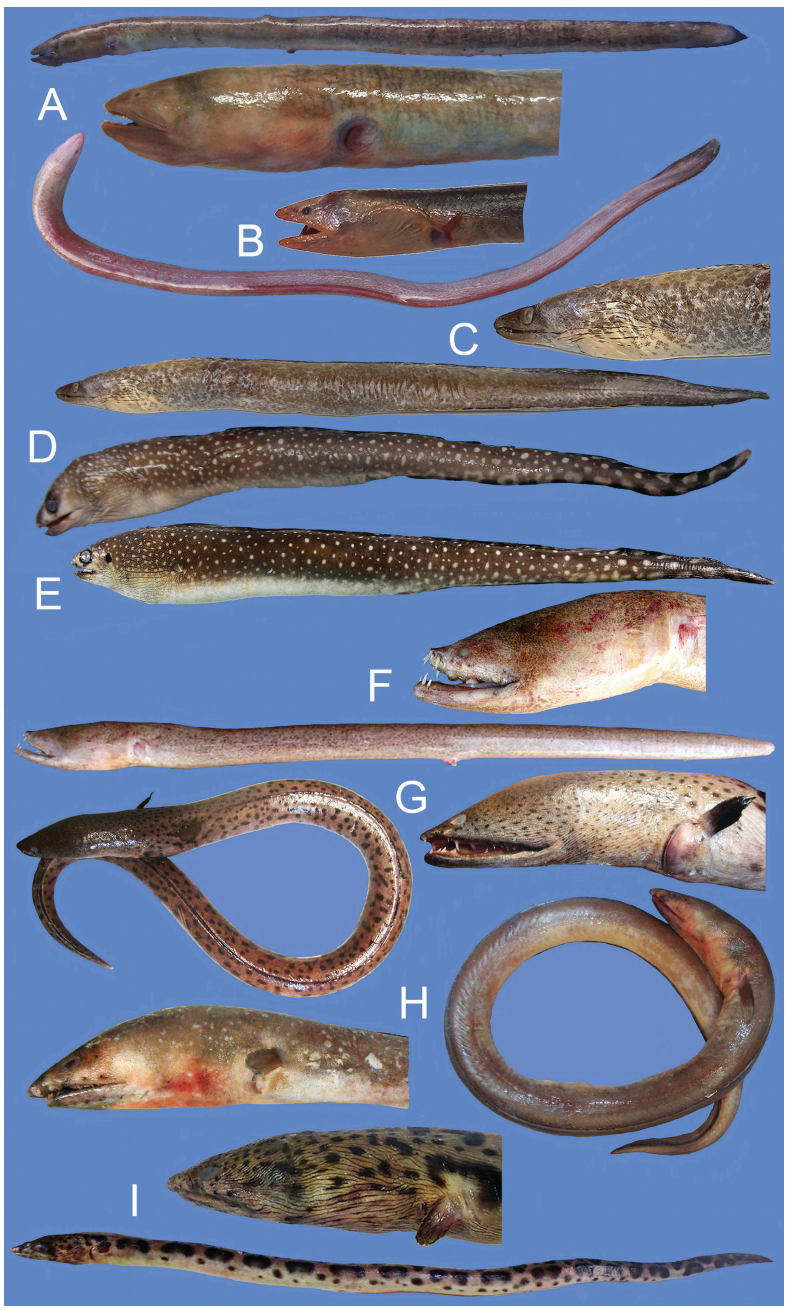

Fig. 4. Species of the order Anguilliformes, family Heterenchelyidae, (A) *Pythonichthys sanguineus*, MPEG 35269, 493 mm TL, family Moringuidae, (B) *Neoconger* sp., AZUSC 4931, 254 mm TL, family Muraenidae, (C) *Enchelycore nigricans*, AZUSC 5432, 298 mm TL, (D) *Gymnothorax conspersus* AZUSC 5059, 326 mm TL, (E) *Gymnothorax ocellatus* AZUSC 5069, 464 mm TL, family Ophichthidae, (F) *Aplatophis chauliodus* not calaloged, 520 mm TL, (G) *Echiophis punctifer* MPEG 35510, 932 mm TL, (H) *Ophichthus cylindroideus* MPEG 35152, 645 mm TL, (I) *Ophichthus ophis* AZUSC 5179, 1052 mm TL.

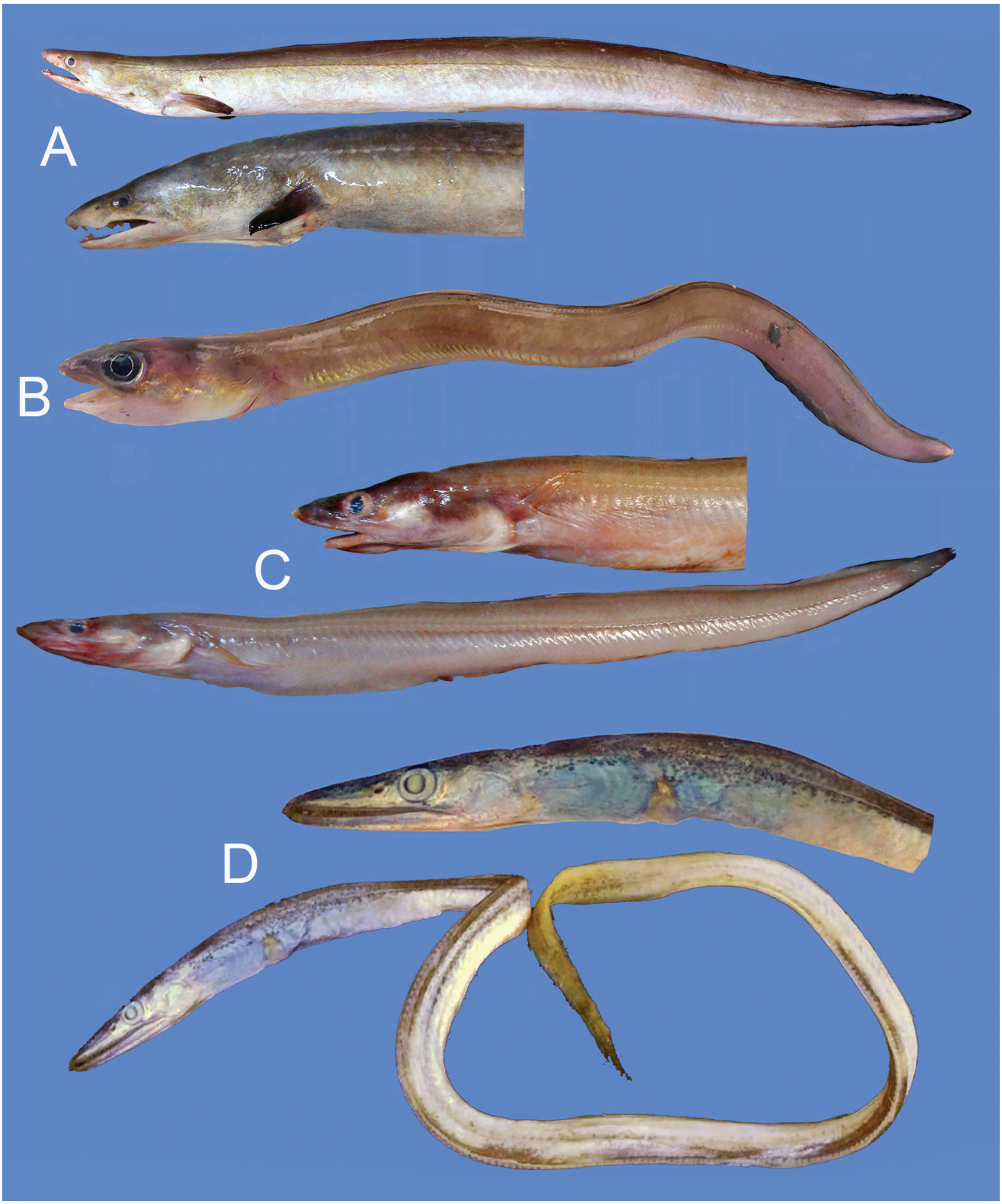

Fig. 5. Species of the order Anguilliformes, family Muraenesocidae, (A) *Cynoponticus savanna* MPEG 35777, 566 mm TL, family Congridae, (B) *Paraconger guianensis* MPEG 35216, 195 mm TL, (C) *Rhynchoconger flavus* MPEG 35746, 365 mm TL, family Nettastomatidae, (D) *Hoplunnis macrura* AZUSC 5670, 320 mm TL.

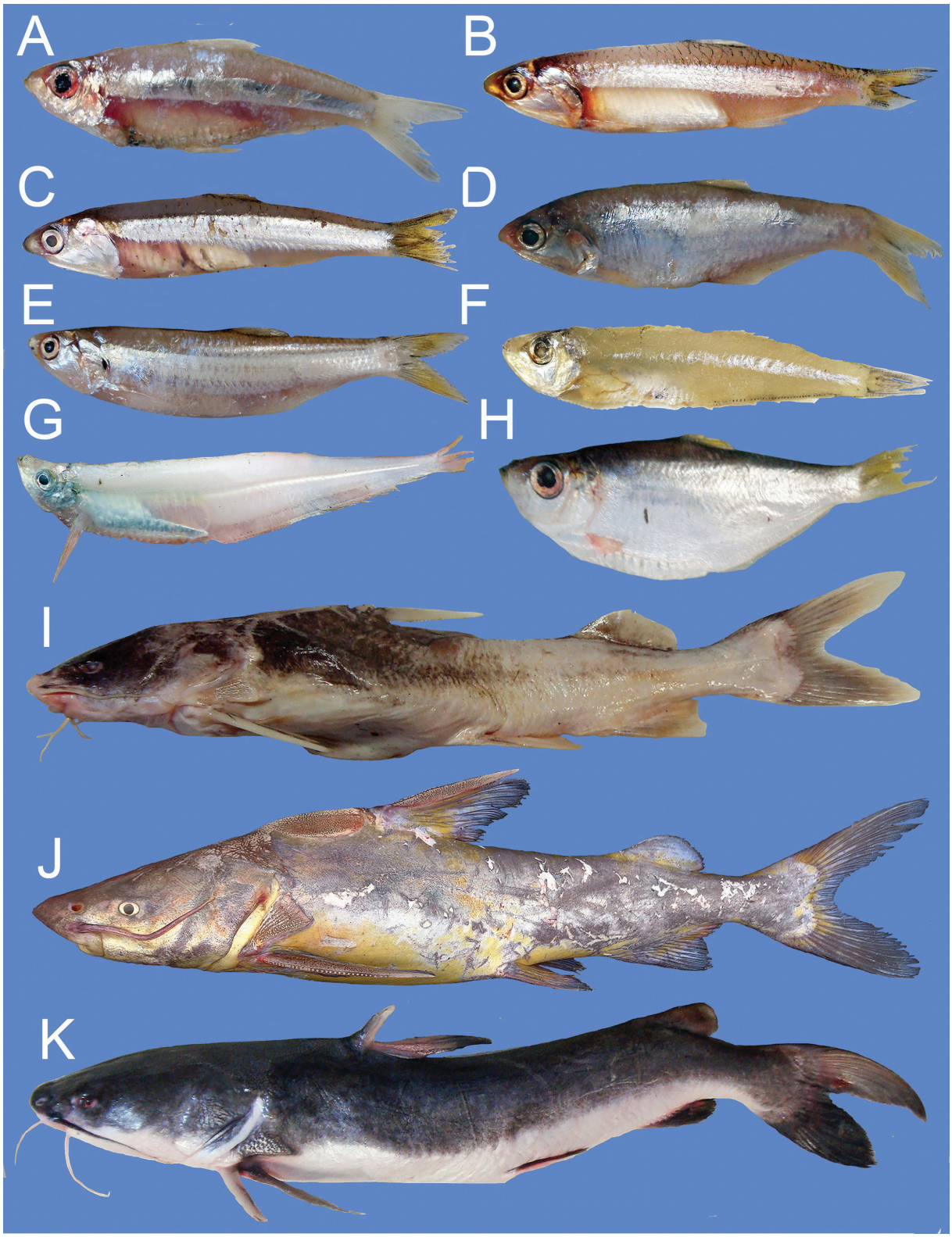

Fig. 6. Species of the order Clupeiformes, family Clupeidae, (A) *Lile piquitinga* MPEG 35023, 95 mm TL, family Engraulidae, (B) *Anchoa filifera* MPEG 35122, 31 mm TL, (C) *Anchoa pectoralis* not cataloged, 100 mm TL, (D) *Anchovia clupeoides* not cataloged, 94 mm TL, (E) *Anchoviella lepidentostole* MPEG 35240, 118 mm TL, family Pristigasteridae, (F) *Chirocentrodon bleekerianus* MPEG 35674, 108 mm TL, (G) *Odontognathus mucronatus* MPEG 35048, 142 mm TL, (H) *Pellona harroweri* MPEG 35700, 136 mm TL, ordem Siluriformes, family *Ariidae*, (I) *Amphiarius phrygiatus* MPEG 35077, 345 mm TL, (J) *Notarius grandicassis* MPEG 35204, 410 mm TL, (K) *Sciades couma* not cataloged, 423 mm TL.

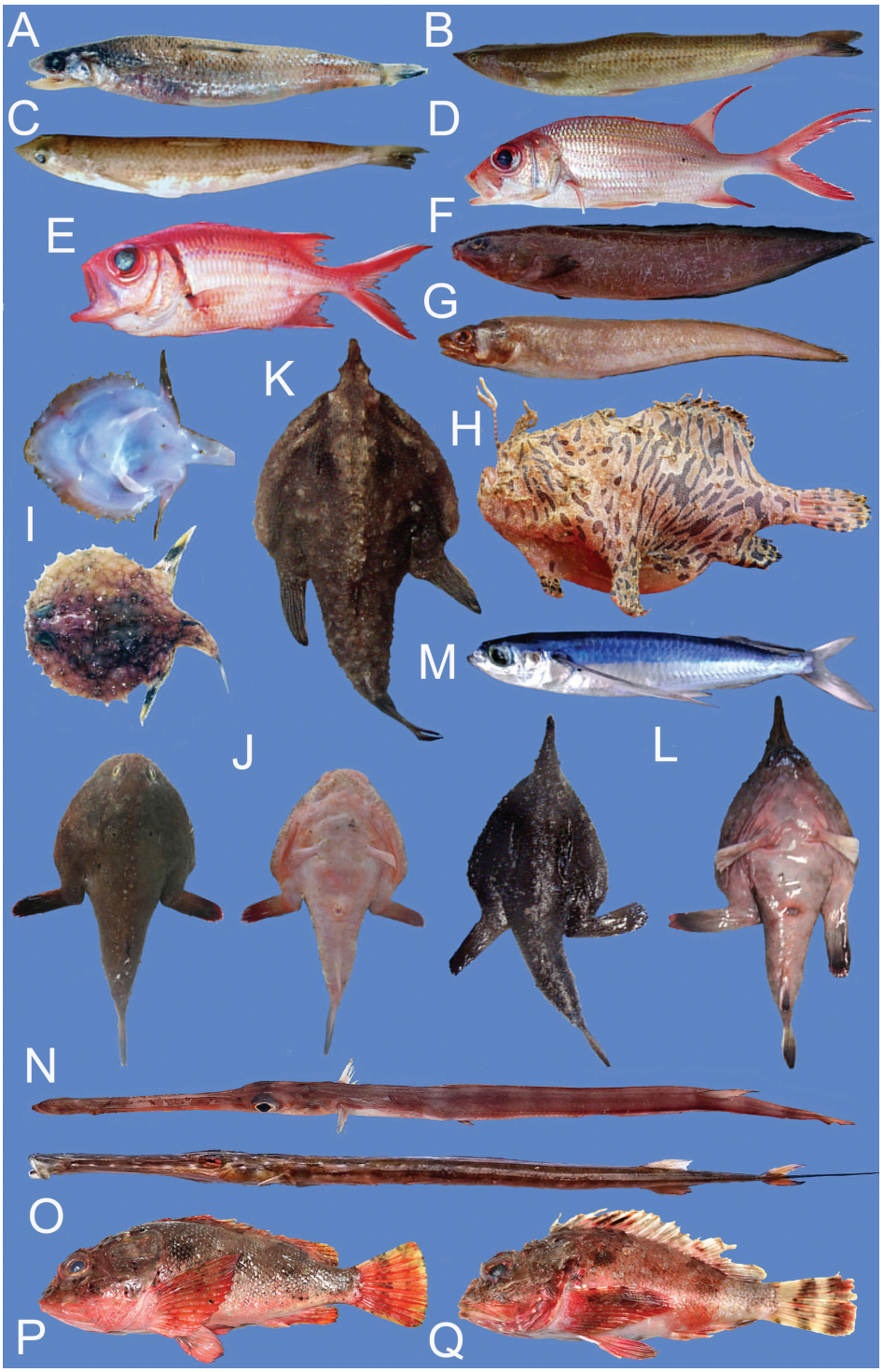

Fig. 7. Species of the order Aulopiformes, family Synodontidae, (A) *Saurida caribbaea* MPEG 35598, 94 mm TL, (B) *Synodus bondi* MPEG 35202, 262 mm TL, (C) *Synodus poeyi* not cataloged, 160 mm TL, order Holocentriformes, family Holocentridae, (D) *Holocentrus adscensionis* AZUSC 5180, 210 mm TL, (E) *Myripristis jacobus* AZUSC 5181, 128 mm TL, order Ophidiiformes, family Ophidiidae, (F) *Brotula barbata* AZUSC 5141, 202 mm TL, (G) *Lepophidium brevibarbe* MPEG 35849, 234 mm TL, order Lophiiformes, family Antennariidae, (H) *Antennarius striatus* MPEG 35201, 114 mm TL, family Ogcocephalidae, (I) *Halieutichthys aculeatus* MPEG 35851, 36 mm TL, (J) *Ogcocephalus nasutus* MPEG 35167, 131 TL, (K) *Ogcocephalus notatus* AZUSC 5068, 120 mm TL, (L) *Ogcocephalus pumilus* MPEG 34615, 157 mm TL, order Beloniformes, family Exocoetidae, (M) *Parexocoetus hillianus* not cataloged, 150 mm TL, order Gasterosteiformes, family Fistulariidae, (N) *Fistularia petimba* AZUSC 5182, 560 mm TL, (O) *Fistularia tabacaria* AZUSC 5669, 590 mm TL, (O) *Scorpaena brasiliensis* MPEG 35141, 119 mm TL, (Q) *Scorpaena isthmensis* AZUSC 5644, 97 mm TL.

Fig. 8. Species of the ordem Perciformes, family Centropomidae, (A) *Centropomus ensiferus* MPEG 35060, 352 mm TL, family Serranidae, (B) *Alphestes afer* MPEG 35142, 174 mm TL, (C) *Cephalopholis fulva* not cataloged, 240 mm TL, (D) *Diplectrum radiale* MPEG 35149, 221 mm TL, (E) *Epinephelus morio* AZUSC 5428, 368 mm TL, (F) *Hyporthodus nigritus* not cataloged, 140 mm TL, (G) *Hyporthodus niveatus* MPEG 35841, 113 mm TL, (H) *Mycteroperca bonaci* not cataloged, 420 mm TL, (I) *Paralabrax dewegeri* AZUSC 5183, 70 mm TL, (J) *Paranthias furcifer* not cataloged, 270 mm TL, (K) *Serranus flaviventris* AZUSC 5103, 71 mm TL, (L) *Serranus phoebe*, AZUSC 5526, 116 mm TL, family Opistognathidae, (M) *Lonchopisthus higmani*, not cataloged, 80 mm TL, family Priacanthidae, (N) *Priacanthus arenatus* MPEG 35707 323 TL, family Malacanthidae, (O) *Caulolatilus guppyi* AZUSC 5668, 180 mm TL, (P) *Malacanthus plumieri* not cataloged, 420 mm TL, family Pomatomidae, (Q) *Pomatomus saltatrix* not cataloged, 380 mm TL, family Echeneidae, (R) *Echeneis naucrates* MPEG 35159, 296 mm TL.

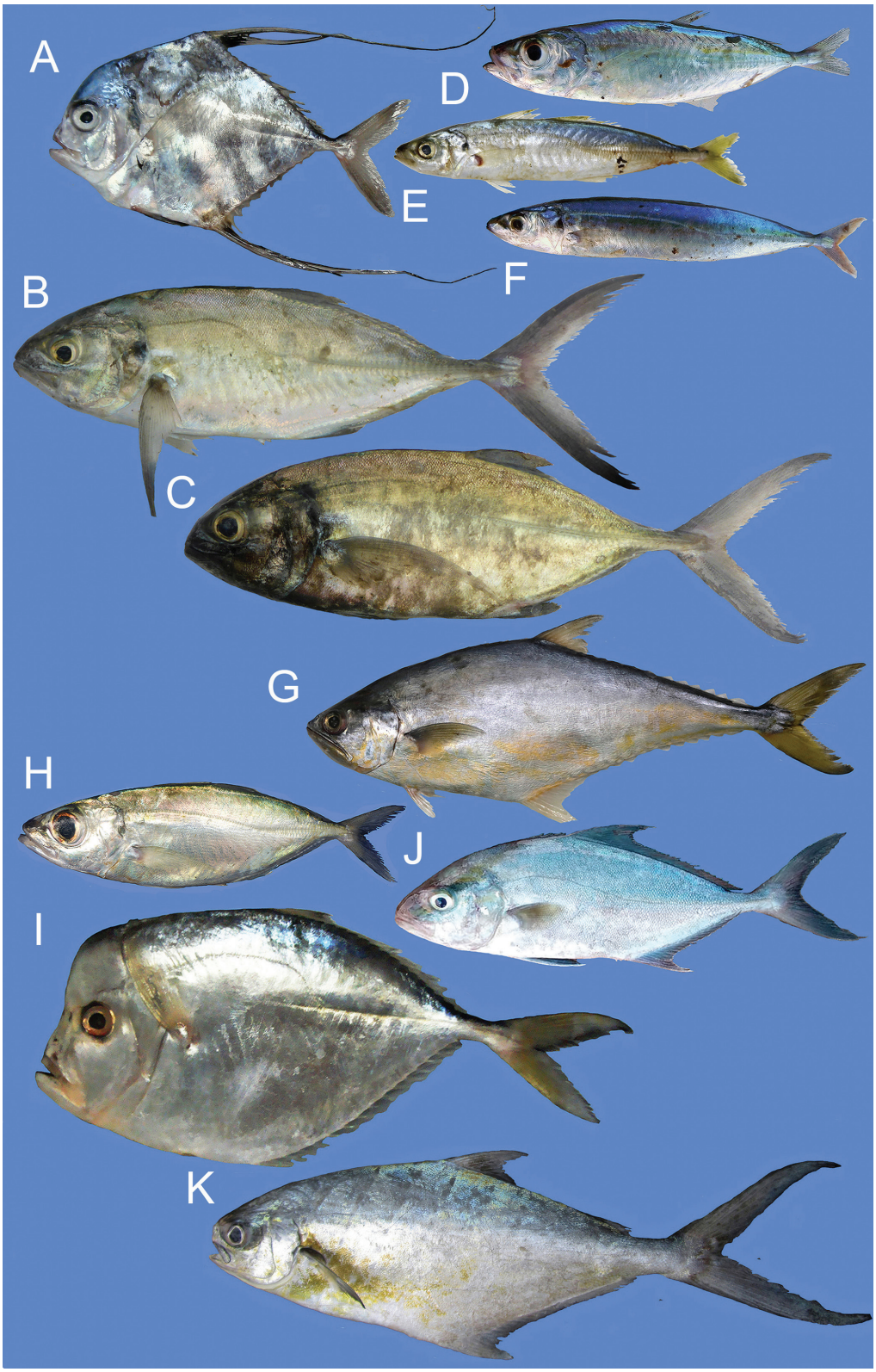

Fig. 9. Species of the order Perciformes, family Carangidae, (A) *Alectis ciliaris* MPEG 35701, 221 mm TL, (B) *Caranx bartholomaei* MPEG 35181, 323 mm TL, (C) *Caranx crysos* MPEG 35183, 350 mm TL, (D) *Decapterus macarellus* not cataloged, 220 mm TL, (E) *Decapterus punctatus* AZUSC 5551, 176 mm TL, (F) *Decapterus tabi* not cataloged, 240 mm TL, (G) *Oligoplites saliens* AZUSC 4660, 280 mm TL, (H) *Selar crumenophthalmus* MPEG 35137, 266 mm TL, (I) *Selene setapinnis* MPEG 35190, 243 mm TL, (J) *Seriola dumerili* not cataloged, 200 mm TL, (K) *Trachinotus cayennensis* MPEG 34410, 265 mm TL.

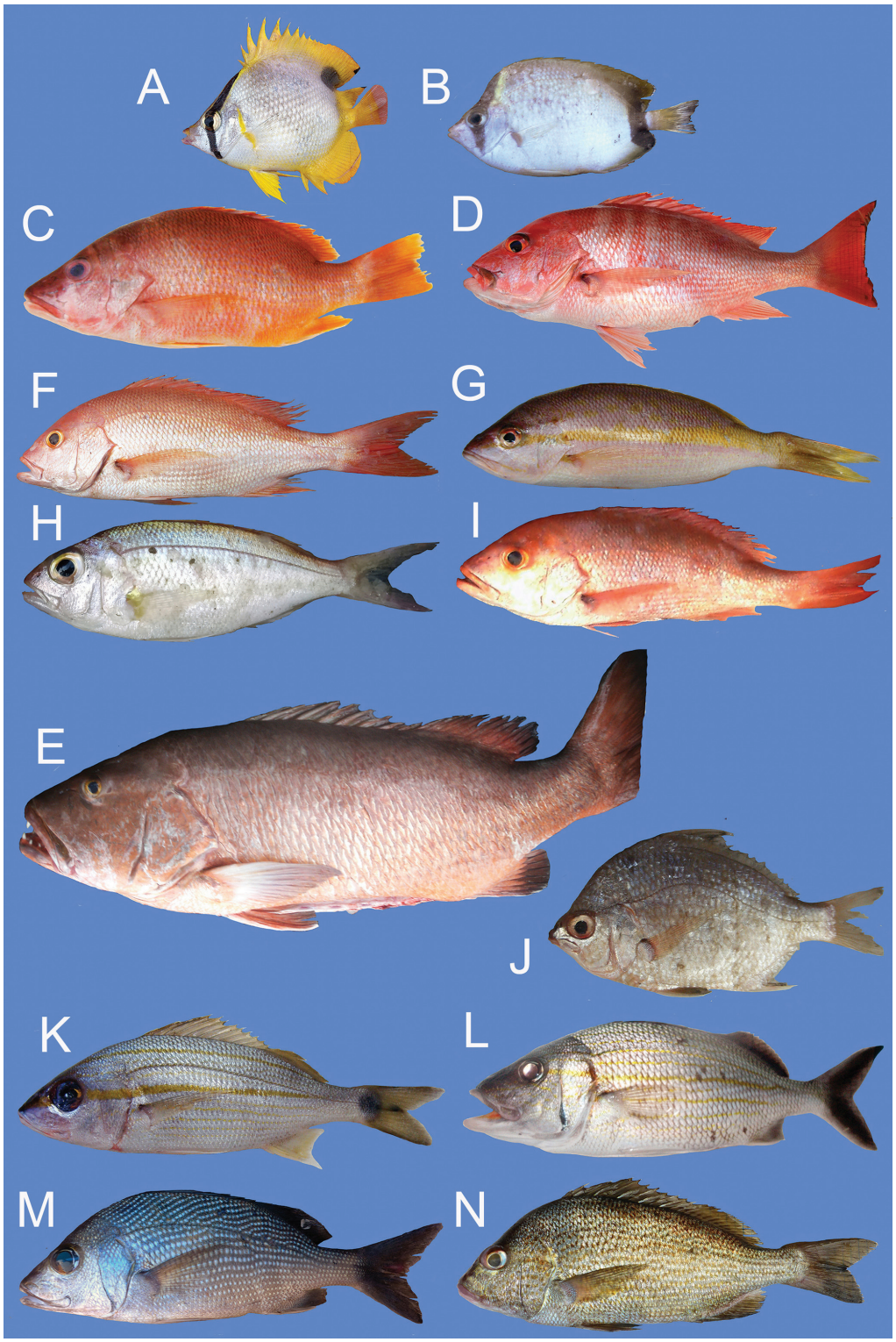

Fig. 10. Species of the order Perciformes, family Chaetodontidae, (A) *Chaetodon ocellatus* MPEG 35121, 91 mm TL, (B) *Chaetodon sedentarius* not cataloged, 150 mm TL, order Perciformes, family Lutjanidae, (C) *Lutjanus apodus* MPEG 34520, 272 mm TL, (D) *Lutjanus campechanus,* AZUSC 5483, 330 mm TL, (E) *Lutjanus cyanopterus* not cataloged, 490 mm TL, (F) *Lutjanus vivanus* MPEG 35576, 283 mm TL, (G) *Ocyurus chrysurus* not cataloged, 260 mm TL, (H) *Pristipomoides aquilonaris* AZUSC 5186, 200 mm TL, (I) *Rhomboplites aurorubens* not cataloged, 330 mm TL, family Gerreidae, (J) *Diapterus rhombeus* MPEG 35191, 192 mm TL, family Haemulidae, (K) *Haemulon aurolineatum* not cataloged, 170 mm TL, (L) *Haemulon carbonarium* not cataloged, 260 mm TL, (M) *Haemulon* sp. MPEG 35708, 189 mm TL, (N) *Orthopristis scapularis* MPEG 35647, 185 mm TL.

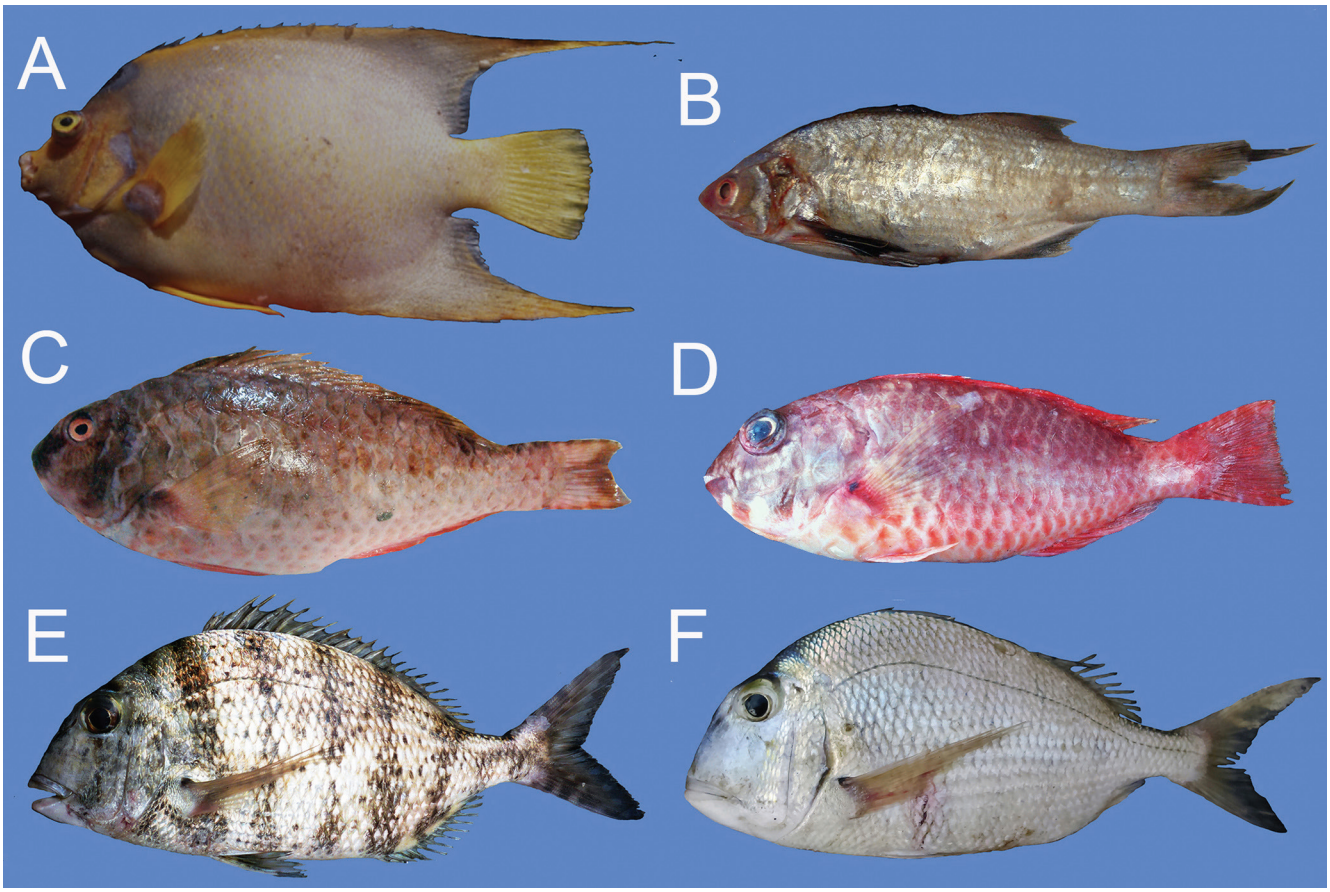

Fig. 11. Species of the order Perciformes, family Pomacanthidae, (A) *Holacanthus ciliaris* not cataloged, 350 mmm TL, family Polynemidae, (B) *Polydactylus virginicus* MPEG 35182 306 mm TL, family Scaridae, (C) *Sparisoma axillare* not cataloged, 170 mm TL, family Sparidae, (D) *Sparisoma frondosum* AZUSC 5446, 120 mm TL, (E) *Calamus penna* MPEG 35709, 226 mm TL, (F) *Calamus pennatula* not cataloged, 230 mm TL.

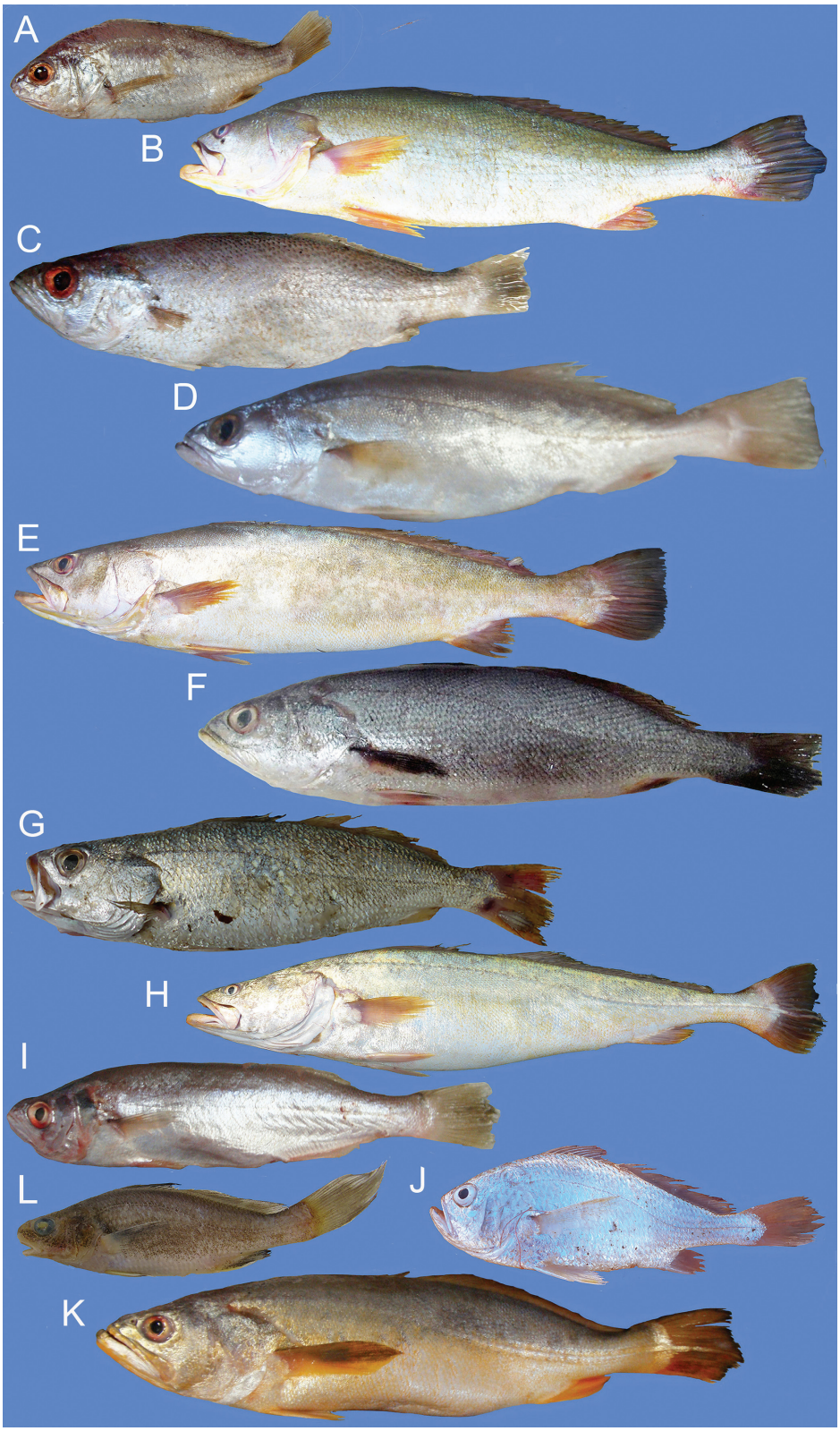

Fig. 12. Species of the order Perciformes, family Sciaenidae, (A) *Ctenosciaena gracilicirrhus* MPEG 35609, 145 mm TL, (B) *Cynoscion acoupa* not cataloged, 310 mm TL, (C) *Cynoscion jamaicensis* MPEG 35588 173 mm TL, (D) *Cynoscion leiarchus* MPEG 35229 183 mm TL, (E) *Cynoscion microlepidotus* not cataloged, 320 mm TL, (F) *Cynoscion similis* MPEG 35042 254 mm TL, (G) *Cynoscion steindachneri* not cataloged, 250 mm TL, (H) *Cynoscion virescens* not cataloged, 340 mm TL, (I) *Isopisthus parvipinnis* MPEG 35051, 175 mm TL, (J) *Larimus breviceps* MPEG s/n, 150 mm TL, (K) *Macrodon ancylodon* MPEG 35059, 230 mm TL, (L) *Ophioscion punctatissimus* AZUSC 5178, 160 mm TL.

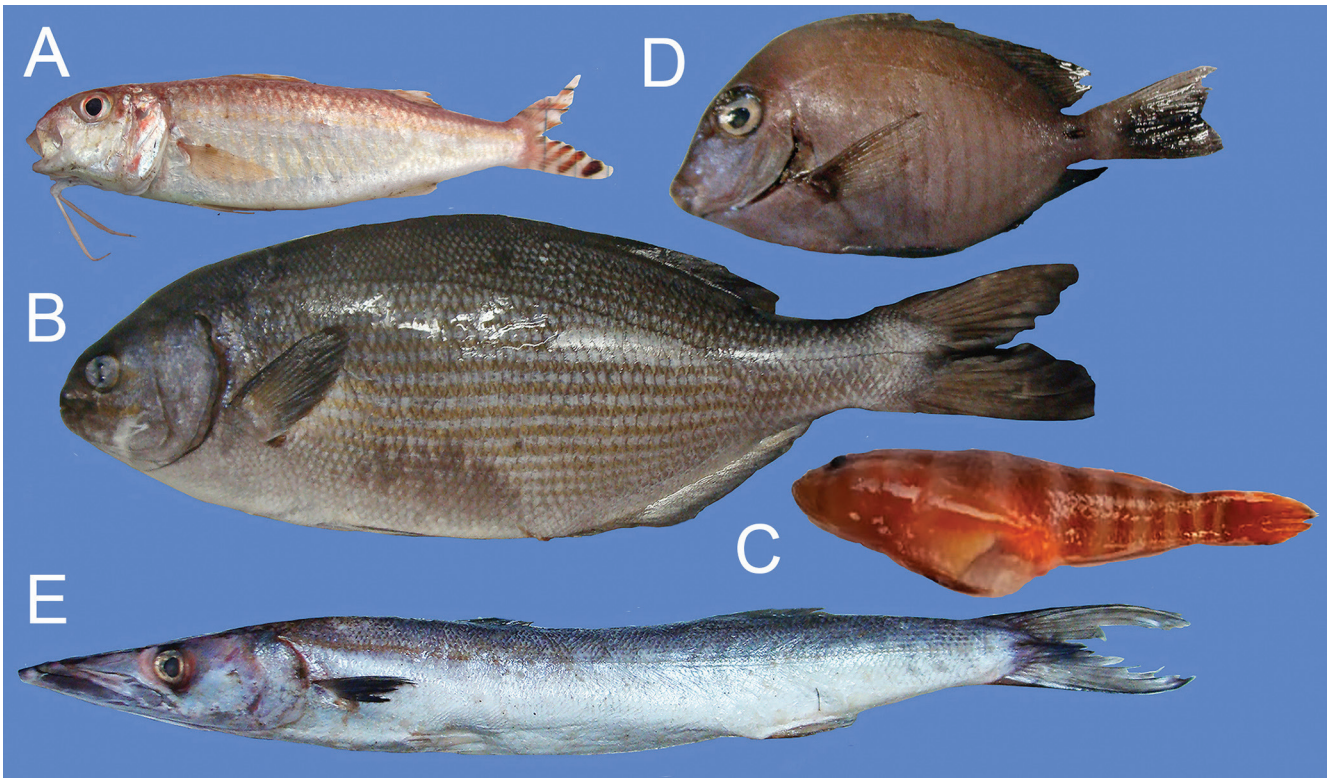

Fig. 13. Species of the order Perciformes, family Mullidae, (A) *Upeneus parvus* AZUSC 5445, 167 mm TL, family Kyphosidae, (B) *Kyphosus vaigiensis* MPEG 35156, 524 mm TL, family *Gobiidae*, (C) *Priolepis dawsoni* not cataloged, AZUSC 5667, 80 mm TL, family Acanthuridae, (D) *Acanthurus chirurgus* MPEG 35178, 85 mm TL, family Sphyraenidae, (E) *Sphyraena guachancho* MPEG 35063, 297 mm TL.

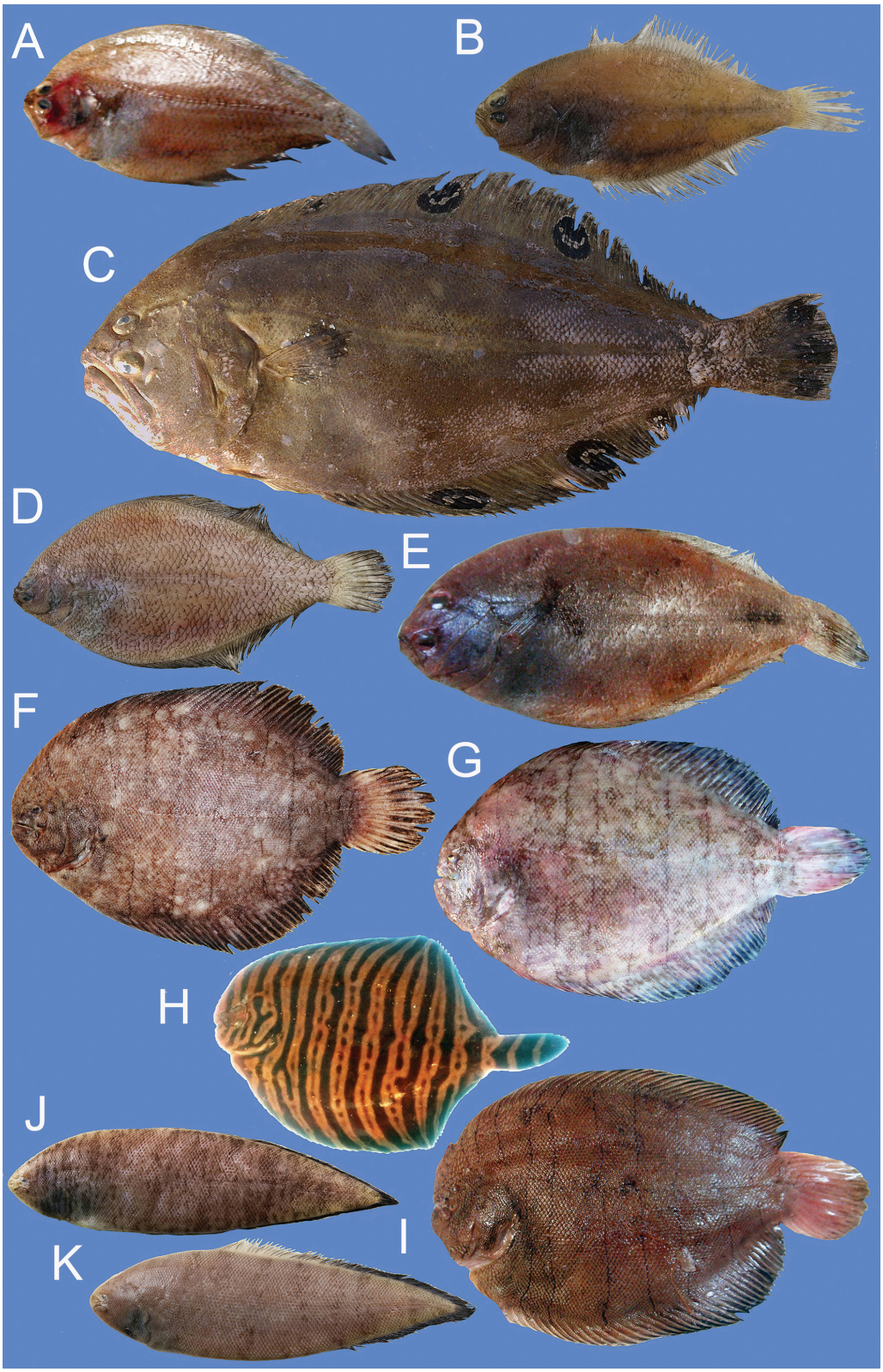

Fig. 14. Species of the order Pleuronectiformes, family Paralichthyidae, (A) *Citharichthys arenaceus* MPEG 35148, 109 mm TL, (B) *Citharichthys macrops* AZUSC 5119, 77 mm TL, (C) *Cyclopsetta chittendeni* MPEG 35119, 293 mm TL, (D) *Etropus crossotus* MPEG xxx mm TL, (E) *Syacium papillosum* MPEG 35559, 179 mm TL, family Achiridae, (F) *Achirus declivis* AZUSC 5461, 150 mm TL, (G) *Achirus lineatus* MPEG 35113, 173 mm TL, (H) *Gymnachirus nudus* not cataloged, 150 mm TL, (I) *Trinectes paulistanus* MPEG 35762, 190 mm TL, family Cynoglossidae, (J) *Symphurus oculellus* AZUSC 4935 4935, 119 mm TL, (K) *Symphurus tesselatus* MPEG 35503, 202 mm TL.

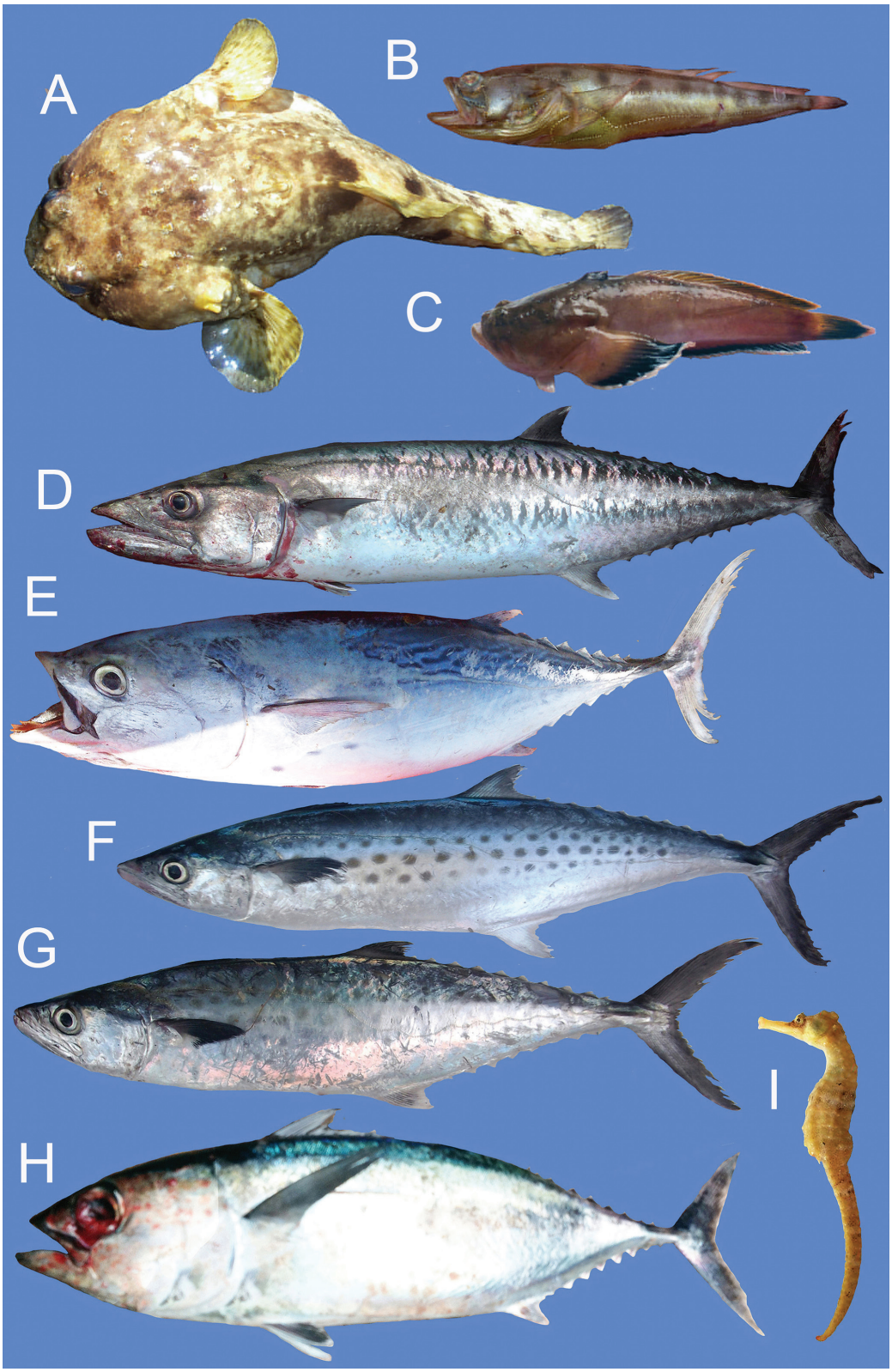

Fig. 15. Species of the Ordem Batrachoidiformes, family Batrachoididae, (A) *Amphichthys cryptocentrus* not cataloged, 240 mm TL, (B) *Porichthys plectrodon* MPEG 35664, 43 mm TL, (C) *Thalassophryne nattereri* not cataloged, 140 mm TL, Ordem Scombriformes, family Scombridae, (D) *Acanthocybium solandri* not cataloged, 450 mm TL, (E) *Euthynnus alletteratus* not cataloged, 390 mm TL, (F) *Scomberomorus brasiliensis* MPEG 35108, 509 mm TL, (G) *Scomberomorus cavalla* not cataloged, 420 mm TL, (H) *Thunnus atlanticus* not cataloged, 480 mm TL, Ordem Syngnathiformes, family Syngnathidae, (I) *Hippocampus reidi*, AZUSC 5388, 98 mm TL.

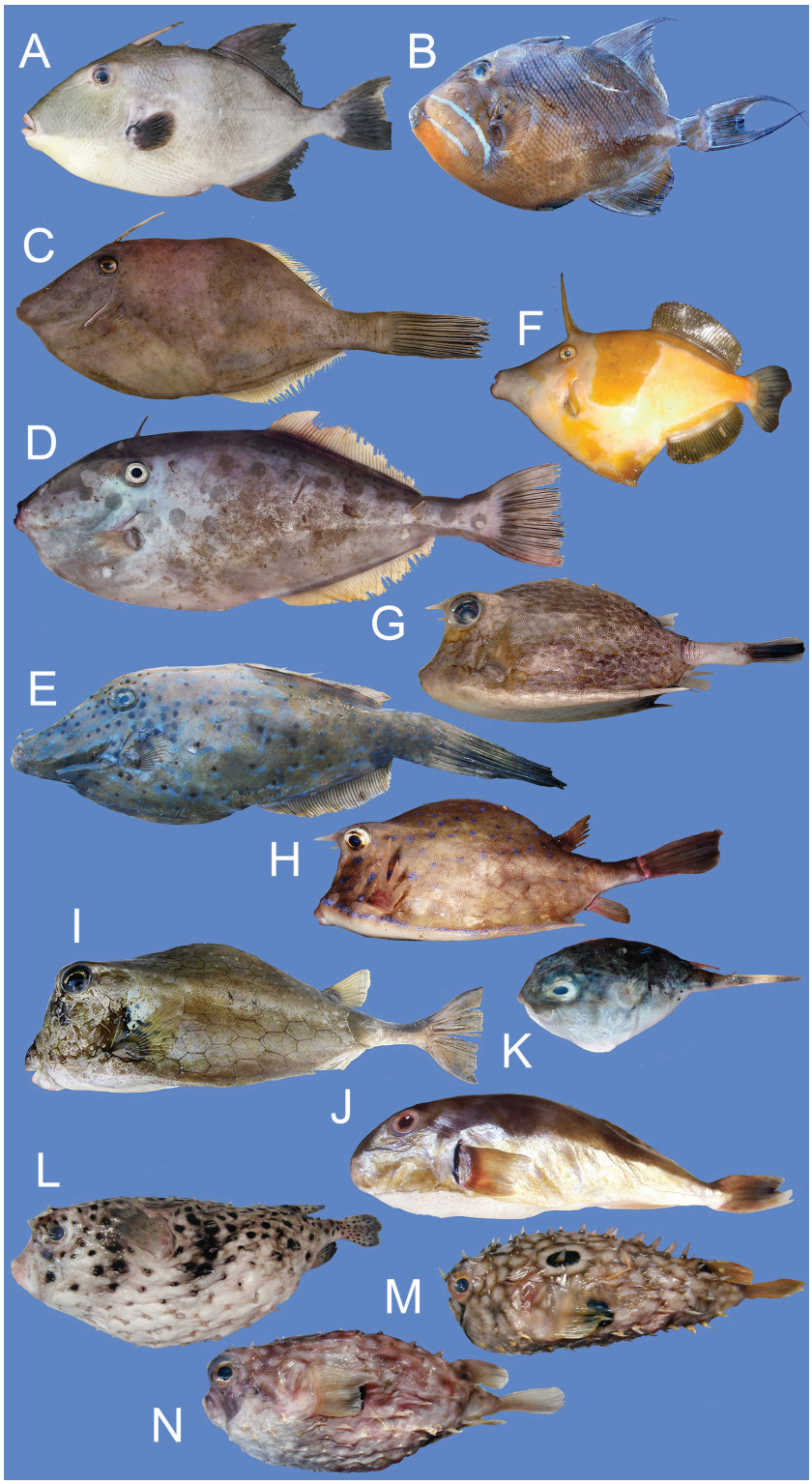

Fig. 16. Species of the order Tetraodontiformes, family Balistidae, (A) *Balistes capriscus* MPEG 33692, 259 mm TL, (B) *Balistes vetula* not cataloged, 180 mm TL, family Monacanthidae, (C) *Aluterus heudelotii*, AZUSC 5494, 350 mm TL, (D) *Aluterus monoceros* MPEG 35756, 481 mm TL, (E) *Aluterus scriptus* not cataloged, 360 mm TL, (F) *Cantherrines macrocerus* not cataloged, 220 mm TL, family Ostraciidae, (G) *Acanthostracion polygonius* MPEG 35154, 161 mm TL, (H) *Acanthostracion quadricornis* MPEG 35174, 276 mm TL, (I) *Lactophrys trigonus* AZUSC 5188, 180 mm TL, family Tetraodontidae, (J) *Lagocephalus laevigatus* MPEG 35175, 340 mm TL, (K) *Sphoeroides dorsalis* not cataloged, 60 mm TL, family Diodontidae, (L) *Chilomycterus reticulatus* MPEG 35614, 206 mm TL, (M) *Chilomycterus spinosus* MPEG 35562, 138 mm TL, (N) *Chilomycterus antillarum* MPEG 35185, 182 mm TL.

The Brazilian national plan for the sustainable exploitation of marine shrimp (Neto, 2011) considers that the harvesting of pink-shrimp is responsible for the unintentional capture of more than 100 fish species. On the North coast alone, Isaac, Braga (1999) estimated that at least 150 species (which were not listed) of aquatic organisms are caught in trawls, of which 80% are teleost fish, that is, approximately 120 species (Damasceno, Evangelista, 1991). While previous studies have referred to the enormous diversity of fish species found off the northern Brazilian coast (Maia *et al*., 2016), the diversity of the fish fauna harvested by trawlers off the North coast of Brazil, has never been systematically assessed, with most of the available data limited to commercially-valuable species, which are not discarded during the fishery operations (Oliveira *et al*., 2004; Pinheiro, Frédou, 2004; Maia *et al*., 2016). The results of the present study provide the most comprehensive inventory of the teleost fish fauna harvested by trawlers on the continental shelf of the North coast of Brazil, even including the data provided by the REVIZEE program (Lucena, Asano-Filho, 2006), reinforcing the existence of a major lacuna in the scientific inventory of the marine-estuarine fishes of the North coast of Brazil (Marceniuk *et al*., 2013; 2017), given, in particular, that 42 (19.4%) of the species were recorded in zoological collections for the first time, including five species that had not been registered previously in Brazil (see Menezes *et al*., 2003).

The definition of the composition of the different fish communities is fundamental to the decision-making necessary for the conservation of the environment and the biota impacted by trawling operations, given that these communities may be characterized by temporal or spatial transitions (Sepkoski, 1988; Williams, 1996), mosaics of habitat partitioning, and edge effects (Harrison, 1997; Fahr, Kalko, 2011). The present study represents an important contribution to the understanding of this process, showing that a considerable proportion of the species harvested by the industrial trawling fleet of northern Brazil are associated with estuarine environments, reflecting the dominant conditions of Amazon-Orinoco plume (Camargo, Isaac, 2001; Marceniuk *et al*., 2013), while a second key group is composed of reef-dwelling species. In this sense, the results of the Kernel density analysis indicate that the industrial trawling fleet of the North Coast of Brazil operates within an important ecotone, which encompasses the transition zones of different fish communities.

It is important to note that the monitoring of fisheries is one of the most effective strategies for the sampling of aquatic communities for biological studies, providing data on population parameters and the impact of fishery operations (Shepherd, 1984, 1988). Samples obtained from fisheries also provide an important tool for the diagnosis of the biological diversity of areas that are poorly-sampled or where financial resources are insufficient for scientific cruises.

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