SHARKS AND BATOIDS (SUBCLASS ELASMOBRANCHII) CAUGHT IN THE INDUSTRIAL FISHERIES OFF THE BRAZILIAN NORTH COAST

TUBARÕES E BATOIDES (SUBCLASSE ELASMOBRANCHII) CAPTURADOS NA PESCA INDUSTRIAL DA COSTA NORTE BRASILEIRA

TIBURONES Y BATOIDES (SUBCLASE ELASMOBRANCHII) CAPTURADOS EN LA PESQUERÍA INDUSTRIAL FRENTE A LA COSTA NORTE DE BRASIL

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Abstract

The Brazilian North coastline comprises a total area of approximately 223,000 km2, representing one of the world's most essential fishing grounds. Availability of data on the diversity of fishes caught in the industrial fishery trawlers in the region are

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usually limited to the commercially important and targeted species. Knowledge gaps on the related marine fish fauna are eminent, which hamper both fisheries and conservation efforts of the local biodiversity. A comprehensive taxonomic list of elasmobranch species captured off the North coast from Brazil through industrial trawl fishery is provided. Trawling operations acting regionally included pink-shrimp and several fish (outrigger trawling) and piramutaba catfish (pair trawlers). Sixty-eigth elasmobranch species belonging to 20 families and nine orders were recorded for this region, according to fish collection, fishery observer and literature data. Thirty-two are by-catch species caught in the local trawl operations, including endemic and rare species as well as four new records and one possible undescribed species of electric ray.

Keywords: elasmobranch; industrial fisheries; biodiversity; conservation; Brazilian North coast.

Resumen

La costa norte brasileña comprende un área total de aproximadamente 223.000 km2, que representa uno de los caladeros más esenciales del mundo. La disponibilidad de datos sobre la diversidad de peces capturados en los arrastreros de pesca industrial en la región generalmente se limita a las especies comercialmente importantes y seleccionadas. Las brechas de conocimiento sobre la fauna de peces marinos son eminentes, lo que dificulta tanto la pesca como los esfuerzos de conservación de la biodiversidad local. En este trabajo se proporciona una lista taxonómica integral de especies de elasmobranquios capturadas en la costa norte de Brasil a través de la pesca de arrastre industrial. Las operaciones de arrastre que actúan a nivel regional incluyeron camarones rosados y varios peces (arrastre de estabilizadores), asi como el bagre piramutaba (arrastreros de parejas). Se registraron 60 especies de elasmobranquios pertenecientes a 20 familias y nueve órdenes para esta región, de acuerdo con la recolección de peces, el observador de pesca y los datos de la literatura. Treinta y dos son especies de captura secundaria obtenidas en las operaciones locales de arrastre, incluidas especies endémicas y raras, así como cuatro nuevos registros y una posible especie de raya eléctrica no descrita.

Palabras llave: elasmobranch; pesca industrial; biodiversidade; conservación; Costa norte brasileña.

Resumo

A costa norte do Brasil compreende uma área total de aproximadamente 223.000 km2, representando uma das áreas de pesca mais importantes do mundo. A disponibilidade de dados sobre a diversidade de peixes capturados na pesca industrial de arrasto de fundo da região é limitada apenas às espécies comercialmente importantes. Esta lacuna de conhecimento da fauna de peixes marinhos é preocupante, por dificultar o monitoramento da pesca, assim como esforços de conservação da biodiversidade local. Uma lista taxonômica de Elasmobrânquios capturados na costa norte do Brasil pela pesca industrial de arrasto de fundo é aqui apresentada. As operações de arrasto que atuam sobre o camarão-rosa e peixes diversos (arrasto de portas) e a Piramutaba

(parelhas) foram aqui monitoradas. Com base na observação de bordo, acervo de coleções zoológicas e literatura, 68 espécies de Elasmobrânquios, pertencentes a 20 famílias e nove ordens, foram registradas para a região. Trinta e duas espécies foram registradas como fauna acompanhante da pesca de arrasto, incluindo espécies endêmicas e raras, bem como quatro novos registros e uma possível espécie não descrita de raia-elétrica.

Palavras-chave: elasmobrânquios; pesca industrial; biodiversidade; conservação; costa norte do Brasil.

INTRODUCTION

Elasmobranch fishes (batoids and sharks) currently comprise 1,139 species worldwide in which 224 species occur in Brazil with distribution in marine, brackish and freshwater environments from shallow coastal waters to deep oceanic zones (Weigmann 2016). Elasmobranches are extensively caught as by-catch in industrial and artisanal fisheries as part of the global effort on targeting commercially important teleost species. Usually, sharks and batoids are captured using longlines, gill nets, purse and beach seine nets, and demersal trawls (Lessa et al. 1999). Shark meat exhibits reduced commercial values when compared to those of teleosts. Shark finning (and that also includes batoids), however, represents a valuable economical trend within the fishing industry in Brazil and elsewhere (Ussami 2015; Barreto et al. 2017). Reduction of fishing stocks and growing demand of protein for consumption has lately boosted the exploration of the elasmobranch fishing grounds that often are sold as mislabelled seafood products national and internationally (Bornatowski et al. 2017).

Annnually, 12,000 and 5,000 tons of sharks and batoids, respectively, are caught in the Brazilian fishing industry which place the country within the sixth highest sellers of shark meat worldwide (IUCN 2018; IBAMA/MMA 2007; Feitoza et al. 2018). Fisheries statistics from industrial and artisanal fisheries in Brazil and particularly at the North coast, where Pará State is the second in fishing production of the country, are lacking since 2017 (Pinheiro and Fredou 2004; Cintra et al. 2015; Lutz et al. 2016; Klautau et al. 2016), which hampers responsible conservation efforts. Furthermore, growing fishing interests in elasmobranch species of this region is alarming (Fredou and Asano-Filho 2006) as it functions as nursery area (SBEEL 2005).

The reliable identification of sharks and batoids species from the Brazilian North coast is a fundamental criteria for fisheries zoning as well as to the knowledge improvement on the diversity of the marine environment and the fish communities affected by fisheries activities in the region (sensu Manthey and Fridley, 2009). Inaccurate and unavailability of taxonomic data on sharks and batoids species captured through outrigger trawlers hamper the development of effective local

conservation measures and management of the exploited ecosystems (Thrush et al., 1998; Greenstreet and Rogers, 2004; Juan and Demestres, 2012).

In this context, the present study intends to provide a comprehensive inventory of the elasmobranch species caught in the industrial fisheries off the North coast of Brazil at the pink-shrimp, several fish, and piramutaba catfish trawling operations. Regional elasmobranch diversity is also investigated herein through literature review in order to understand the status of the taxonomic knowledge.

MATERIAL AND METHODS

Study area

Brazilian North coastline comprises the region between Oiapoque (04023'N) and Parnaíba (02053'S) River mouths which discharge sediments in the Western Atlantic Ocean (Fig. 1). Usually, it is divided into three sectors (Studart-Gomes 1988): (i) Maranhão coast located between Parnaíba River mouth (02053'S) and Cape Gurupi (00053'S) off Pará state which is characterized by muddy and sandy beaches, (ii) Pará coast (02030'N, 00050'S) with predominantly muddy bottoms, and (iii) Amapá coast (04023'N, 02030'N) within Cape Orange with hard and rocky bottoms. This region is embedded within a vast shrimp fishing ground that extends northwestwards to an area adjacent to Orinoco River mouth in Venezuela (IBAMA 1997). The study area comprised the second and third sectors where industrial fisheries based in Belém, Pará state are intensively operating within the continental shelf (Figure 1) (Marceniuk et al. 2019).

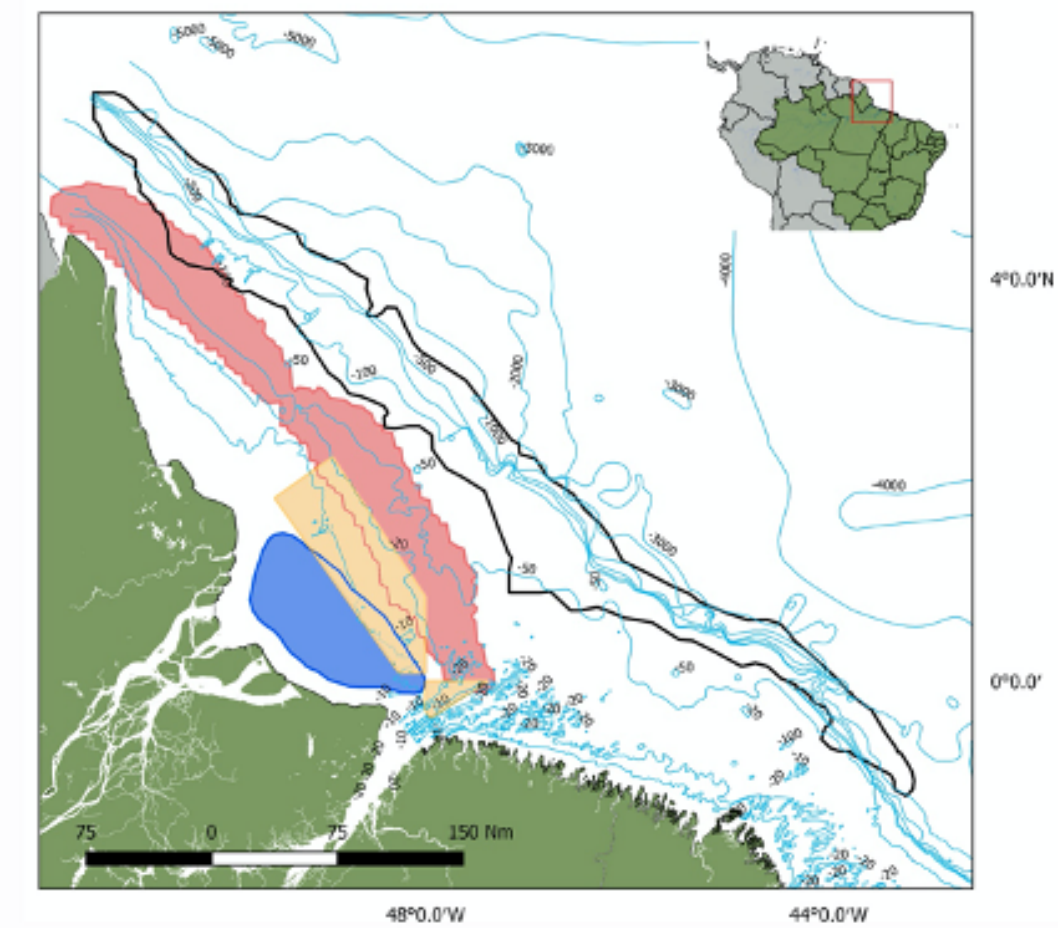

Figure 1. Industrial trawling zone off the North coast of Brazil (modified from Aragão et al., 2001; Brasil, 2011). Outriggers that target pink-shrimp (red), several fish (orange) (outrigger trawling) and Piramutaba catfish (blue) (pair trawlers). The Great Amazon Reef System as defined in Moura et al. (2016) is in shaded black.

Material examined

Species-specific accounts were based on fishery observer data collected between 2016 and 2018 from the *Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha da Costa Norte do Brasil* (CEPNOR) in Belém, Pará state, Brazil. A total of 522 trawls were monitored during the study period, corresponding to 1.666 operational hours and 277 days at sea, including 164 days during the shrimping season and 103 during the off season (Fig. 2A). Photographs of specimens were taken onboard the fishing vessels. Examination of specimens collected in Amapá and Pará were also included in the analysis and data obtained from the following ichthyological collections: Museu Paraense Emílio Goeldi, Belém (MPEG); Zoological collection of the Universidade Santa Cecilia, Santos (AZUSC); Laboratório de Biologia e Genética de Peixes (LBP) from the Universidade Estadual Paulista Júlio de Mesquita, Botucatu.

Additional data were obtained from the literature that cite, list or describe elasmobranch species off the Brazilian North coast: species available in the literature on bottom trawling (Pinheiro and Fredou 2004; Cintra et al. 2015; Klautau et al. 2016; Lutz et al. 2016; see Table 1B); species recorded in taxonomic works (Lessa et al. 1999; Almeida et al. 2008; see Table 1C); species recorded in exploratory fishing work (Asano-Filho et al. 2005, 2007; Fredou and Asano-Filho 2006; Oliveira et al. 2007; see Table 1D); and species recorded in molecular identification work (Carmona et al. 2008; Rodrigues-Filho et al. 2012; Palmeira et al. 2013; Gemaque 2017; Silveira 2017; Feitosa et al. 2018; see Table 1E).

Figure 2. By-catch elasmobranches exploited off Brazilian North coast, showing fishing observers of the *Centro de Pesquisa e Gestão de Recursos Pesqueiros do Litoral Norte* (CEPNOR) onboard the fishing trawl vessels. A. *Pristis pristis*. B. *Hypanus americanus*. C. *Hypanus guttatus*. D. *Rhinoptera bonasus*. E. *Ginglymostoma cirratum*. F. *Fontitrygon geijskesi*.

Taxonomy and ecology

Species identifications are based on Gomes et al. (2010), Ebert et al. (2013), FAO (2016) and Last et al. (2016a,b,c) besides comparative material and/or consultation with experts. Classification and updated nomenclature of species follow, respectively, Van der Laan et al. (2019) and Fricke et al. (2019). Genera and species-names for each family are given in alphabetical order. Species were also classified according to distribution area (Table 1F) and ecological habits, following Froese and Pauly (2019) and Marceniuk et al. (2019) (Table 1G).

Threatened status and fishing gear type

Conservation status were also provided according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2018) and/or *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* (ICMBio/MMA 2018) (Table 1H). Fishing gears that were applied for capturing each species off the North coast from Brazil are also listed (Table 1I).

Taxonomic procedures

The species labelled as "sp." represent a possible undescribed species currently under investigation by our research team: *Narcine* sp. (Rotundo et al. in preparation).

RESULTS AND DISCUSSION

Elasmobranch diversity from the Brazilian North coast

Based on the photographs and the specimens examined, a total of 34 species were caught in the trawl fisheries off the North Coast of Brazil between 2016 and 2018 (Tab. 1, Table 1A). Out of these only seven species were previously registered in studies about the fish fauna caught through the fishing trawls (see Pinheiro and Fredou, 2004; Cintra et al. 2015; Klautau et al., 2016; Lutz, et al. 2016, see Table 1B). Two species that were not observed during the present study were listed in these accounts (Table 1B). Three ray species are reported herein for the first time in the region: *N. bancroftii*; *P. horkelii*; *U. jamaicensis*; *Narcine* sp. (see Table 1C–E). The latter species represents an undescribed species and it is under investigation by MM Rotundo and colaborators.

Forty-eight elasmobranch species are currently recognized in the study area (see Lessa et al. 1999; Santos et al. 2004; Almeida et al. 2008; Table 1C). Twenty-three species

were also identified through the DNA barcoding of the (CO1) cytochrome oxidase-1 mitochondrial gene (Carmona et al. 2008; Rodrigues-Filho et al. 2012; Palmeira et al. 2013; Silva,2016; Gemaque 2017; Silveira 2017; Feitosa et al. 2018; Table 1E). Additionally, 27 species were previously listed in exploratory fisheries studies (e.g. Asano-Filho et al. 2005, 2007; Fredou and Asano-Filho 2006; Oliveira et al. 2007; Table1D). For the current data analysis, the diversity of sharks and batoids off the Brazilian North coast is represented by 69 species (Table 1). The complete data set (present study plus previously published data) supports that elasmobranches from the Brazilian North coast are classified within 20 families and nine orders of the Class Chondrichthyes (Tabela 1). Carcharhinidae (16 spp.) and Sphyrnidae (5 spp.) from the order Carcharhiniformes show the highest diversity followed by Potamotrygonidae (8 spp.), Dasyatidae (6 spp.) and Myliobatidae (5 spp.) from the order Myliobatiformes.

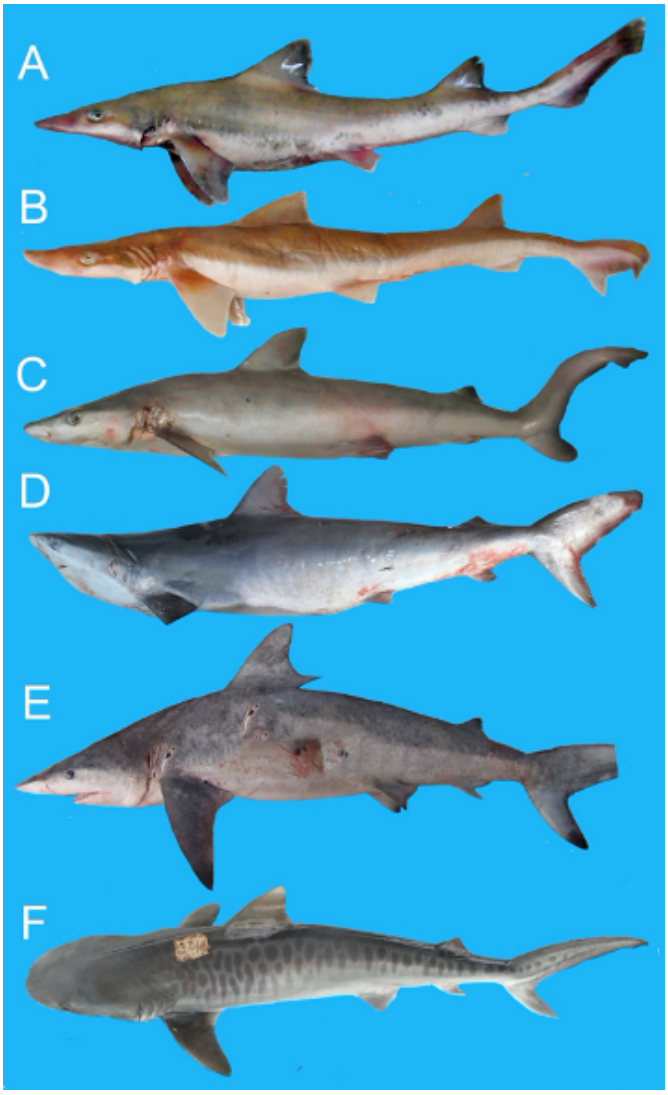

Figure 3. Species of sharks occurring in Belém, Pará state (order Carcharhiniformes): (A) *Mustelus canis*, MPEG 35158, 380 mm TL, (B) *M. higmani*, AZUSC 5016, 497 mm TL; (C) *Carcharhinus acronotus*, AZUSC 5655, 493 mm TL, (D) *C. falciformis*, not cataloged, (E) *C. limbatus,* not cataloged, (F) *Galeocerdo cuvier*, not cataloged.

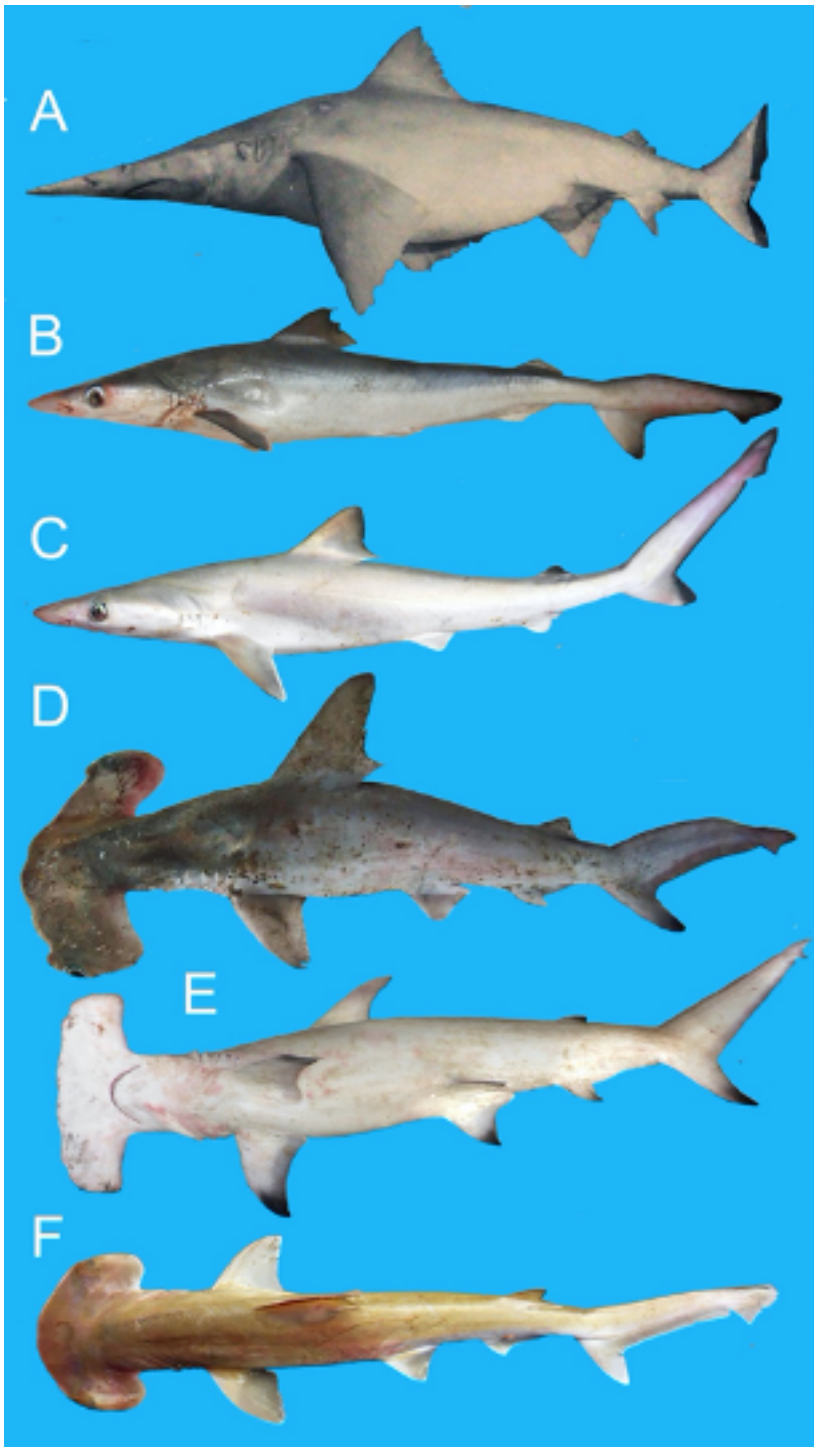

Figure 4. Species of the order Carcharhiniformes, family Carcharhinidae, (A) *Isogomphodon oxyrhynchus*, MPEG 1297, 360 mm TL; (B) *Rhizoprionodon lalandii*, AZUSC 5380, 401mm TL; (C) *R. porosus*, AZUSC 5395, 441 mm TL; (D) *Sphyrna lewini*, AZUSC 5565, 503 mm TL; (E) *Sphyrna mokarran*, not cataloged; (F) *Sphyrna tiburo*, AZUSC 5393, 447 mm TL.

Twenty species (29.0% of the total species listed here) have wide geographical distribution, 30 species (43.5%) are broadly distributed along the Atlantic Ocean, whereas 11 species (15.9%) are endemic to the Amazon-Orinoco Plume and also confined to a specific locality that where has been intensively exploited in trawling operations (Table 1F). The majority of the sharks and batoids caught in the region display coastal shallow waters and oceanic habits (49 and 13 species, respectively) while seven freshwater species (*Potamotrygon* and *Plesiotrygon*) are occasionally caught. These results thus support a much higher local diversity than previously thought for the Brazilian North region. However, local species richness is lower than other regions in the country such as for the Northeastern and Southeast Brazil in Gadig et al. (2000) and Gomes et al. (2010).

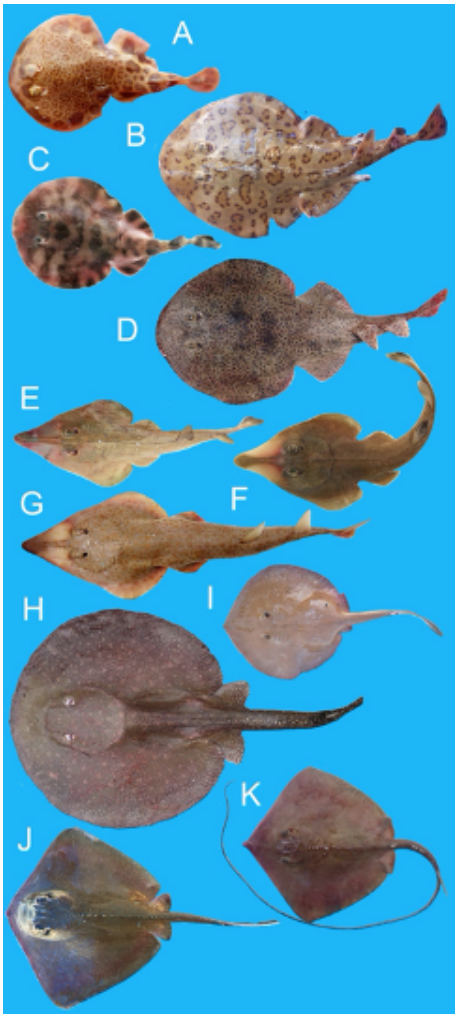

Figure 5. Batoid species caught off Belém, Pará state of the order Torpediniformes (A–D), Rhinopristiformes (E–G) and Myliobatiformes (H–K): (A) *Diplobatis picta*, AZUSC 5003, 75 mm TL; (B) *Narcine bancroftii*, MPEG 35118, 319 mm TL; (C) *N. brasiliensis*, AZUSC 5543, 86 mm TL; (D) *Narcine* sp., AZUSC 5406, 340 mm TL; (E-F) *Pseudobatos horkelii*, AZUSC 5356, 139 mm TL; (G) *P. percellens*, AZUSC 5373, 259 mm TL; (H) *Urobatis jamaicensis*, not cataloged; (I) *Urotrygon microphthalmum*, AZUSC 4985, 318 mm TL; (J) *Hypanus americanus*, AZUSC 4644, 795 mm TL; (K) *H. guttatus*, AZUSC 5300, 647 mm TL.

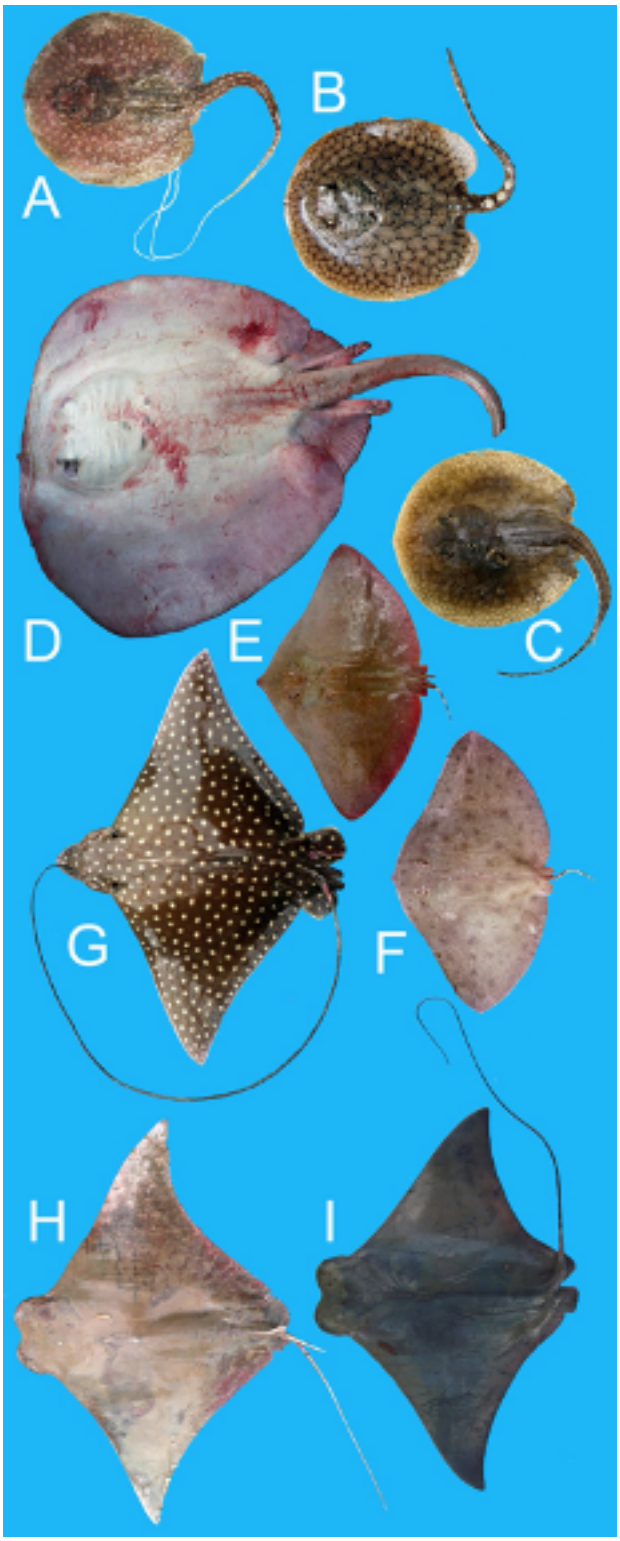

Figure 6. Other batoid species caught in the industrial trawl fisheries in the region (order Myliobatiformes): (A) *Plesiotrygon iwamae*, MPEG 35522, 500 SL, (B) *Potamotrygon humerosa*, MPEG 35526, 623 mm TL; (C) *P. orbignyi*, AZUSC 5002, 382 mm TL; (D) *Styracura schmardae*, not cataloged; (E–F) *Gymnura micrura*, AZUSC 4640, 167 mm TL; (G) *Aetobatus narinari*, not cataloged; (H) *Rhinoptera brasiliensis*, not cataloged; (I) *R. bonasus*, not cataloged.

Shark fishing exploitation in the region

The most common fishing gear employed in the region is demersal trawls (39 species) followed by gill nets (for 28 species) and longlines (19 species) (Table 1I). Out of the 69 species occurring along the Brazilian North coast, 36 elasmobranch species are associated to industrial trawl fisheries (Table 1A-B). From these, nine species were previously reported in studies about fishery data using demersal trawls (e.g. Pinheiro and Fredou 2004; Cintra et al. 2015; Klautau et al. 2016; Lutz et al. 2016) (Table 1A,B) while only two species listed in these studies were not observed here (Table 1A,B).

Local shark conservation

Twenty-eight species (39.7% of the total caught) are currently under threat according to the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN 2018) and at "*Livro Vermelho da Fauna Brasileira Ameaçada de Extinção*" (Table 1H): 13 species as critically endangered (CR); four as Endangered (EN); 11 as Vulnerable (VU). Conservation efforts are of major concern off the North coast of Brazil as many sharks and batoids are naturally vulnerable to overfishing due to their K-selected features which include slow growth, late maturity, long gestation period and low fecundity (Dulvy et al. 2014). Little information on species life cycles, population trends and threats are available, especially for local endemics (Lessa et al. 2000, 2016) as twenty-six elasmobranch species are classified as Data Deficient (DD) at the present.

CONCLUSION

Bottom trawl fisheries off the Northern coast of Brazil have targeted 34 elasmobranch species out of the 69 species occurring in the region, according to the fishery reports from between 2016 and 2018 together with data taken from fish collections and previously published studies. Eleven species (15.9% of the total) are coastal and freshwater endemics from the Orinoco-Amazon plume. Industrial fisheries represent a significant economic activity in the region (IBAMA 2007). However, little is known about the fish diversity that are exploited (Marceniuk et al. 2019). Approximatelly, 65%–90% of the species listed here are locally exploited as by-catch. Yet, conservation efforts in the region are still neglected with exception to the Largetooth Sawfish *Pristis pristis* and the Smalltooth Sawfish *P. pectinata* as well as more six shark species and seven batoid species that are internationally protected by law through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Hence, this goes against the recommendations of the Brazilian Shark Conservation Planning (SBEEL 2005) that take into account

conservation measures for protecting national species such as banning exploitation of certain species ("*quati*" *Isogomphodon oxyrhynchus*, and "*rudela*" *Sphyrna lewini*), creation of environmentally protected areas, environmental law enforcement and undertake effective fisheries observer and landing data.

Biodiversity knowledge is imperative for conservation and management of the natural aquatic resources worldwide. Species identification, for instance, guarantees reliable fishery data of commercially important species that are captured in direct or indirect fisheries (Bester-van der Merwe and Gledhill, 2015). Fisheries monitoring together with biological scientific surveys contribute to sampling of aquatic communities that are still poorly-known to science (Marceniuk et al. 2019) such as elasmobranches. Understanding the local fish fauna also supports studies that reveal regional environmental conditions and assists the fisheries zoning for creating novel fishing grounds. The latter usually contemplate the local diversity in terms of species richness, habitats and communities that are affected (*sensu* Manthey and Fridley 2009).

Inexistence of fisheries statistics in Brazil and, more specifically, in the Northern region disrupts effective monitoring of these natural resources and thus hampers future economical reliablity of this activity as species-specific reported catches data remains unknown. Beyond the political framework this scenario represents, the taxonomic impediment behind any existing Brazilian fishery data is characterized by the absence of species-specific identification and usage of vernacular names (e.g. *cação*, *raia*, *tubarão*). This is usually associated to minor investments in taxonomic research, ex-situ conservation actions (e.g. ichthyological collections) and lack of fish experts in the region as noticed in Marceniuk et al. (2013). For instance, *Fontitrygon colarensis* occurring exclusively in Pará State has not been collected since its original description in Santos et al. (2004) as it is observed in the present study and in recent molecular analysis of local species (e.g. Carmona et al. 2008; Rodrigues-Filho et al. 2012; Palmeira et al. 2013; Gemaque 2017; Silveira 2017; Feitosa et al. 2018; Table 1E). It is thus not surprising that the known local elasmobranch diversity is significantly lower than neighboring areas from the Atlantic Ocean (see Weigmann 2016). Collecting efforts and research initiatives like the present one are urgently required in order to improve the biodiversity knowledge and catch data of sharks and batoids in the Brazilian Northen region.

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Table 1. List of sharks and batoid species from the Brazilian North coast. **A.** Species recorded in the present study. **B.** Species available in the literature on bottom trawling. **C.** Species recorded in taxonomic works. **D.** Species recorded in exploratory fishing work. **E.** Species recorded in molecular identification work. **F.** Distribution area: (GG) circumglobal; (ED) Pluma do Amazonas-Orinoco endemic; (NE) neotropical; (WA) Western Atlantic Ocean. **G.** Habitat: (C) coastal (between 0 to 100 meters deep); (FW) freshwater (restricted to freshwater influence); (O) oceanic (above 100 meters depth). **H.** Red List of Threatened Species (IUCN) and *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* conservation status (respectively): (CR) critically endangered; (DD) data deficient; (EN) endangered; (LC) least concern; (NT) near threatened; (VU) vulnerable (X) Not Evaluated. **I.** Type of fishing used for catching: (DT) demersal trawl; (T) traps; (GN) gill net; (L) longline; (X) Not Evaluated.

Order	Family	Species		A	B	C	D	E	F	G	H	I
Orectolobiformes	Ginglymostomatidae	*Ginglymostoma cirratum* (Bonnaterre 1788)	Fig. 2e	X		X	X	X	WA	C	DD/VU	DT
Laminiformes	Mitsukurinidae	*Mitsukurina owstoni* Jordan 1898					X		CG	O	LC	X
Laminiformes	Pseudocarchariidae	*Pseudocarcharias kamoharai* (Matsubara 1936)					X		CG	O	DD/LC	L
Laminiformes	Alopiidae	*Alopias superciliosus* Lowe 1841					X		CG	O	VU	L
Laminiformes	Alopiidae	*Alopias vulpinus* (Bonnaterre 1788)					X		CG	O	VU	L
Laminiformes	Laminidae	*Isurus oxyrinchus* Rafinesque 1810					X		CG	O	EN/NT	L
Laminiformes	Laminidae	*Isurus paucus* Guitart Manday 1966					X		CG	O	EN/DD	L
Carcharhiniformes	Scyliorhinidae	*Schroederichthys tenuis* Springer 1966				X			ED	O	DD	DT
Carcharhiniformes	Scyliorhinidae	*Scyliorhinus haeckelii* (Miranda Ribeiro 1907)				X			WA	C	DD/LC	DT
Carcharhiniformes	Triakidae	*Mustelus canis* (Mitchill 1815)	Fig. 3a	X		X	X		WA	C	NT/EN	DT

Order	Family	Species		A	B	C	D	E	F	G	H	I
Carcharhiniformes	Triakidae	*Mustelus higmani* Springer & Lowe 1963	Fig. 3b	X		X	X		WA	C	LC	DT
Carcharhiniformes	Carcharhinidae	*Carcharhinus acronotus* (Poey 1860)	Fig. 3c	X		X	X	X	WA	C	NT	DT; GN; L
Carcharhiniformes	Carcharhinidae	*Carcharhinus brevipinna* (Valenciennes 1839)					X		CG	C	NT/DD	L
Carcharhiniformes	Carcharhinidae	*Carcharhinus falciformis* (Müller & Henle 1839)	Fig. 3d	X		X	X		CG	C	VU/NT	DT; GN; L
Carcharhiniformes	Carcharhinidae	*Carcharhinus leucas* (Valenciennes 1839)				X		X	CG	C	NT	GN; L
Carcharhiniformes	Carcharhinidae	*Carcharhinus limbatus* (Valenciennes 1839)	Fig. 3e	X		X	X	X	CG	C	NT	DT; GN; L
Carcharhiniformes	Carcharhinidae	*Carcharhinus longimanus* (Poey 1861)					X		CG	O	CR/VU	L
Carcharhiniformes	Carcharhinidae	*Carcharhinus obscurus* (Lesueur 1818)				X		X	CG	C	EN	GN
Carcharhiniformes	Carcharhinidae	*Carcharhinus perezi* (Poey 1876)				X			WA	C	NT/VU	GN; L
Carcharhiniformes	Carcharhinidae	*Carcharhinus plumbeus* (Nardo 1827)				X			CG	C	VU/CR	GN
Carcharhiniformes	Carcharhinidae	*Carcharhinus porosus* (Ranzani 1839)		X		X	X	X	WA	C	DD/CR	DT; GN; L
Carcharhiniformes	Carcharhinidae	*Galeocerdo cuvier* (Péron & Lesueur 1822)	Fig. 3f	X		X	X	X	CG	C	NT	DT; GN; L
Carcharhiniformes	Carcharhinidae	*Isogomphodon oxyrhynchus* (Müller & Henle 1839)	Fig. 4a	X		X	X	X	ED	C	CR	DT; GN
Carcharhiniformes	Carcharhinidae	*Negaprion brevirostris* (Poey 1868)				X			NE	C	NT/VU	X
Carcharhiniformes	Carcharhinidae	*Prionace glauca* (Linnaeus 1758)					X		CG	O	NT	L

Order	Family	Species		A	B	C	D	E	F	G	H	I
Carcharhiniformes	Carcharhinidae	*Rhizoprionodon lalandii* (Valenciennes 1839)	Fig. 4b	X		X		X	WA	C	DD/NT	DT; GN
Carcharhiniformes	Carcharhinidae	*Rhizoprionodon porosus* (Poey 1861)	Fig. 4c	X		X	X	X	WA	C	LC/DD	DT; GN; L
Carcharhiniformes	Sphyrnidae	*Sphyrna lewini* (Griffith & Smith 1834)	Fig. 4d	X		X	X	X	CG	C	CR	DT; GN; L
Carcharhiniformes	Sphyrnidae	*Sphyrna media* Springer 1940				X			NE	C	DD/CR	X
Carcharhiniformes	Sphyrnidae	*Sphyrna mokarran* (Rüppell 1837)	Fig. 4e	X		X			CG	C	CR/EN	DT; GN
Carcharhiniformes	Sphyrnidae	*Sphyrna tiburo* (Linnaeus 1758)	Fig. 4f	X		X	X	X	NE	C	LC/CR	DT; GN; L
Carcharhiniformes	Sphyrnidae	*Sphyrna tudes* (Valenciennes 1822)				X		X	NE	C	VU/CR	GN
Squaliformes	Centrophoridae	*Zameus squamulosus* (Günther 1877)					X		CG	O	DD/LC	X
Squatiniformes	Squatinidae	*Squatina dumeril* Lesueur 1818				X			WA	C	LC/DD	X
Torpediniformes	Narcinidae	*Diplobatis picta* Palmer 1950	Fig. 5a	X		X		X	ED	C	VU/X	DT
Torpediniformes	Narcinidae	*Narcine bancroftii* (Griffith & Smith 1834)	Fig. 5b	X					WA	C	LC/DD	DT; GN
Torpediniformes	Narcinidae	*Narcine brasiliensis* (Olfers 1831)	Fig. 5c	X	X	X		X	WA	C	DD	DT
Torpediniformes	Narcinidae	*Narcine* sp	Fig. 5d	X						C		DT
Rajiformes	Rajidae	*Breviraja spinosa* Bigelow & Schroeder 1950					X		WA	O	DD/LC	X
Rajiformes	Rajidae	*Gurgesiella atlantica* (Bigelow & Schroeder 1962)				X			WA	O	DD/LC	X
Rajiformes	Rajidae	*Rajella purpuriventralis* (Bigelow & Schroeder 1962)					X		WA	O	LC	X

Order	Family	Species		A	B	C	D	E	F	G	H	I
Rhinopristiformes	Rhinobatidae	*Pseudobatos horkelii* (Müller & Henle 1841)	Fig. 5e-f	X					WA	C	CR	DT; GN
Rhinopristiformes	Rhinobatidae	*Pseudobatos percellens* (Walbaum 1792)	Fig. 5g	X		X			WA	C	NT/DD	DT
Rhinopristiformes	Pristidae	*Pristis pectinata* Latham 1794				X			CG	C	CR	DT
Rhinopristiformes	Pristidae	*Pristis pristis* (Linnaeus 1758)	Fig. 2a	X	X	X		X	ED	C	CR	DT
Myliobatiformes	Urolophidae	*Urobatis jamaicensis* (Cuvier 1816)	Fig. 5h	X					WA	C	LC/X	DT; GN
Myliobatiformes	Urolophidae	*Urolophus* sp				X				C		X
Myliobatiformes	Urolophidae	*Urotrygon microphthalmum* Delsman 1941	Fig. 5i	X		X			WA	C	LC/DD	DT; GN
Myliobatiformes	Urolophidae	*Fontitrygon colarensis* (Santos et al 2004)				X			ED	C	VU/VU	X
Myliobatiformes	Dasyatidae	*Fontitrygon geijskesi* (Boeseman 1948)	Fig. 2f	X	X			X	ED	C	NT/DD	DT; GN
Myliobatiformes	Dasyatidae	*Hypanus americanus* (Hildebrand & Schroeder 1928)	Fig. 5j	X		X	X	X	WA	C	DD	DT; GN
Myliobatiformes	Dasyatidae	*Hypanus guttatus* (Bloch & Schneider 1801)	Fig. 5k	X	X	X	X	X	WA	C	DD/LC	DT
Myliobatiformes	Dasyatidae	*Hypanus marianae* (Gomes Rosa & Gadig 2000)					X		WA	C	DD	ES
Myliobatiformes	Dasyatidae	*Hypanus sabinus* (Lesueur 1824)					X		WA	C	LC/X	DT
Myliobatiformes	Dasyatidae	*Hypanus say* (Lesueur 1817)				X			WA	C	LC/DD	X
Myliobatiformes	Potamotrygonidae	*Paratrygon aiereba* (Müller & Henle 1841)				X			ED	FW	DD/CR	DT; T

Order	Family	Species		A	B	C	D	E	F	G	H	I
Myliobatiformes	Potamotrygonidae	*Plesiotrygon iwamae* Rosa et al., 1987	Fig. 6a	X		X			ED	FW	DD/NT	DT; T
Myliobatiformes	Potamotrygonidae	*Potamotrygon humerosa* Garman, 1913	Fig. 6b	X		X			NE	FW	DD	DT; T
Myliobatiformes	Potamotrygonidae	*Potamotrygon motoro* (Müller & Henle 1841)				X			NE	FW	DD/LC	DT; T
Myliobatiformes	Potamotrygonidae	*Potamotrygon ocellata* (Engelhardt, 1912)				X			ED	FW	DD	DT; T
Myliobatiformes	Potamotrygonidae	*Potamotrygon orbignyi* (Castelnau 1855)	Fig. 6c	X		X			NE	FW	LC	DT
Myliobatiformes	Potamotrygonidae	*Potamotrygon scobina* (Müller & Henle 1841)			X	X			ED	FW	DD/LC	DT
Myliobatiformes	Potamotrygonidae	*Styracura schmardae* (Werner 1904)	Fig. 6d	X		X			ED	C	DD	DT; GN
Myliobatiformes	Gymnuridae	*Gymnura micrura* (Bloch & Schneider 1801)	Fig. 6e-f	X	X	X	X	X	WA	C	DD/NT	DT; GN
Myliobatiformes	Myliobatidae	*Aetobatus narinari* (Euphrasen 1790)	Fig. 6g	X	X	X		X	WA	C	NT/DD	DT; GN
Myliobatiformes	Myliobatidae	*Mobula birostris* (Walbaum 1792)			X				CG	C	VU	X
Myliobatiformes	Myliobatidae	*Mobula hypostoma* (Bancroft 1831)				X			WA	C	EN/VU	GN
Myliobatiformes	Myliobatidae	*Rhinoptera brasiliensis* Müller 1836	Fig. 6h	X				X	WA	C	EN/CR	DT; GN
Myliobatiformes	Myliobatidae	*Rhinoptera bonasus* (Mitchill 1815)	Fig. 6i	X	X	X		X	WA	C	NT/DD	DT