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DIVERSITY OF ELASMOBRANCHS CAUGHT IN THE SURROUNDINGS OF BARRA DE GUARATIBA, RIO DE JANEIRO, BRAZIL

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Abstract. This study conducted a one-year survey of fisheries landing monitoring in Barra de Guaratiba, Rio de Janeiro, state of Rio de Janeiro, along the southeastern coast of Brazil, and close to the protection area known as Reserva Biológica de Guaratiba (RGB), an estuarine ecosystem that may serve as a nursery area for elasmobranchs. In a total of 671 elasmobranch specimens captured, more than half were from a single genus, with two known occurring species being under some level of threat. By comparing the results found here to previous studies, we observed a loss of taxa diversity and a shift in the most dominant species in the region. Additionally, eight species were absent, while two new species were registered for the first time. Continuous fisheries landing monitoring should be carried out in this area to better understand the long-term dynamics of elasmobranch populations and to promote efficient management and conservation strategies.

Keywords: biodiversity; conservation; fisheries; rays; sharks.

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Elasmobranchs compose a subclass of Chondrichthyes, which is divided into two groups: Selachii (sharks) and Batoidea (skates and rays) (Naylor *et al*. 2012; Fricke *et al*. 2026). These organisms are usually considered top predators, even though, especially during their juvenile phases, some species act as prey for other aquatic animals (Vaudos & Heithaus 2012; Heithaus *et al*. 2022). Therefore, elasmobranchs occupy different trophic levels and have essential ecological roles, such as predators, prey, competitors, nutrient vectors and facilitators (Heithaus *et al*. 2022).

Sharks and batoids represent important fishery resources and are more vulnerable to fishing activities due to their life history, characterized by small populations, small offspring and late maturity (Stevens et al. 2000). Fishing activities date back to more than a thousand years ago, as evidenced by shell mounds (Gaspar *et al*. 2011), but their recent impacts on the ecosystem have resulted in many degrees of extinction threat to several species, with more than a third of elasmobranch species threatened according to the International Union for Conservation of Nature (IUCN 2024, Dulvy *et al*. 2021).

In general, fishing has been a present and constant activity in the region of Barra de Guaratiba (Tomás *et al*. 2010), an estuary ecosystem that possibly serves as a nursery area for many species of elasmobranchs (*e.g.*, Heupel & Simpfendorfer 2011) located in the state of Rio de Janeiro, Brazil. Currently, shark and batoid meat are sold as *cação* fillets in Rio de Janeiro, consisting of a great number of endangered species to overcome costumer's resistance (Araújo *et al*. 2020), which is worrisome in addition to the fact that the coast is a conservation priority area for sharks (Lucifora *et al*. 2011). Therefore, monitoring fishing activities is essential to comprehend which species are being caught by artisanal fisheries throughout the year.

In this study, we evaluated the diversity and number of individuals caught of elasmobranch species captured and landed by artisanal fishermen from colony Z-14, situated at Barra de Guaratiba Beach, Rio de Janeiro, Brazil (23° 04 '06.1"S, 43° 34' 03.7"W; Figure 1A), over 12 months, once up to twice a week between May 2024 and April 2025. The area is near the Reserva Biológica de Guaratiba (RBG), which includes and protects an important mangrove area associated with Sepetiba Bay (Figure 1B).

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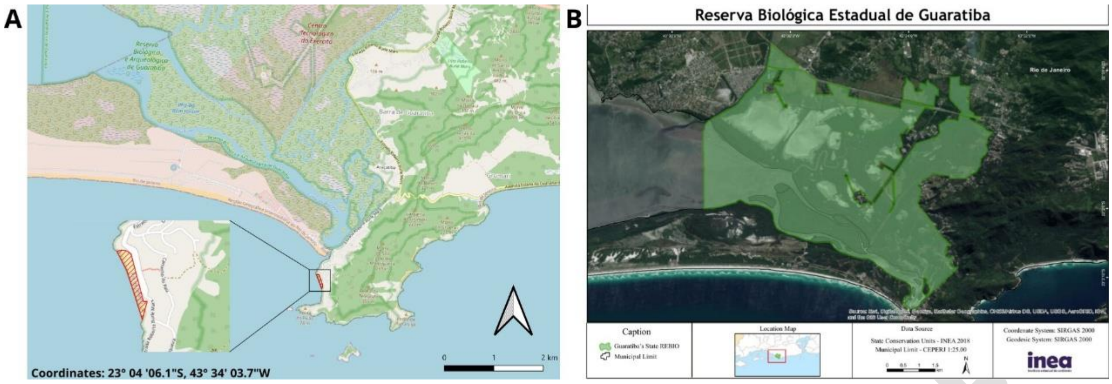

Figure 1. A) Map showing the study area and its surroundings. The red hatched area represents where the fishermen from fish colony Z-14 landed and where the elasmobranchs were registered. B) Map showing the Reserva Biológica de Guaratiba (RBG) and its coverage area and limits.

The fishing fleet usually consisted of two fishermen that used one of two types of gillnets, one for pelagic species and another for benthic species. Gillnets were placed before sunset on the previous day and then collected on the next day at dawn, no further than 20 km from the beach. The following data were recorded for each elasmobranch specimen landed whenever possible: species, total length (TL, 1.0 cm), disc width (DW, 1.0 cm) for batoids, sex, sexual maturity and capture date.

Landed individuals were identified *in situ* to the lowest taxonomic level following Gomes *et al*. (2019), which was also used to assess maturity stages through total length and/or disc width. Pregnant females and the presence or absence of fetuses were also registered. Photographs (dorsal, ventral and lateral views) of the specimens were stored for later analysis. Descriptive statistics, such as the number of individuals caught and sex ratio, and graphs were generated in Microsoft Excel.

During a one-year survey, 671 elasmobranch specimens were captured, distributed across five orders (Carcharhiniformes, Squatiniformes, Rhinopristiformes, Rajiformes and Myliobatiformes), eight families (Carcharhinidae, Sphyrnidae, Squatinidae, Rhinobatidae, Arhynchobatidae, Gymnuridae, Dasyatidae and Rhinopteridae), 12 genders and 17 species, with the ones with the highest number of individuals caught being *Pseudobatos horkelii* (Müller & Henle, 1841), *Rhizoprionodon lalandii* (Valenciennes, 1839), *R. porosus* (Poey, 1861), *Sphyrna zygaena* (Linnaeus, 1758) and *Squatina guggenheim* (Marini, 1936) (Table 1). The total number

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of specimens registered indicated a sound sample size for analysis according to the sample completeness curve and the species accumulation curve, which were generated using the number of individuals caught of each species and comparing to the results of Tomás *et al*. (2010) (Chao *et al*. 2014, Chao *et al*. 2016, Figure 2). The specimens donated by the fishermen for research were vouchered and stored in the Chondrichthyes Laboratory at the Universidade Federal do Rio de Janeiro (Supplementary Material S1).

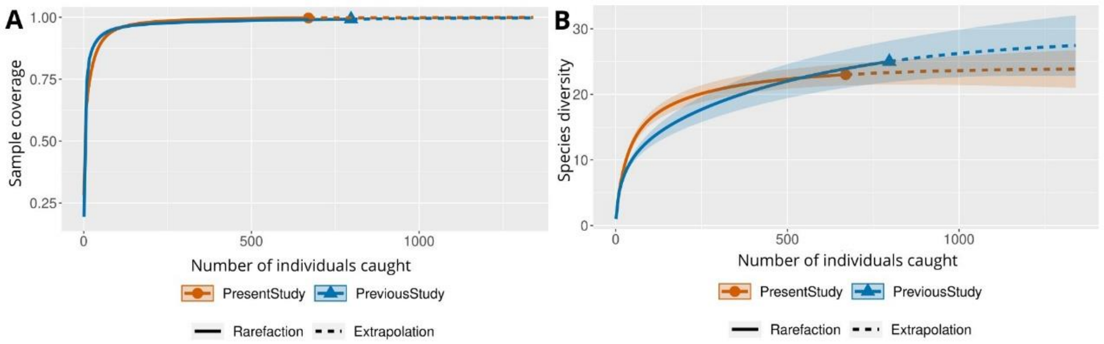

Figure 2. Species richness curves of elasmobranchs captured at Reserva Biológica de Guaratiba, state of Rio de Janeiro, Brazil. A) Sample completeness curve, where the Y axis represents the percentage of data coverage contemplated, with 1.0 representing 100%, comparing present and previous study. B) Species accumulation curve comparing the present and previous studies. The shaded areas around the curve represent the 95% confidence intervals. The dotted lines represent the extrapolation from the sample size in each study.

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Table 1. Number of individuals (N), sex ratio (M:F), total length (TL), disc width (DW), Relative Importance Index (RII), ICMBIO and IUCN status (SALVE 2025, IUCN 2024) for each elasmobranch species captured and identified in Barra de Guaratiba, state of Rio de Janeiro, Brazil, from May 2024 to April 2025. The RII was calculated using the frequency of occurrence and the percentage of individuals caught for each species. * - only individuals without their heads.

Species	Relative Importance Index (RII)	Male	Female	Undefined	Sex ratio (M:F)	TL (cm) min-max	DW (cm) min-max	N	ICMBio Status	IUCN Status
Rhizoprionodon lalandii	3.24%	20	35	2	1:1.75	24.3-77.5	-	57	DD	VU
Rhizoprionodon porosus	1.64%	19	20	3	1:1.05	47.5-99.0	-	42	DD	VU
Squatina guggenheim	1.10%	16	15	-	1:0.94	56.0-84.5	-	31	CR	EN
Pseudobatos horkelii	0.51%	10	9	5	1:0.9	70.0-121.0	24.5-41.0	24	CR	CR
Sphyrna zygaena	0.47%	10	8	1	1:0.8	80.0-164.0	-	19	CR	VU
Carcharhinus brevipinna	0.30%	5	10	2	1:2	82.5-125.0	-	17	VU	VU
Pseudobatos percellens	0.21%	6	9	-	1:1.5	83.5-120.0	26.7-42.8	15	VU	EN
Galeocerdo cuvier	0.34%	2	7	3	1:3.5	87.0-149.5	-	12	NT	NT
Sphyrna lewini	0.25%	8	1	1	1:0.125	62.0-170.0	-	10	CR	CR
Dasyatis hypostigma	0.06%	1	5	-	1:5	30.0-83.0	13.5-52.0	6	DD	EN

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Atlantoraja castelnaui	0.09%	-	2	3	-	108.0	57.5-78.3	5	EN	CR
Gymnura altavela	0.03%	2	1	1	1:0.5	46.5-88.3	71.7-147.4	4	CR	EN
Carcharhinus limbatus	0.03%	1	2	0	1:2	76.6-89.7	-	3	NT	VU
Squatina occulta	0.01%	-	2	-	-	77.0-88.2*	-	2	CR	CR
Hypanus guttatus	0.01%	-	2	-	-	170.0	79.8-85.0	2	LC	NT
Rhinoptera bonasus	0.00%	-	1	-	-	46.0	42.0	1	-	-
Rioraja agassizii	0.00%	-	1	-	-	51.0	33.5	1	VU	VU

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Sex ratios were mostly dominated by females, while males were predominant for *Pseudobatos* spp., *Pseudobatos horkelii*, *Squatina guggenheim*, *Sphyrna zygaena*, *Sp. lewini* and *Gymnura altavela*; a balanced sex ratio was observed for *Sphyrna* species. Adult individuals were recorded for both sharpnose shark species (*R. lalandii* and *R. porosus*), angular angelshark (*Squatina guggenheim*), both guitarfish species (*Pseudobatos horkelii* and *P. percellens*), scalloped hammerhead shark (*Sphyrna lewini*), and Rio skate (*Rioraja agassizii*). A greater total length was recorded for a male specimen of *Rioraja agassizii* (51 cm) than previously reported in the literature (Gomes *et al*. 2019, Soares *et al*., 2021).

The two most representative and relatively important shark species were *R. lalandii* and *R. porosus* (Table 1) both having peak capture in October and not being recorded from November to January (Figures 3A, 3B). Individuals of *Sphyrna zygaena* were captured from August to February, with the number of individuals caught peaking in September (Figure 3C). The angelshark *Squatina guggenheim* and the Brazilian guitarfish *Pseudobatos horkelii* were not landed between May and August, and their respective numbers of individuals peaked in October and March (Figures 3D, 3E). The highest number of individuals caught was observed in February, while the highest species diversity in October (n = 14); the lowest number of individuals caught and variety of taxa was found in May, mostly due to the low fishing activity during this period. Additionally, even though *P. percellens* and *Carcharhinus brevipinna* had a higher number of individuals caught than *Galeocerdo cuvier*, the latter had a higher Relative Importance Index (RII; Table 1).

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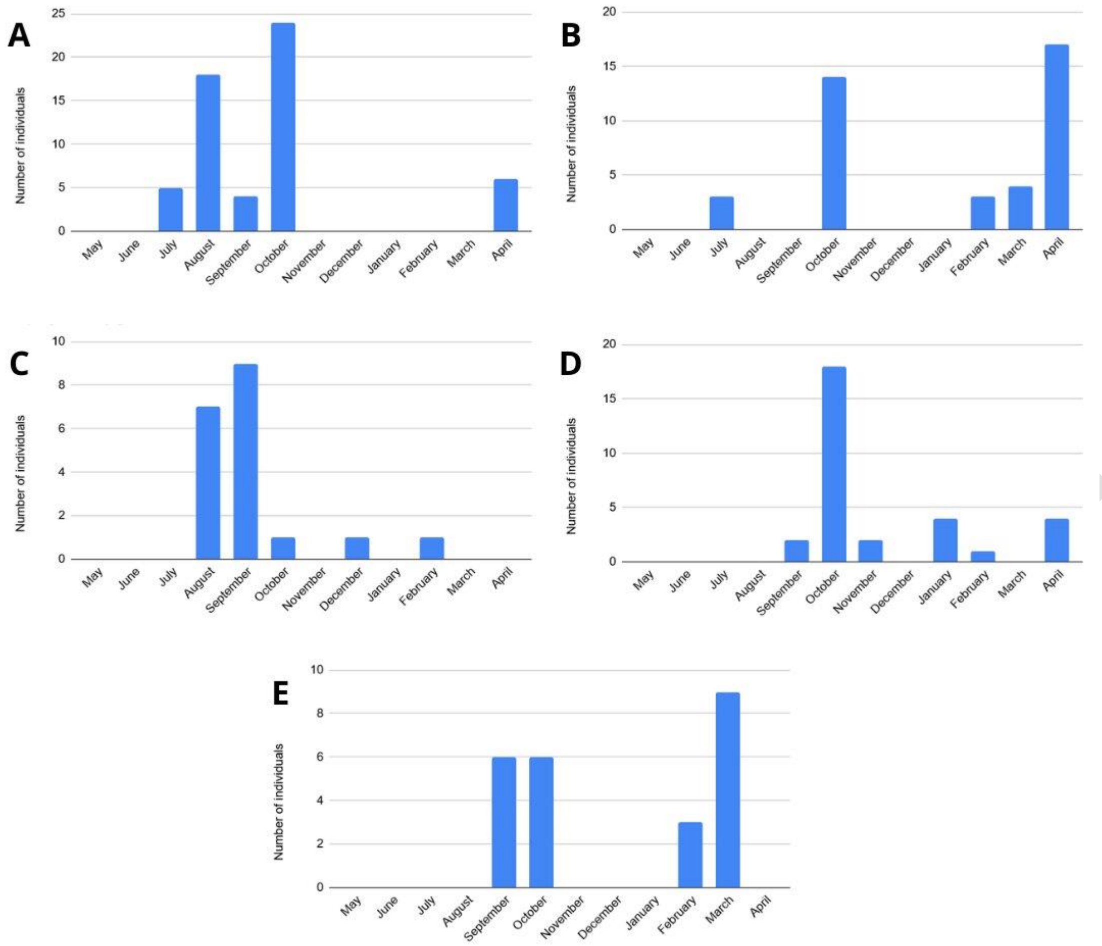

Figure 3. Number of individuals of each predominant species of elasmobranch captured per month in Barra de Guaratiba, state of Rio de Janeiro, Brazil, from May 2024 to April 2025. A) *Rhizoprionodon lalandii*, B) *Rhizoprionodon porosus*, C) *Sphyrna zygaena*, D) *Squatina guggenheim*, E) *Pseudobatos horkelii*

Most species recorded are under some degree of threat according to IUCN and ICMBio (2025), such as the Brazilian guitarfish (*P. horkelii*), the scalloped hammerhead shark (*Sp. lewini*), the spotback skate (*A. castelnaui*) and the hidden angelshark (*Sq. occulta*), which are classified as 'Critically Endangered' (Table 1). Three species are classified as 'Data Deficient': *R. lalandii*, *R. porosus* and *D. hypostigma* (Table 1). Only the tiger shark (*G. cuvier*) and the longnose stingray (*Hypanus guttatus*) are not under any level of threat in both lists. Taking into consideration the Biodiversity Extinction Risk Assessment System (SALVE) from the Chico Mendes Institute for Biodiversity Conservation - ICMBio, both angelshark species (*Sq. guggenheim* and *Sq. occulta*), both hammerhead species (*Sp. lewini* and *Sp. zygaena*), the Brazilian guitarfish and the spiny butterfly ray (*Gymnura altavela*) are classified at the highest level of threat (CR).

A different taxa composition was found in this study in comparison to the work of Tomás *et al*. (2010). Eight species previously recorded for Barra de Guaratiba (*Carcharhinus plumbeus*, *Mustelus canis*, *M. schmitti*, *Cetorhinus maximus*, *Isurus oxyrinchus*, *Squalus* sp., *Myliobatis* sp. and *Carcharias taurus*) were not captured during 2025, whereas *Pseudobatos percellens* and *Rioraja agassizii* are recorded for the first time. The difference between the species registered might be due to the rarity of captures (lower than 5) when compared to other species (Supplementary Material S3) (Tomás *et al*. 2010).

The Brazilian sharpnose shark (*Rhizoprionodon lalandii*) was the most abundant shark species, as also demonstrated by Tomás *et al*. (2010). However, a considerable number of individuals of *R. porosus* were captured, reducing the difference between both species over the years. Females of *R. lalandii* were slightly more numerous than males, differing from previous works (Motta *et al*. 2005), but no significant difference in the sex ratio was found. A pregnant female was caught in early August, which agrees with the hypothesis that females move toward the coast to give birth during winter and that the reproductive cycle of *R. lalandii* is intimately associated with the southern coast of Brazil (Ferreira 1988, Araújo et al. 2020). A pregnant female of *Dasyatis hypostigma* was recorded in the middle of April, but more studies are needed to better understand the reproductive cycle and population dynamics of this species.

A higher abundance of tiger shark (*G. cuvier*) specimens was recorded in this study, differing from the low number registered in previous studies (Tomás *et al.* 2010, Araújo *et al*. 2020). All individuals were sexually immature (as well as for *C. brevipinna*) and these findings suggest that juveniles inhabit coastal waters during fall and winter, preferring shallow waters (Heithaus *et al* 2002, Aximoff *et al*. 2022). Nevertheless, fishing gears used by artisanal fishermen are more selective in regard to specimen size, which could also impact the biodiversity data obtained (Armstrong *et al*. 1990).

According to Tomás et al. (2010), *Sphyrna lewini* was prevalent over *S. zygaena* from 1982 to 1985, which differs from our results and for other regions (e.g., São Paulo, Amorim *et al*. 2011). Many individuals of *Sphyrna* in fish landings were not identified to the species taxonomic level

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due to the lack of their heads, thus masking the real numbers of each *Sphyrna* species. An inversion in terms of sex ratio was also recorded for *S. zygaena*, with males being more dominant during the last year.

The Brazilian guitarfish (*Pseudobatos horkelii*) had one of the highest number of caught individuals among all species observed. Lessa et al. (1986) suggested a peak capture notably higher during summer, when females move toward the coast to give birth, which contrasts to our results, since the lowest number of individuals caught was observed in December, January and February. This could be related to a shift in temperature due to events such as El Niño or La Niña, which have previously been shown to impact elasmobranch behavior (Osgood *et al*. 2021). Males of *Pseudobatos horkelii* stay in deep waters in southern Brazil, while females swim toward the coast to give birth, highlighting an important migratory behavior that makes those females more susceptible to fishing activities compared to males (Lessa *et al*. 1986). The high number of recorded guitarfish specimens (including *P. horkelii*, *P. percellens* and *Pseudobatos* individuals not identified to the species level; n = 381) is alarming since both species are threatened (IUCN 2024, ICMBio 2025). Integrating molecular tools (e.g., DNA barcoding) for the identification of *Pseudobatos* specimens is fundamental to enlarge our understanding about biology and population dynamics of these guitarfishes.

The Rio de Janeiro Shelf was recently classified as an Important Shark and Ray Areas (Lucifora *et al*. 2011, ISRA 2025) and our study reinforces the relevance of the surroundings of Barra de Guaratiba for the conservation of shark and batoids. Additionally, the mangrove close to this area could be important to elasmobranch diversity, however, there is a scarcity of studies on its ecological role. Therefore, with more studies conducted on the area, it could be assessed whether the area serves as a nursery.

Our results showed an apparent reduction of the number of individual captures of most elasmobranch species by artisanal fishing in the region. The fishing pressure possibly exhausted the elasmobranchs stock throughout the years between this study and the one conducted by Tomás *et al*. (2010). Elasmobranch populations are speculated to decrease over time (IUCN 2024), which

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reinforces the need for management and conservation strategies to protect these species that rely on the coastal region of Rio de Janeiro.

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