NOTE

Side effects for batoids' conservation in the vacuum of fishery management

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ABSTRACT. A shift verified in batoid landings by artisanal fisheries during 2017-2021 is interpreted as a potential consequence of legal measures set by the Brazilian government in 2014. In this five-year period, the increasing landings of stingrays concomitant with a decrease in the landings of guitarfish might be a result of fishing bans established for the Brazilian guitarfish *Pseudobatos horkelii* and the Shortnose guitarfish *Zapteryx brevirostris*, which are both endemic to the coasts of Southern Brazil, Uruguay, and Argentina and listed as threatened at national and global levels. In 2022, more batoids became protected, so it is expected that shifts in captures will continue, reaching species whose stocks have not yet been evaluated and for which conservation measures are not foreseen. Considering the sociocultural and economic relevance of artisanal fisheries in the country, the observed shift is discussed here as it relates to batoids' effective conservation and adherence to legal measures by the fishery sector in Southern Brazil.

Key words: Guitarfish, stingrays, artisanal fisheries, Brazil, Southwestern Atlantic Ocean.

Consecuencias del vacío en la gestión pesquera para la conservación de los batoideos

RESUMEN. El cambio verificado en los desembarques de batoideos en las pesquerías artesanales durante 2017-2021, se interpreta como una posible consecuencia de las medidas legales establecidas por el gobierno brasileño en 2014. En este período de cinco años, los crecientes desembarques de rayas concomitantes con una disminución en los desembarques de pez guitarra podrían ser el resultado de las prohibiciones de pesca establecidas para el pez guitarra brasileño *Pseudobatos horkelii* y el pez guitarra de pico corto *Zapteryx brevirostris*, que son endémicos de las costas del sur de Brasil, Uruguay y Argentina, y figuran como amenazados a nivel nacional y mundial. En 2022, se protegieron más batoideos, por lo que se espera que continúen los cambios en las capturas, llegando a especies cuyos *stocks* aún no han sido evaluados y para las cuales no se prevén medidas de conservación. Teniendo en cuenta la relevancia sociocultural y económica de la pesca artesanal en el país, el cambio observado se analiza aquí en relación con la conservación efectiva de los batoideos y el cumplimiento de las medidas legales por parte del sector pesquero en el sur de Brasil.

Palabras clave: Pez guitarra, rayas, pesquerías artesanales, Brasil, Océano Atlántico Sudoccidental.

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Received: 16 November 2022
Accepted: 21 December 2022

ISSN 2683-7595 (print)
ISSN 2683-7951 (online)

https://ojs.inidep.edu.ar

Journal of the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP)

With growing concern about guitarfish conservation (Dulvy et al. 2017, 2021), the precarious situation these animals have been facing has become increasingly evident, with high rates of unreported catches and poor management across their home range (Sherman et al. 2022). This urgent matter was first raised by Moore (2017), with solid evidence that guitarfish were following the same path as sawfish –another group of elasmobranchs at

high risk of extinction. Since then, the situation has worsened, as now Rhino Rays (i.e. guitarfish and wedgefish) are the most threatened vertebrates, with about 76% of species listed under an extinction risk category globally. In the Parana coast, Southern Brazil, elasmobranch commercial fishery is a tradition, with several families depending on their capture as a source of income. Elasmobranch commercial capture is now an urgent matter at the global level, as population declines can be high as 90% in certain regions for some species. In Brazil, some species receive legal protection from the federal government since 2014. However, fisheries management in the country is still an enormous challenge, as there are many socio-ecological aspects which are rarely taken into account when fishing bans are set.

When detached from the alternatives for fishery production maintenance, are capture bans effective for conservation? On the Southern Brazilian coast, data showed that capture bans on the Brazilian guitarfish *Pseudobatos horkelii* (Müller and Henle, 1841) (Rhinobatidae) in 2014 was followed, for at least five years, by a gradual and expressive increase in the landings of Dasyatidae rays. As this was possibly not a coincidence, in 2022 more batoids were protected. This gives rise to one important question: for whom will the fishing gears work from now on?

Protecting the guitarfish

Although the batoid production by commercial fisheries in Brazil is small, it is growing. In the early 21st century, landings totaled 6,000 t year^{-1}, equivalent to 40% of the shark production (MMA 2003), which increased to 7,200 t year^{-1} and 50%, respectively, by 2009-2011 (MPA 2011). This was the last national survey performed and included batoid families such as Rhinobatidae, Dasyatidae, Myliobatidae, Gymnuridae, Narcinidae, and Rajidae without species distinction (MPA 2011).

The trend is slightly different on the Parana coast, at approximately 25° S-48° W (Figure 1). Among elasmobranchs, batoid production has grown from < 30% to > 40% in the past 50 years, exceeding that of sharks in 2019. However, batoid production fell from 12-80 t year^{-1} in the 1970s (Loyola e Silva and Nakamura 1975) to < 5 t year^{-1} in 2021 (FUNDEPAG 2022), along with a reduction in shark production, from 30-200 t year^{-1} to < 5 t year^{-1} (Figure 2).

Landing surveys in Brazil are not continuous, but the natural history of batoids and sharks has received progressive attention. Studies have focused on reproductive biology, age structure, and population dynamics, because of the demands highlighted in the National Plan for Conservation of Threatened Marine Elasmobranchs (Lessa et al. 2021). For example, the high extinction risk of *P. horkelii* led Brazil to ban its capture in 2014 (Portaria MMA 445 2014). This guitarfish occurs in shallow waters from Southeast Brazil to Argentina (Alemany et al. 2021; Cardoso et al. 2021; Froese and Pauly 2022), and it was the first elasmobranch targeted by Brazilian fisheries (Lessa et al. 2021). In the southern region of Brazil, catches reached 1,800 t year^{-1} during 1975-1987, making *P. horkelii* the most landed and marketed batoid (Vooren et al. 2005). The conservation-driven nature of fishing ban has resulted in conflicts between the government, conservationists, and fishery sectors. Two key facts hindered its efficacy in areas from Southern Brazil, including the Parana coast: (1) the shared vulnerability with its sympatric species to the same fishing gear, particularly bottom trawling and gillnets with 18 cm opposite knots (Chaves and Silva 2019; Afonso and Chaves 2021); and (2) challenges to properly distinguish the guitarfish with permitted capture from the one with bans set. The sympatric guitarfish is *P. percellens* (Walbaum, 1792), also found in shallow waters but distributed from Caribe to Southern Brazil (Froese and Pauly 2022). External similarities between *P. horkelii* and *P. percellens* were ana-

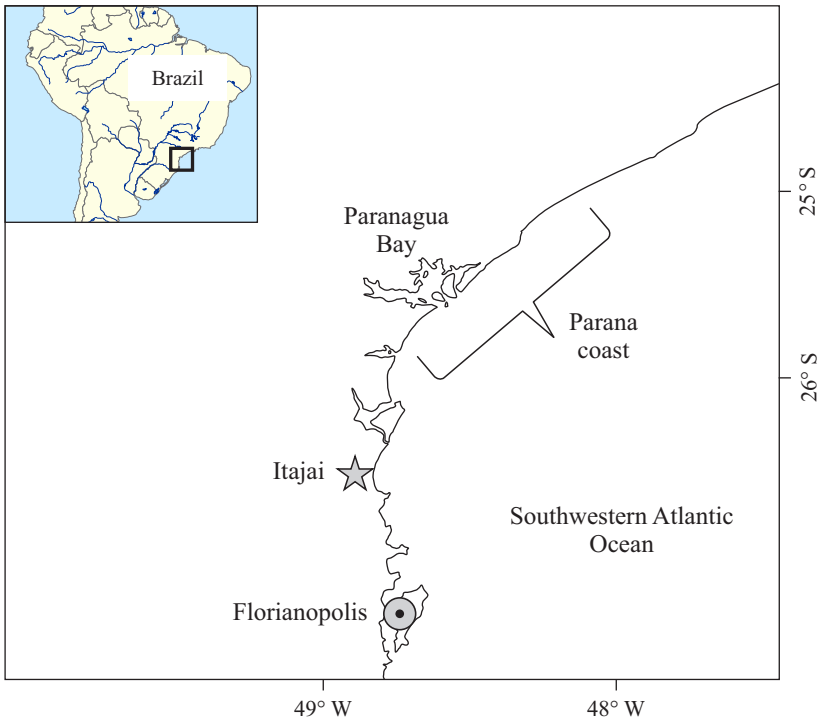

Figure 1. Map of the Parana coast in Southern Brazil, Southwestern Atlantic Ocean. Small square shows a section ranging from 25.29° S-48.09 W to 25.98° S-48.57° W. Grey star: Itajaí, the main national fishery port. Small circle: Florianópolis (both cities in Santa Catarina State).

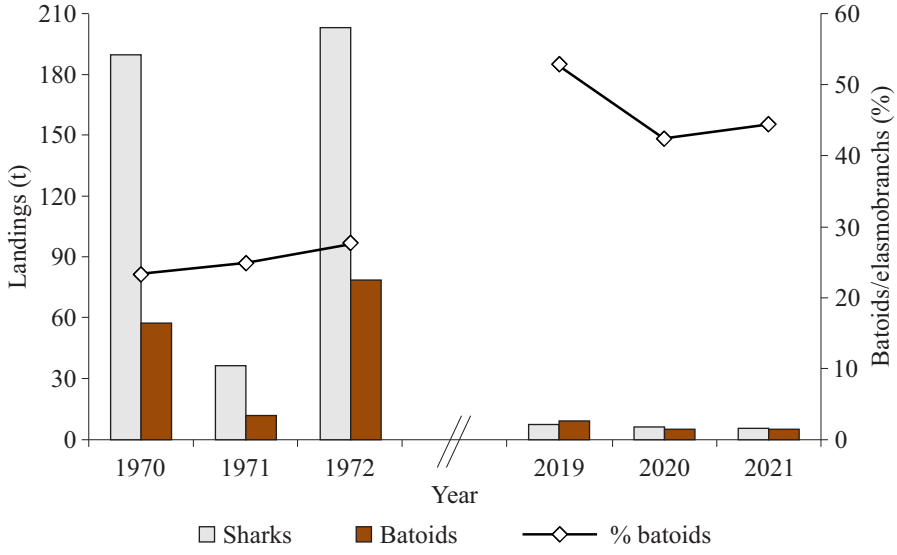

Figure 2. Annual artisanal landings of sharks and batoids on the Parana coast comprising two periods: 1970-1972 (Loyola e Silva and Nakamura 1975) and 2019-2021 (data: FUNDEPAG 2022). The % batoids refers to the percentage of batoids landed in relation to the total amount of elasmobranchs.

lyzed by genetic, physiological and population studies aimed at better understanding their similarities and differences (Franco 2010; Cruz et al. 2021; Leite 2022).

Concerns on other batoids

On the Parana coast, fisheries are mostly artisanal, with a predominance of two fishing gears: shrimp trawling, where batoids, mainly *Pseudobatos* spp., *Zapteryx brevirostris* (Müller and Henle, 1841), *Narcine brasiliensis* (Olfers, 1831), and Dasyatidae species, corresponding to 1% of the total production, are also captured as bycatch; and gillnets, where the above mentioned batoids plus *Rhinoptera* spp. and *Rioraja agassizii* (Müller and Henle, 1841), corresponding to 2-3% of the total production, are captured too (Robert 2012; Afonso and Chaves 2021; Chaves 2021). Other fisheries include bottom longline, which for the 2017-2021 period the Dasyatidae (hereafter: stingrays) catch accounted for up to 80% of the total elasmobranch volume, and 20% when considering all species caught (FUNDEPAG 2022).

Recently, the conservation status of other batoids has been evaluated, resulting in new restrictions on commercial fisheries in Brazilian waters and reactions from stakeholders. In June 2022, the Sindicato dos Armadores e das Indústrias de Pesca de Itajaí e Região (the largest Brazilian fishery syndicate, based in Southern Brazil; Figure 1) expressed their discontent, stating that comprehension challenges would limit compliance with legal restrictions (SINDIPI 2022). The new bans (Portaria MMA 148 2022) now include two stingrays, *Hypanus americanus* (Hildebrand and Schroeder, 1928) and *H. marianae* (Gomes, Rosa and Gadig, 2000), along with *P. percellens*, all of which have historic landings in Southern Brazil (Vooren et al. 2005; Costa and Chaves 2006; Robert 2012; Santos et al. 2016). The new ban on *P. percellens* has the potential to neutralize the challenges of co-occurrence mentioned above, as no *Pseudobatos* species can be landed. However, the fishery sector will face another challenge: which fish to land.

Regional data on fishery production (FUNDEPAG 2022) reveal that the landings of *Pseudobatos* spp. by artisanal fleets in Parana are decreasing. The total production decreased from 3 t in 2017 to 0.5 t in 2021. Landings may not have reached zero, as until 2021 *P. percellens* capture was allowed. Simultaneously, however, the total non-guitarfish batoid production has grown from < 0.5 t in 2017 to > 4 t in 2021, an increment mostly from stingrays (Figure 3).

There is a possible cause-effect relationship between legal restrictions for certain species –guitarfishes– and the increasing landings of others –stingrays. The capture effort is not measured, nor is the status of the stocks, but it is known that between 2017 and 2021 gillnetting production decreased in Parana, from > 400 t year^{-1} to < 150 t year^{-1} (Figure 4). This decrease reflects teleost production, whose total volume exceeds 15 times both elasmobranch and crustacean production (FUNDEPAG 2022). At the same period, longline production also decreased (Figure 4), despite the increment in stingray landings observed from 2019. This indicates a greater interest in this resource as well as greater availability, and/or retention onboard. The commercial use of non-targeted elasmobranchs is common worldwide, and batoid retention or non-retention is usually decided onboard (as reported by Tamini et al. 2006 for bottom trawling in Argentina). By comparison, in the China Sea, 28 shark species listed as NT, VU, and EN (IUCN list) are caught in drift gillnets, bottom trawl nets, and hook-and-line fisheries, all of which are retained and marketed (Araí and Azri 2019).

There are approximately sixty fishing communities along the Parana coast (Robert 2012). As batoids are a common and (supposedly) welcomed bycatch, conservation measures can limit fishing activities, but their acceptance depends on the alternatives offered to the sector. The

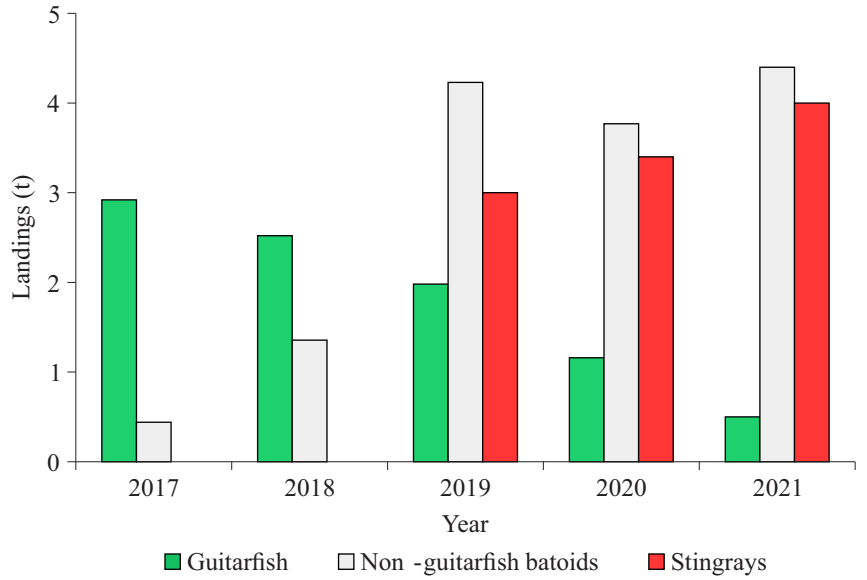

Figure 3. Annual landings of guitarfish (*Pseudobatos* spp.), non-guitarfish batoids, and stingrays only (Dasyatidae) by artisanal fleets in the Parana coast, Southern Brazil, between 2017 to 2021. Data source: FUNDEPAG (2022).

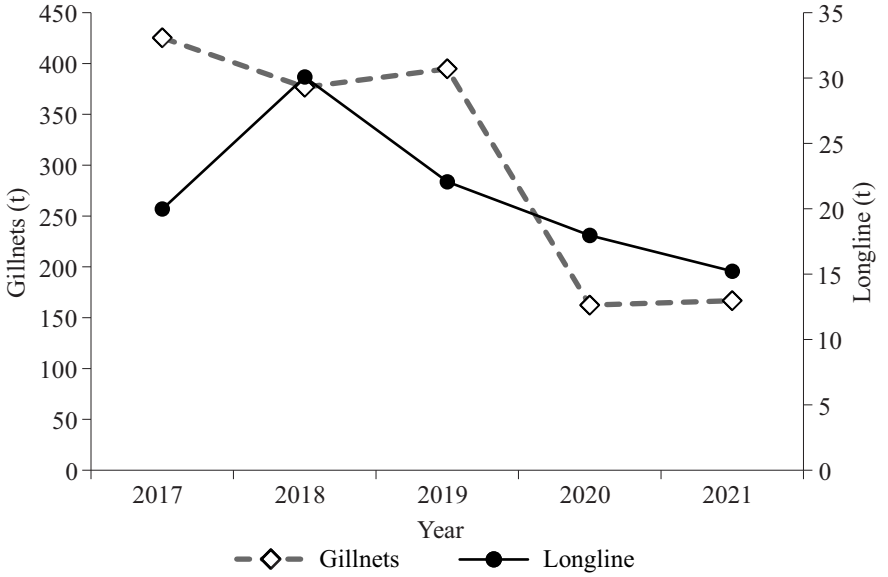

Figure 4. Annual landings of artisanal fisheries performed in the Parana coast, Southern Brazil, from 2017 to 2021. All fishery resources are summed according to the fishing gear employed. Data source: FUNDEPAG (2022).

Brazilian law 11959/2009, Art. 3, requires the government 'to calculate, authorize, and plan access regimes, and fix allowed catches; indeed, it is the government's obligation to consider fisheries' particularities and fishers' needs, aiming to assure the permanence and continuity' of artisanal fisheries. The most recognized and suggested labor activity shift model (i.e. extractive activ-

ities for ecotourism) can be restrictive in some regions, in addition to imposing changes in family structures and traditions that are not always well accepted (Das and Chatterjee 2015). In Brazil, there is a lack of prospecting for sustainable exploitation, which creates a gap between fishing bans and proper redirection to alternatives that do not impose a new lifestyle on fishers, without their consent.

RECOMMENDATIONS AND CONCLUSIONS

Considering the influence of stakeholders on species conservation, socio-ecological systems, assuming the need to integrate biodiversity management with people, are particularly relevant (Refulio-Coronado et al. 2021). This approach recognizes the complexity, unpredictability, dynamics, and non-linearity of fishing activities, assuming that decisions need to evolve towards strategies adapting to the distinct reality of traditional communities. In this context, the mitigation hierarchy model integrates biological and operational aspects of fisheries, considering the socioeconomic context to manage potential trade-offs between conservation initiatives and human needs (Booth et al. 2019). Such an approach can be applied to develop holistic and adaptive measures for batoid fishery management.

Hence, participatory management is a promising conservation measure for threatened species, concomitant with the coordinated exploitation of new resources, aimed at sustainable fisheries (Cota-Nieto et al. 2018). Management plans for stocks not yet overexploited should thus consider biological variables allowing the establishment of minimum and maximum capture sizes, in addition to quotas and seasonal bans for batoids. Furthermore, measures to mitigate overexploitation must be presented to fishers (Gupta et al. 2020), to develop conservation initiatives without affecting the financial gains of traditional communities.

Altogether, an artisanal landing shift on the Parana coast has been noted, which might be a reflex of the slow yet progressive fulfillment of the conservation measures proposed by the federal government in 2014. Despite the population collapse being a possibility, onboard monitoring and access to fisher ecological knowledge in the past four years provide strong evidence that the number of captured individuals remains constant (Wosnick et al. in preparation). Moreover, the reduction in landings might also be a result of a conservation initiative based on the release of live animals performed in Parana for over a decade (Wosnick et al. 2020), at least for *Z. brevirostris*. It is also important to consider that the decrease in guitarfish landings might also be a result of fewer fishers turning their efforts to fisheries that catch them, possibly because of bans turning landing into a great risk. Thus, monitoring efforts must be intensified in the region, aiming to understand the putative causes (or a combination of them) of the reduction in landings retracted in regional fisheries statistics.

It is also imperative that fisheries management be directed towards the economic-viable stingrays, along with monitoring efforts to understand drivers behind this shift in catches in the region. Finally, fishers must be included and consulted at every stage of the development of conservation measures to ensure that socio-cultural values are recognized and preserved. This will result in management plans fully adopted and, most importantly, supported by the fishery sector.

REFERENCES

Afonso MG, Chaves PTC. 2021. A pesca de emalhe costeiro de pequena escala no litoral do Paraná: um estudo de caso para a conservação. Rev CEPSUL Biodiv Cons Mar. 10: e2021001. DOI: https://doi.org/10.37002/revistacepsul.vol10.1754e2021001

Alemany D, Rico MR, Lagos AN, Martos P, Mendolar M, Carozza C. 2021. Evolución temporal de la diversidad, abundancia y estructura del ensamble de peces costeros en el área de "El Rincón" (39° S-41° 30′ S), Argentina. Mar Fish Sci. 34 (2): 143-180. DOI: https://doi.org/10.47193/mafis.3422021010602

Araí T, Azri A. 2019. Diversity, occurrence and conservation of sharks in the southern South China Sea. PLoS ONE. 14 (3): e0213864. DOI: https://doi.org/10.1371/journal.pone.0213864

Booth H, Squires D, Milner-Gulland EJ. 2019. The mitigation hierarchy for sharks: a risk-based framework for reconciling trade-offs between shark conservation and fisheries objectives. Fish Fish. 19: 1-21. DOI: https://doi.org/10.1111/faf.12429

Cardoso LG, da Silveira Monteiro D, Haimovici M. 2021. An assessment of discarded catches from the bottom pair trawling fishery in southern Brazil. Mar Fish Sci. 34 (2): 197-210. DOI: https://doi.org/10.47193/mafis.3422021010609

Chaves PTC. 2021. Juveniles and undersized fish in small-scale fisheries: gillnets are not less implied than trawling. Mar Fish Sci. 35 (2): 165-180. DOI: https://doi.org/10.47193/mafis.3522022010501

Chaves PTC, Silva AVF. 2019. Recursos-alvo que são também bycatch, e recomendação para a gestão da pesca de emalhe no litoral do Paraná, Brasil. Rev CEPSUL Biodiv Cons Mar. 8: 1-11. DOI: https://doi.org/10.37002/revistacepsul.vol8.732e2019001

Costa L, Chaves PTC. 2006. Elasmobrânquios capturados pela pesca artesanal na costa sul do Paraná e norte de Santa Catarina, Brasil. Biota Neotrop. 6 (3): bn02706032006. DOI: https://doi.org/10.1590/S1676-06032006000300007

Cota-Nieto JJ, Erisman B, Aburto-Oropeza O, Moreno-Báez M, Hinojosa-Arango G, Johnson AF. 2018. Participatory management in a small-scale coastal fishery–Punta Abreojos, Pacific coast of Baja California Sur, Mexico. Reg Stud Mar Sci.18:68-79. DOI: https://doi.org/10.1016/j.rsma.2017.12.014

Cruz VP, Adachi AMC, Oliveira PH, Ribeiro GS, Paim FG, Souza BS, Rodrigues ASF, Vianna M, Delpiani SM, Díaz de Astarloa JM, et al. 2021. Genetic diversity in two threatened species of guitarfish (Elasmobranchii: Rhinobatidae) from the Brazilian and Argentinian coasts: an alert for conservation. Neotrop Ichthyol. 19 (2): e210012. DOI: https://doi.org/10.1590/1982-0224-2021-0012

Das M, Chatterjee B. 2015. Ecotourism: a panacea or a predicament? Tour Manag Perspect. 14: 3-16. DOI: https://doi.org/10.1016/j.tmp.2015.01.002

Dulvy NK, Pacoureau N, Rigby CL, Pollom RA, Jabado RW, Ebert DA, Finucci B, Pollock CM, Cheok J, Derrick DH, et al. 2021. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. Curr Biol. 31 (21): 4773-4787. DOI: https://doi.org/10.1016/j.cub.2021.08.062

Dulvy NK, Simpfendorfer CA, Davidson LN, Fordham SV, Bräutigam A, Sant G, Welch DJ. 2017. Challenges and priorities in shark and ray conservation. Curr Biol. 27 (11): 565-572. DOI: https://doi.org/10.1016/j.cub.2017.04.038

Franco BA. 2010. Identificação das raias-viola *Rhinobatos horkelii*, *Rhinobatos percellens* e *Zapteryx brevirostris* (Chondrichthyes, Rhinobatidae) na costa central e sul do Brasil utilizando marcadores moleculares [PhD thesis]. Botucatu: Universidade Estadual Paulista. 59 p.

Froese R, Pauly D, editors. 2022. FishBase. [accessed 2022 Oct 25]. https://www.fishbase.org.

[FUNDEPAG] Fundação de Desenvolvimento da Pesquisa do Agronegócio. 2022. PMAP, Projeto de monitoramento da atividade pesqueira no Estado do Paraná. Banco de dados do monitoramento pesqueiro do litoral do

Parana. São Paulo: FUNDEPAG. [accessed 2022 Oct 31]. http://propesq-pr.fundepag.br.

Gupta T, Booth H, Arlide W, Rao C, Manorakrishnan M, Namboothri N, Shanker K, Milner-Gulland EJ. 2020. Mitigation of elasmobranch bycatch in trawlers: a case study in Indian fisheries. Front Mar Sci. 7: 571. DOI: https://doi.org/10.3389/fmars.2020.00571

Leite RD. 2022. Morfofisiologia de elasmobrânquios e sua aplicabilidade para os planos de manejo do grupo [PhD thesis]. Curitiba: Universidade Federal do Paraná. 149 p.

Lessa R, Colonello J, Santana F, Mas F. 2021. Ecología y dinámica reproductiva de los condrictios. Herramientas para la conservación. In: Ecología reproductiva y pesquerías en el contexto iberoamericano. Vigo: INVIPESCA Red de Investigación Pesquera p. 141-173. http://hdl.handle.net/10261/255913.

Loyola e Silva J, Nakamura IT. 1975. Produção do pescado no litoral paranaense. Acta Biol Par, Curitiba. 4 (3, 4): 75-119. DOI: https://doi.org/10.5380/ABPR.V4I0.840

[MMA] Ministério do Meio Ambiente. 2003. Estatística da pesca 2001 Brasil. Tamandaré: CEPENE, MMA. 97 p.

[MPA] Ministério da Pesca e Aquicultura. 2011. Boletim estatístico da pesca e aquicultura 2011. Brasília: MPA. 60 p.

Moore ABM. 2017. Are guitarfishes the next sawfishes? Extinction risk and an urgent call for conservation action. Endanger Species Res. 34: 75-88. DOI: https://doi.org/10.3354/esr00830

Portaria MMA 445. 2014. Reconhecer como espécies de peixes e invertebrados aquáticos da fauna brasileira ameaçadas de extinção aquelas constantes da "Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção - Peixes e Invertebrados Aquáticos". Brasília: Diário Oficial da União, 18 December 2014, Seção 1. p. 126.

Portaria MMA 148. 2022. Altera os anexos da Portaria nº 443, de 17 de dezembro de 2014, da Portaria nº 444, de 17 de dezembro de 2014, e da Portaria nº 445, de 17 de dezembro de 2014, referentes à atualização da lista nacional de espécies ameaçadas de extinção. Brasília: Diário Oficial da União, 8 June 2022, Seção 1. p. 74.

Refulio-Coronado S, Lacasse K, Dalton T, Humphries A, Basu S, Uchida H, Uchida E. 2021. Coastal and marine socio-ecological systems: a systematic review of the literature. Front Mar Sci. 8: 648006. DOI: https://doi.org/10.3389/fmars.2021.648006

Robert MC. 2012. A captura de elasmobrânquios na costa paranaense. In: Bornatowski H, Abilhoa V, editors. Tubarões e raias capturados pela pesca artesanal no Paraná: guia de identificação. Curitiba: Hori Consultoria Ambiental. 124 p.

Santos LO, Cattani AP, Spach HL. 2016. Ictiofauna acompanhante da pesca de arrasto para embarcações acima de 45 hp no litoral do Paraná, Brasil. Bol Inst Pesca. 42 (4): 816-830. DOI: https://doi.org/10.20950/1678-2305.2016v42n4p816

Sherman CS, Simpfendorfer CA, Haque AB, Digel ED, Zubick P, Eged J, Matsushiba JH, Sant G, Dulvy NK. 2022. Guitarfishes are plucked: undermanaged in global fisheries despite declining populations and high volume of unreported international trade. bioRxiv. DOI: https://doi.org/10.1101/2022.10.05.510982

[SINDIPI] Sindicato dos Armadores e das Indústrias da Pesca de Itajaí e Região. 2022. Notícias. Publicada portaria que altera a lista da 445. [published 2022 Jun 9; accessed 2022 Oct 31]. https://www.sindipi.com.br/post/publicada-portaria-que-altera-a-lista-da-445.

Tamini LL, Chiaramonte GE, Perez JE, Cappozzo HL. 2006. Batoids in a coastal trawl fishery of Argentina. Fish Res. 77: 326-332. DOI: https://doi.org/10.1016/j.fishres.2005.08.013

Vooren CM, Lessa RP, Klippel S. 2005. Biologia e status de conservação da viola *Rhinobatos horkelii*. In: Vooren CM, Klippel S, editors. Ações para a conservação de tubarões e raias no sul do Brasil. Porto Alegre: Garé. p. 33-56.

Wosnick N, Wosiak CCDL, Machado-Filho OC. 2020. Pay to conserve: what we have achieved in 10 years of compensatory releases of threatened with extinction guitarfishes. Anim Conserv. 24 (4): 537-539. DOI: https://doi.org/10.1111/acv.12651