



## NEW RECORDS AND PRELIMINARY REPRODUCTIVE ASPECTS OF ELASMOBRANCHS OF THE TRINDADE-MARTIN VAZ INSULAR COMPLEX

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**Abstract:** Here we presented records of elasmobranchs obtained during a longline pelagic fishing monitoring around the Trindade-Martin Vaz insular complex, including one new record. New information on the reproductive aspects of the blue shark (*Prionace glauca*) and pelagic stingray (*Pteroplatytrygon violacea*) suggest the use of this area as mating and parturition ground for these species. The most abundant species was the *P. glauca* (N = 65), followed by shortfin mako shark *Isurus oxyrinchus* (N = 12). We also recorded for the first time the smooth hammerhead shark *Sphyrna zygaena* (N = 3) and the bigeye thresher shark *Alopias superciliosus* (N = 2), and other shark species previously reported for the insular complex, including the oceanic whitetip *Carcharhinus longimanus* (N = 2), and the tiger shark *Galeocerdo cuvier* (N = 1). Our findings highlight the importance of further studies at the Trindade-Martin Vaz insular complex considering the pelagic biodiversity and reproductive aspects of elasmobranchs.

**Keywords:** insular ichthyofauna; oceanic islands; pelagic biodiversity; conservation; shark; stingray; reproduction.

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The ichthyofauna at the Trindade-Martin Vaz insular complex, unlike other Brazilian oceanic islands, is still poorly known, as well as the ecological and reproductive aspects of large predators in this environment (e.g. Pinheiro *et al.* 2010, 2015, Simon *et al.* 2013, Guabiroba *et al.* 2020, Pimentel *et al.* 2020). Historical records of the species occurring in the study area show the occurrence of 173 species in Trindade and 80 in Martin Vaz, among those, endemic species with low ecological amplitude were observed (Simon *et al.* 2013, Pinheiro *et al.* 2015, Guabiroba *et al.* 2020). Concerning elasmobranchs, nineteen shark species and two

stingray species have been recorded to this region, all listed on the IUCN Red List under some degree of threat (Table 1). Sharks such as the *Prionace glauca* and *Carcharhinus longimanus* show long-range migrations (Campana *et al.* 2011, Howey-Jordan *et al.* 2013). Despite the scarcity of studies, it is known that the strong anthropic pressure carried by fisheries in this region can affect the integrity of the fish community structure. For example, for the *P. glauca* the impact of pelagic longline fishery and a possible population decline have been reported (Sampaio *et al.* 2009, Pinheiro *et al.* 2010). In this context, the present work aims to report new

records and provide complementary information on the reproductive aspects of the elasmobranch species captured around the Trindade-Martin Vaz insular complex, contributing to the knowledge on biological aspects and future conservation and management strategies in this region.

Trindade island (20°30'S; 29°20'W) and the Martin Vaz archipelago (20°28'S; 28°50'W) form

the most remote insular group in Brazil, located 1.160 km away from the coast of Espírito Santo State. Trindade island has a total surface of 9.28 km<sup>2</sup>, maximum altitude of 620 m, and maximum depth around the island of 5.800 m (Serafini *et al.* 2010). The Martin Vaz archipelago is composed by three small islands, comprising a total area of 0.3 km<sup>2</sup> and maximum altitude of 175 m on the main

**Table 1.** List of species of elasmobranchs from the Trinidad Island complex-Martin Vaz. IUCN Red List categories and Brazil (MMA): CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concern, DD - Data Deficient (IUCN; IBAMA).

Family/Species	References	N	Total length (min-max)	Conservation Status	
				IUCN	Brazil (MMA)
<b>Alopiidae</b>					
<i>Alopias superciliosus</i>	Present study	2	--	VU	VU
<b>Carcharhinidae</b>					
<i>Carcharhinus leucas</i>	Pinheiro <i>et al.</i> (2015)	--	--	NT	NT
<i>Carcharhinus limbatus</i>	Carvalho (1950)	1	--	NT	NT
	Mazzoleni & Schwingel (2002)	5	116.0-182.0 cm		
<i>Carcharhinus longimanus</i>	Pinheiro <i>et al.</i> (2015)	2	--	VU	VU
	Present study	2	--		
<i>Carcharhinus galapagensis</i>	Pinheiro <i>et al.</i> (2015)	--	--	LC	CR
<i>Carcharhinus falciformis</i>	Pinheiro <i>et al.</i> (2015)	--	--	VU	NT
<i>Carcharhinus obscurus</i>	Carvalho (1950)	1	--	EN	EN
<i>Carcharhinus perezi</i>	Pereira-Filho <i>et al.</i> (2011)	--	--	NT	VU
	Pimentel <i>et al.</i> (2020)	11	mean 105.0 cm		
<i>Carcharhinus plumbeus</i>	Pinheiro <i>et al.</i> (2015)	--	--	VU	CR
	Carvalho (1950)	--	--		
<i>Galeocerdo cuvier</i>	Pinheiro <i>et al.</i> (2009; 2015)	--	--	NT	NT
	Pimentel <i>et al.</i> (2020)	2	mean 263.0 cm		
	Present study	1	250.0 cm		
<i>Prionace glauca</i>	Pinheiro <i>et al.</i> (2009; 2015)	--	--		
	Mazzoleni & Schwingel (2002)	104	140.0-302.0 cm	NT	NT
	Present study	65	170.0-270.0 cm		
<b>Ginglymostomatidae</b>					
	Carvalho (1950)	1	--		
<i>Ginglymostoma cirratum</i>	Pinheiro <i>et al.</i> (2010; 2015)	--	--	DD	VU
	Simon <i>et al.</i> (2013)	--	--		
	Pimentel <i>et al.</i> (2020)	2	mean 157.0 cm		
<b>Lamnidae</b>					
<i>Carcharodon carcharias</i>	Miranda-Ribeiro (1919)	--	--	VU	VU
<i>Isurus oxyrinchus</i>	Mazzoleni & Schwingel (2002)	2	210.0-227.0 cm	EN	NT
	Present study	12	110.0-270.0 cm		

Table 1. Continues on next page...

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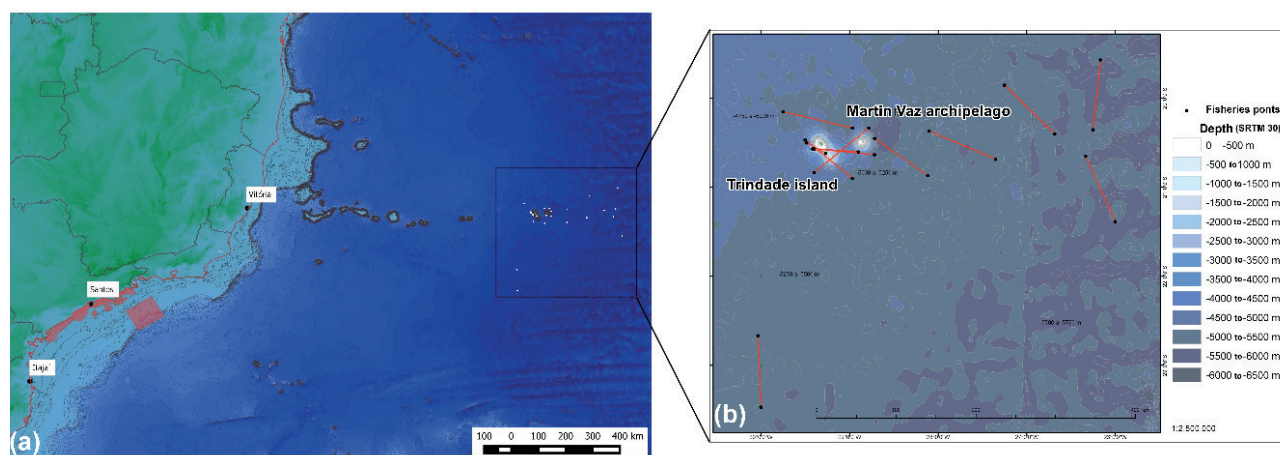
Family/Species	References	N	Total length (min-max)	Conservation Status	
				IUCN	Brazil (MMA)
<b>Rhincodontidae</b>					
<i>Rhincodon typus</i>	Pinheiro <i>et al.</i> (2009)	1	--	VU	DD
<b>Sphyrnidae</b>					
<i>Sphyrna lewini</i>	Mazzoleni & Schwingel (2002)	1	292.0 cm	CR	CR
	Pinheiro <i>et al.</i> (2015)	--	--		
	Pimentel <i>et al.</i> (2020)	3	mean 208.0 cm		
<i>Sphyrna zygaena</i>	Present study	3	210.0 cm	VU	CR
<b>Dasyatidae</b>					
<i>Pteroplatytrygon violacea</i>	Mazzoleni & Schwingel (2002)	48	30.0-66.0 cm	LC	DD
	Present study	2	40.0-56.0 cm		
<b>Myliobatidae</b>					
<i>Aetobatus narinari</i>	Pinheiro <i>et al.</i> (2009)	1	--	NT	DD

island. Despite the proximity between Trindade and Martin Vaz (48 km), they present a distinct fauna (Simon *et al.* 2013, Guabiroba *et al.* 2020).

Longline fisheries were monitored between November 23<sup>th</sup>, and December 18<sup>th</sup>, 2014, aboard the Marbella I (total length: 23.57 m; propulsion: Cummins 380 hp engine; propulsion Auxiliary: 120 hp MWM engine with generator of 140 KWA) from *Kowalsky Industria e Comercio de Pescados Ltda.* Boarding was authorized as observer / researcher independent of programs. The fishing spots were located between 19°34'S, 26°00'W to 23°28'S, 30°03'W, at Trindade-Martin Vaz region (Figure 1). The target species were swordfish (*Xiphias gladius*), big eye tuna (*Thunnus obesus*), oilfish (*Ruvettus pretiosus*) and *P. glauca* (although considered a

bycatch, it is very popular in the Brazilian trade). The chub mackerel (*Scomber japonicus*) was used as bait. The fishing gear was launched to water twelve times; a 56 nm nylon with 1500 hooks between 16:00 h to 22:00 h and fishing (bait recovery) occurred between 4:30 h or 6:30 h to 14:00 h or 16:00 h (release to withdrawal) depending on launching time and the catch. Registered temperatures of the water varied from 24.7 °C to 27.1 °C (recorded information of boat equipment). The boat brought a total of 20-35 tons of fish in one trip of 30 days.

Elasmobranchs caught were sexed and identified at the species level. Morphological characteristics related to the reproductive aspects (presence / absence of embryos) were recorded for all *P. glauca* females caught, and the occurrence of



**Figure 1.** (a) The location of the Trindade-Martin-Vaz insular complex region, in southeastern Brazil, identified with a black square. (b) Fishing spots performed (red lines).

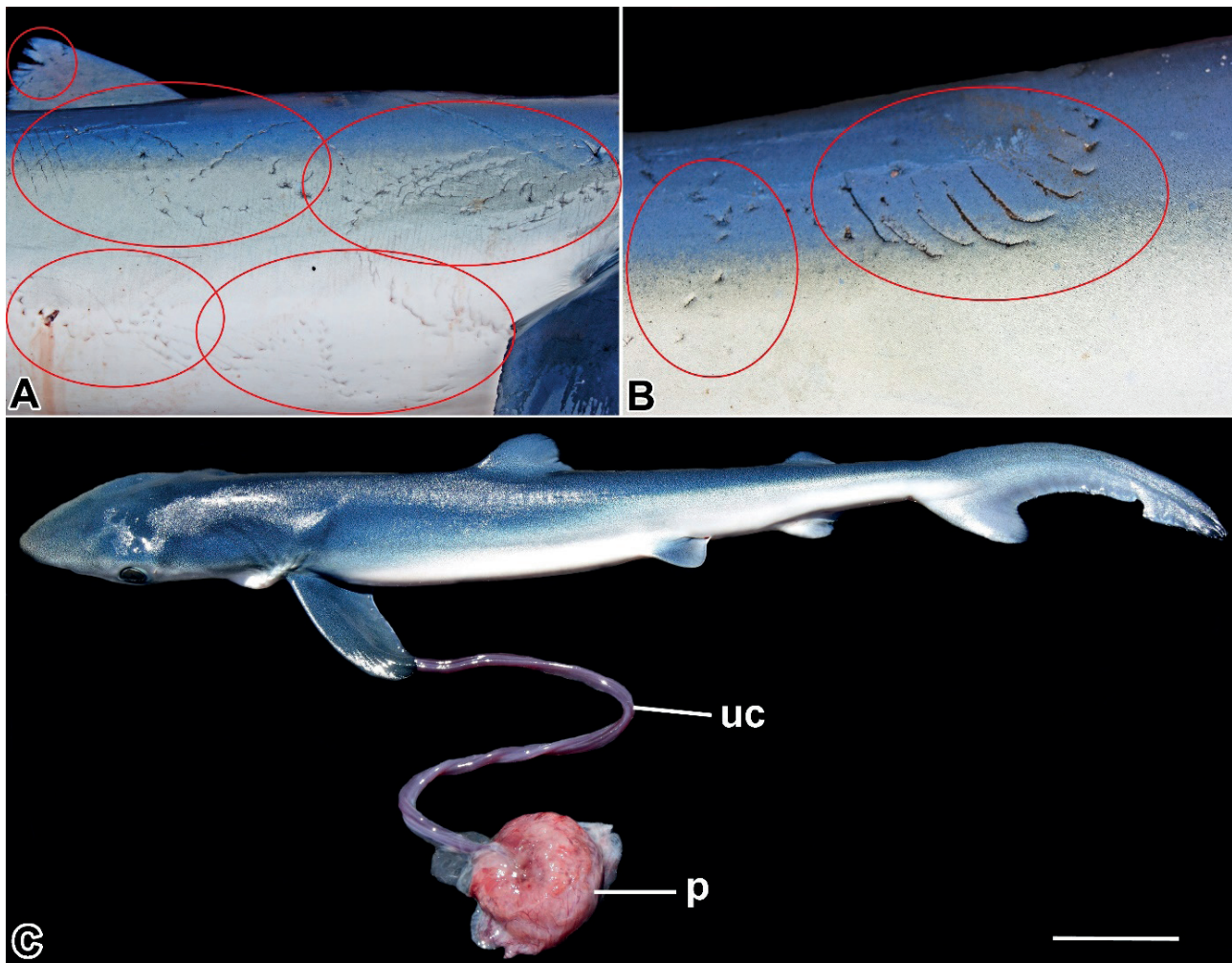


mating scars was recorded. The total length (TL) were recorded for some sharks and disk width (DW) were recorded for the rays. However, it was not possible to measure and identify the sex of all individuals, due to reduced research team on board.

A total of twelve bids were observed, totaling approximately 119 hours (considering the early longline release and withdrawal). From the seven elasmobranch species registered in this study, six were sharks and one was a ray species, including two new records for the smooth hammerhead shark *Sphyrna zygaena* and the bigeye thresher shark *Alopias superciliosus*. The most abundant species was the *P. glauca* (N = 65; 201.0 ± 46.1 cm TL, of those measured), followed by shortfin mako shark *Isurus oxyrinchus* (N = 12; 191.0 ± 40.4 cm TL), both composed mostly by mature males. One of the pregnant females of *P. glauca* (200.0 cm TL) presented twenty-five full-term embryos with an

average size of 45 cm TL. However, most of the females (N = 12) presented an empty uterus and fresh mating scars (bite marks; Figure 2).

Findings from a previous study in this same region for *P. glauca*, observed mating scars in 39.4 % of the females, while fertilized eggs were recorded in 84.2 % of pregnant females, indicating that these females were in the beginning of the gestation period (Mazzoleni & Schwingel 2002). Taken together, previous and current work suggests that the Trindade-Martin Vaz insular complex may function as a mating (presence of bite marks on the females and mature males) and possible parturition ground for the *P. glauca*, as was observed females with term embryos (Heupel *et al.* 2007). These results corroborate with the description of Montealegre-Quijano *et al.* (2014) that blue shark mating season occurs from December to February in the Southeast of Brazil, with pregnant females in the austral summer at latitudes over 25°S. The



**Figure 2.** (A-B) mating scars (bite marks) observed on females of *Prionace glauca*. (C) term embryo of *P. glauca*, labels: umbilical cord (uc), placenta (p). Scale bar: 5 cm.

pregnant females at the end of gestation (term embryos) occurring from September to December in the Brazilian Southern continental slope, with a gestational period around 9 months (Montealegre-Quijano *et al.* 2014). Future studies should investigate the importance of Trindade-Martin Vaz insular complex in the life-history stages and reproductive cycle for the *P. glauca*, as nursery and parturition grounds in the Atlantic have reported to occur in the south-west off southern Brazil and Uruguay, but also in the north-east off the Azores Islands (review in Coelho *et al.* 2017).

The smooth hammerhead, *S. zygaena* (N = 3; 210.0 cm TL, the only individual measured; mature males) and the bigeye thresher shark *A. superciliosus* (N = 2; released by fishermen) were recorded for the first time at the Trindade-Martin Vaz insular complex. The other two shark species registered, the oceanic whitetip *C. longimanus* (N = 2; released by fishermen) and the tiger shark *G. cuvier* (N = 1; 250.0 cm TL), have been reported in other studies in this region (Table 1). For the pelagic stingray *P. violacea*, two female individuals were captured ( $48.0 \pm 11.3$  cm DW), one of them presenting both an enlarged uterus with well-developed trophonemata in the uterine epithelium, indicating a recent parturition, according to Veras *et al.* (2014). Reproduction information on *P. violacea* is scarce, however Mazzoleni & Schwingel (2002), reported pregnant females (with 5.4 embryos/female) in south regions of Trindade-Martin Vaz insular complex, suggesting that the region also could be used as a parturition site for *P. violacea*.

Since the Trindade-Martin Vaz insular complex seems to be an important region for reproduction of elasmobranch species, as a potential parturition and mating ground, the absence of environmental and fishing management and local overfishing can be responsible for a significant decline of elasmobranch populations (*e.g.* Barreto *et al.* 2015). Because of their biological characteristics, such as large size, slow growth, low reproduction rate and late maturity, elasmobranchs are particularly vulnerable to increased mortality from fisheries (Stevens *et al.* 2000). Therefore, recent changes on the design of marine protected area, which include the removal of the oceanic islands and adjacent habitats from the no-take areas (Giglio *et al.* 2018), can severely compromise the conservation of elasmobranchs in this region. Further studies

should be conducted in this area to better understand the habitat use and its relationship with the reproductive cycle of elasmobranch species. Considering the threat status of most elasmobranch species, non-lethal sampling should be considered, such as sex hormones to address reproductive state and ultrasound images to assess pregnancy and in-utero pup sizes (*e.g.* Sulikowski *et al.* 2016). We recognize that the number of individuals was low; however, the new information presented here may be important for future studies and management strategies in this region.

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## REFERENCES

- Barreto, R., Ferretti, F., Flemming, J. M., Amorim, A., Andrade, H., Worm, B., & Lessa, R. 2016. Trends in the exploitation of South Atlantic shark populations. *Conservation Biology*, 30(4), 792–804. DOI: 10.1111/cobi.12663.
- Campana, S. E., Dorey, A., Fowler, M., Joyce, W., Wang, Z., Wright, D., & Yashayaev, I. 2011. Migration pathways, behavioural thermoregulation and overwintering grounds of blue sharks in the northwest Atlantic. *PLoS ONE*, 6, e16854. DOI: 10.1371/journal.pone.0016854.
- Carvalho, J. P. 1950. Resultados científicos do cruzeiro do 'Baependi' e do 'Vega' `a I. da Trindade. *Peixes. Boletim do Instituto Paulista de Oceanografia*, 1(1), 97–133.
- Coelho, R., Mejuto, J., Domingo, A., Yokawa, K., Liu, K. M., Cortés, E., Romanov, E. V., Da Silva, C., Hazin, F., Arocha, F., Mwilima, A. M., Bach, P., De Zárata, V. O., Roche, W., Lino, P. G., García-Cortés, B., Ramos-Cartelle, A. M., Forselledo, R., Mas F., Ohshimo, S., Courtney, D., Sabarros, P. S., Perez, B., Wogerbauer, C., Tsai W. P., Carvalho, F., & Santos, M. N. 2017. Distribution patterns and population structure of the blue shark (*Prionace glauca*) in the Atlantic and

- Indian Oceans. *Fish and Fisheries*, 19(1), 90–106. DOI: 10.1111/faf.12238.
- Guabiroba, H. C., Pimentel, C. R., Macieira, R. M., Cardozo-Ferreira, G. C., Teixeira, J. B., Gasparini, J. L., Joyeux, J. C., Simon, T., Rocha L. A., & Pinheiro, H. T. 2020. New records of fishes for the Vitória-Trindade Chain, southwestern Atlantic. *Check List*, 16, 699–705. DOI: 10.15560/16.3.699.
- Giglio, V. J., Pinheiro, H. T., Bender, M. G., Bonaldo, R. M., Costa-Lotufu, L. V., Ferreira, C. E. L., Floeter, S. R., Freire, A., Gasparini, J. L., Joyeux, J. C., Krajewski, J. P., Lindner, A., Longo, G. O., Lotufu, T. M. C., Loyola, R., Luiz, O. J., Macieira, R. M., Magris, R. A., Mello, T. J., Quimbayo, J. P., Rocha, L. A., Segal, B., Teixeira, J. B., Vila-Nova, D. A., Vilar, C. C., Zilberberg, C., & Francini-Filho, R. B. 2018. Large and remote marine protected areas in the South Atlantic Ocean are flawed and raise concerns: comments on Soares and Lucas (2018). *Marine Policy*, 96, 13–17. DOI: 10.1016/j.marpol.2018.07.017.
- Heupel, M. R., Carlson, J. K., & Simpfendorfer, C. A. 2007. Shark nursery areas: concepts, definition, characterization and assumptions. *Marine Ecology Progress Series*, 337, 287–297. DOI: 10.3354/meps337287.
- Howey-Jordan, L. A., Brooks, E. J., Abercrombie, D. L., Jordan, L. K., Brooks, A., Williams, S., Gospodarczyk, E., & Chapman, D. D. 2013. Complex movements, philopatry and expanded depth range of a severely threatened pelagic shark, the oceanic whitetip (*Carcharhinus longimanus*) in the western North Atlantic. *PloS ONE*, 8(2), e56588. DOI: 10.1371/journal.pone.0056588.
- IBAMA – Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. 2003. Lista Nacional das Espécies da Fauna Brasileira Ameaçadas de Extinção. Anexo à Instrução Normativa nº 3 do Ministério do Meio Ambiente, de 27/05/2003, publicada no D.O.U. nº 101, Seção I, de 28/05/2003.
- Mazzoleni, R. C., & Schwingel, P. R. 2002. Aspectos da biologia das espécies capturadas por espinhel pelágico na região sul das ilhas de Trindade e Martín Vaz no verão de 2001. *Notas técnicas da FACIMAR*, 6(1), 51–57.
- Miranda-Ribeiro, A., 1919. A fauna vertebrada da Ilha da Trindade. *Archivos do Museu Nacional*, 22, 169–194.
- Montealegre-Quijano, S., Cardoso, A. T. C., Silva, R. Z., Kinas, P. G., & Vooren, C. M. 2014. Sexual development, size at maturity, size at maternity and fecundity of the blue shark *Prionace glauca* (Linnaeus, 1758) in the Southwest Atlantic. *Fisheries Research*, 160, 18–32. DOI: 10.1016/j.fishres.2014.03.003.
- Pereira-Filho, G. H., Amado-Filho, G. M., Guimarães, S. M. P. B., Moura, R. L., Sumida, P. Y. G., Abrantes, D. P., Bahia, R. G., Güth, A. Z., Jorge, R. R., & Francini-Filho, R. B. 2011. Reef fish and benthic assemblages of the Trindade and Martim Vaz island group, southwestern Atlantic. *Brazilian Journal of Oceanography*, 59(3), 201–212. DOI: 10.1590/S1679-87592011000300001.
- Pimentel, C. R., Andrades, R., Ferreira, C. E. L., Gadig, O. B., Harvey, E. S., Joyeux, J. C., & Giarrizzo, T. 2020. BRUVS reveal locally extinct shark and the way for shark monitoring in Brazilian oceanic islands. *Journal of Fish Biology*, 96(2), 539–542. DOI: 10.1111/jfb.14228.
- Pinheiro, H. T., Camilato, V., Gasparini, J. L., & Joyeux, J. C. 2009. New records of fishes of Trindade-Martim Vaz oceanic insular complex, Brazil. *Zootaxa*, 2298, 45–54. DOI: 10.11646/zootaxa.2298.1.3.
- Pinheiro, H. T., Martins, A. S., & Gasparini, J. L. 2010. Impact of commercial fishing on Trindade Island and Martim Vaz Archipelago, Brazil: characteristics, conservation status of the species involved and prospects for preservation. *Brazilian Archives of Biology and Technology*, 53(6), 1417–1423. DOI: 10.1590/S1516-89132010000600018
- Pinheiro, H. T., Mazzei, E., Moura, R. L., Amado-Filho, G. M., Carvalho-Filho, A., Braga, A. C., Costa, P. A. S., Ferreira, B. P., Ferreira, C. E. L., Floeter, S. R., Francini-Filho, R. B., Gasparini, J. L., Macieira, R. M., Martins, A. S., Olavo, G., Pimentel, C. R., Rocha, L. A., Sazima, I., Simon, T., Teixeira, J. B., Xavier, L. B., & Joyeux, J. C. 2015. Fish biodiversity of the Vitória-Trindade Seamount Chain, southwestern Atlantic: an updated data base. *PLoS ONE* 10, e0118180. DOI: 10.1371/journal.pone.0118180.
- Serafini, T. Z., França, G. B., & Andriguetto-Filho, J. M. 2010. Brazilian oceanic islands: known biodiversity and its relation to the history

- of human use and occupation. *Journal of Integrated Coastal Zone Management*, 10(3), 281–301.
- Simon, T., Macieira, R. M., & Joyeux, J. C. 2013. The shore fishes of the Trindade–Martim Vaz insular complex: an update. *Journal of Fish Biology*, 82(6), 2113–2127. DOI: 10.1111/jfb.12126.
- Stevens, J. D., Bonfil, R., Dulvy, N. K., & Walker, P. A. 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and implications for marine ecosystems. *ICES Journal of Marine Science*, 57(3), 476–494. DOI: 10.1006/jmsc.2000.0724.
- Sulikowski, J. A., Wheeler, C., Gallagher, A. J., Prohaska, B., Langan, B., & Hammerschlag, N. 2016. Seasonal and life-stage variation in the reproductive ecology of a marine apex predator, the tiger shark *Galeocerdo cuvier*, at a protected female dominated site. *Aquatic Biology*, 24, 175–184. DOI: 10.3354/ab00648.
- Veras, D. P., Hazin, F. H. V., Branco, I. S. L., Tolotti, M. T., & Burgess, G. H. 2014. Reproductive biology of the pelagic stingray, *Pteroplatytrygon violacea* (Bonaparte, 1832), in the equatorial and south-western Atlantic Ocean. *Marine and Freshwater Research*, 65(11), 1035–1044. DOI: 10.1071/MF13008.

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