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BRUVS reveal locally extinct shark and the way for shark monitoring in Brazilian oceanic islands

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ABSTRACT

Here we present records of sharks obtained using baited remote underwater stereo-video systems (stereo-BRUVS) at two Brazilian oceanic islands. Fourteen of the 60 deployments recorded 19 sharks in Trindade Island. In Saint Peter and Saint Paul Archipelago (SPSPA), two pelagic and two demersal deployments recorded two and one shark, respectively, including the locally extinct Galapagos shark *Carcharhinus galapagensis*. Stereo-BRUVS should be considered as adjuncts to other non-invasive methods to monitor shark populations.

KEYWORDS

Carcharhinus galapagensis, conservation status, elasmobranch, reef fish, south-western Atlantic Ocean

One hundred and sixty-five species of elasmobranchs have been recorded off the Brazilian coast (Rosa & Gadig, 2014). Although representing only *c.* 13% of the fish species (Menezes *et al*., 2003), sharks and rays species account for 55% of the endangered Brazilian marine ichthyofauna (ICMBio, 2018), with 54 species classified in the IUCN threat categories: Vulnerable, Endangered or Critically Endangered. The main challenge for assessing population trends and conservation statuses of many shark species is the lack of population data (Rosa & Gadig, 2014).

Here, we present records of sharks obtained from surveys using baited remote underwater stereo-video systems (stereo-BRUVS) at the Brazilian oceanic islands of Trindade (October 2017) and Saint Peter and Saint Paul Archipelago (SPSPA; September 2018; Supporting Information Video V1). Trindade (20° 30′ S; 29° 20′ W) is a volcanic island located 1160 km off the coast of Espírito Santo state, south-western Atlantic Ocean, and together with Martin Vaz Archipelago constitutes the eastern end of the Vitória-Trindade Chain. The SPSPA (0° 55′ N; 29° 21′ W) is a small group of rocky islets located about 1000 km off the north-eastern Brazilian coast, on the Mid-Atlantic Ridge in the central equatorial Atlantic Ocean.

Sampling complied with Brazilian laws and was authorized by the Federal Government under the environmental permits #403740/2012–6 and #405426/2012-7.

TABLE 1 Length measurements of the shark species recorded at the Brazilian oceanic islands of Trindade and Saint Peter and Saint Paul Archipelago (SPSPA)

	Fork length (m)							
Trindade								
Carcharhinus perezi	0.79	0.82	0.90	0.95	1.01	1.12	1.29	1.48
Galeocerdo cuvier	2.57	2.69						
Ginglymostoma cirratum	1.10	2.05						
Sphyrna lewini	2.08							
SPSPA								
Carcharhinus falciformis	1.22	1.27	1.41	1.46				
Carcharhinus galapagensis	2.19							

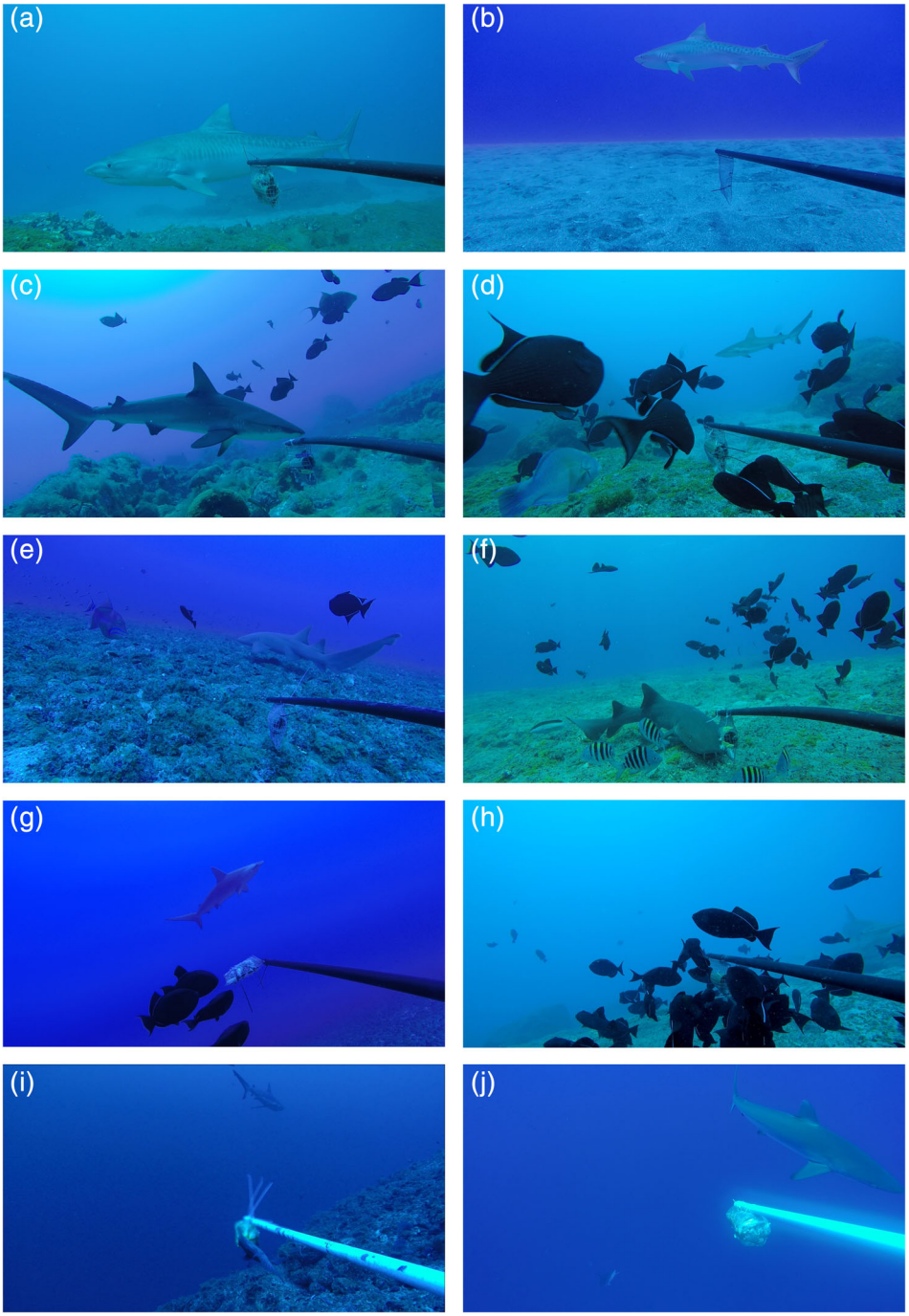

FIGURE 1 Shark species recorded using baited remote underwater stereo-video systems (stereo-BRUVS) at the Brazilian oceanic islands of Trindade: a and b) tiger shark *Galeocerdo cuvier*; c and d) caribbean reef shark *Carcharhinus perezi*; e and f) nurse shark *Ginglymostoma cirratum*; g and h) scalloped hammerhead shark *Sphyrna lewini*; and Saint Peter and Saint Paul Archipelago: i) Galapagos shark *Carcharhinus galapagensis* and j) silky shark *Carcharhinus falciformis*

Demersal stereo-BRUVS were deployed at depths of 10 – 74 m in Trindade (60 h of footage; n = 60 samples) and 30 – 85 m in SPSPA (14 h of footage; n = 14). Pelagic stereo-BRUVS were deployed in SPSPA (10 h of footage; n = 5) at 20 and 30 m depths. In Trindade, stereo-BRUVS were baited with 500 g of small pieces of thawed Brazilian sardinella *Sardinella brasiliensis* (Steindachner 1879), and with 500 g (demersal) or 1 kg (pelagic) of crushed thawed herring *Harengula* sp. in SPSPA. We calibrated the stereo-BRUVS using the CAL software and analysed the video samples using the EventMeasure software (www.seagis.com.au). We identified the sharks at the species level and recorded the relative abundance as the maximum number of individuals of the same species present in a single frame (N_{max}; Cappo *et al*., 2004). We measured the fork length (L_F) of all individuals according to the distance (≤ 7 m) and angle (≤ 45°) to the cameras and the measurement precision (≤ 1 cm).

Fourteen of the 60 deployments recorded 19 sharks in Trindade Island, including two tiger sharks *Galeocerdo cuvier* (Péron & LeSueur 1822) (mean L_F = 2.63 m; Table 1), 11 Caribbean reef sharks *Carcharhinus perezi* (Poey 1876) (mean L_F = 1.05 m), two nurse sharks *Ginglymostoma cirratum* (Bonnaterre 1788) (mean L_F = 1.57 m) and three scalloped hammerhead sharks *Sphyrna lewini* (Griffith & Smith 1834) (L_F = 2.08 m; Figure 1a–h). In SPSPA, only two of five pelagic deployments recorded sharks, two silky sharks *Carcharhinus falciformis* (Müller & Henle 1839) (mean L_F = 1.34 m) in each deployment, and two of 14 demersal deployments recorded one silky shark (not measured) and one Galapagos shark *Carcharhinus galapagensis* (Snodgrass & Heller 1905) (L_F = 2.19 m) (Figure 1i,j).

The main diagnostic characteristics that allowed us to differentiate the Galapagos shark from its congener, the dusky shark *Carcharhinus obscurus* (LeSueur 1818), were the first dorsal fin rather high and straight (only slightly curved near the tip), and a relatively high and short second dorsal fin, as is observed for the anal fin (Garrick, 1982; Voigt & Weber, 2011). Galapagos sharks were regarded as locally extinct in SPSPA (Luiz & Edwards, 2011), although this archipelago has been a designated multiple-use marine protected area (MPA) since 1986 (Brasil, 1986). The main threats are longline and hand line fishing, which until the 1970s caught large quantities of these sharks with low reproductive capacity and limited intrinsic rebound potential (Luiz & Edwards, 2011).

Systematic fish and shark studies using other non-invasive methods (*e.g*., underwater visual census (UVC) and remotely operated vehicle (ROV)) in these two Brazilian oceanic islands have not recorded sharks in recent decades (Pinheiro *et al*., 2011; Luiz *et al*., 2015; Rosa *et al*., 2016). However, it is noteworthy that a small number of sharks have been occasionally sighted, such as nurse and Caribbean reef sharks at Trindade, as well as a hammerhead shark (in 2009; C. E. L. Ferreira, pers. comm.) and a six-gill shark *Hexanchus griseus* (Bonnaterre 1788) (in 2018; H. T. Pinheiro & L. A. Rocha, pers. comm.) in SPSPA. Our data demonstrate the advantages of using stereo-BRUVS for sampling sharks and rays (Harvey *et al*., 2018) as a complementary tool to more traditional methods (Langlois *et al*., 2010; Rolim *et al*., 2019), particularly in fishery-affected ecosystems. Despite the overfishing of sharks at these Brazilian oceanic islands (Luiz & Edwards, 2011; Pinheiro *et al*., 2011), these results demonstrate that a few have remained or occasional individuals have migrated from outer areas.

Long-term monitoring with stereo-BRUVS would confirm local extinctions, indicate stray specimens or follow population recovery. For example, while a few fishery-dependent records of Galapagos sharks near SPSPA have been published subsequent to Luiz & Edwards (2011) paper (Hazin *et al*., 2018), neither those nor our record indicate a recovery of the population. Instead, it brings attention to the urgent need to monitor and assess the population trends of this Critically Threatened species (ICMBio, 2018), especially now that part of these two oceanic islands have been established as no-take areas (Brasil, 2018; Giglio *et al*., 2018).

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