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Inventory

First fish fauna assessment in the Fernando de Noronha Archipelago with BRUVS: Species catalog with underwater imagery

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Abstract: Fish fauna assessments with traditional catch methods are undesired in marine reserves. Underwater visual census on the other hand is biased due to fish-diver interactions, such as shyness or avoidance behavior of large-bodied target species. This study presents the first marine ichthyofauna inventory of the Fernando de Noronha Archipelago, off northeastern Brazil, sampled with non-destructive, independent Baited Remote Underwater Video Systems (BRUVS). High fish species richness, totaling 66 species from 28 families and 10 orders, including five elasmobranch species and other large predatory fish, such as barracudas, groupers and snappers, were recorded from 81 underwater video samples. Additionally, all of the 4,398 individuals sighted were associated to up to four different benthic habitat types. A catalog of underwater fish images and a detailed species list with additional information, such as conservation status, are provided.
Keywords: Ichthyofauna; Biodiversity; Sampling methods; Conservation.

Primeira avaliação da fauna de peixes no Arquipélago de Fernando de Noronha com BRUVS: Catálogo de espécies com imagens subaquáticas

Resumo: Inventários de ictiofauna com métodos tradicionais de captura são indesejáveis em reservas marinhas. O censo visual subaquático, porém, sofre o viés das interações peixe-mergulhador, tais como comportamentos de timidez ou fuga exercido pelas grandes espécies-alvo de pressões pesqueiras, incluindo, a caça submarina. Esse estudo representa o primeiro inventário da ictiofauna marinha do Arquipélago de Fernando de Noronha, costa nordeste do Brasil, utilizando sistemas não-destrutivos independentes de vídeos subaquáticos com iscas (BRUVS). Uma elevada riqueza de espécies de peixes, com 66 espécies de 28 famílias e 10 ordens, incluindo cinco espécies de elasmobrânquios e outros grandes peixes predadores como barracudas, garoupas e dentões, foi registrada em 81 amostras de vídeos subaquáticos. Adicionalmente, todos os 4.398 indivíduos avistados foram associados a até quatro diferentes tipos de habitats bentônicos. Um catálogo de imagens subaquáticas dos peixes e uma lista de espécies detalhada com informações adicionais, tais como o status de conservação, são fornecidos.
Palavras-chave: Ictiofauna; Biodiversidade; Métodos de amostragem; Conservação.

Introduction

The Fernando de Noronha Archipelago (FN) located in the Equatorial Western Atlantic Ocean, off Brazil's northeastern coast, contains a Marine National Park (PARNAMAR) to protect its important marine and terrestrial biodiversity (Soto, 2001; Floeter et al., 2001; IBAMA, 1990; ICMBio, 2017). The reef fish fauna of FN presents a considerable level of endemism (6.3%) (Floeter & Gasparini, 2000; Floeter et al., 2001). Recently, Pinheiro et al. (2018) found that Fernando de Noronha Archipelago may share endemic species with insular regions as far away as Trindade, located 1.860 km south of FN, highlighting the importance of the island in harboring a unique and rich marine biodiversity.

One of the most complete ichthyofauna inventories of the Fernando de Noronha Archipelago and its surroundings was developed based on existing literature and three scientific expeditions (ARFENOR I, II and III), where a combination of visual census with scuba, snorkeling, and fisheries inventory was employed (Soto, 2001). More recent inventories were carried out using visual census with scuba gear to assess the reef fishes of FN (Krajewski & Floeter, 2011; Medeiros et al., 2011), or snorkeling, focusing on the fish fauna of shallow reef areas (Ilarri et al., 2017). Additionally, the intertidal fishes of FN were studied by Andrades et al. (2018) in an assemblage structure approach.

Stressful sampling techniques, inducing the capture and sacrifice of high numbers of specimens is undesirable in marine protected areas, specifically in aquatic ecosystems harboring threatened and endemic species, such as FN (Floeter & Gasparini, 2000; Floeter et al., 2001; Andrades et al., 2018). In regard to traditional underwater visual census, a widespread technique to study reef fishes, fish-scuba diver interactions are a common methodological bias (Kulbicki, 1998; Harvey et al., 2002). This is specifically problematic when studying large bodied species, such as groupers, snappers and parrotfishes (Gotanda et al., 2009; Januchowski-Hartley et al., 2011), commonly targeted along the tropical coast of Brazil (Nunes et al., 2012, 2016).

Sampling the highest possible number of species inhabiting a certain study area is paramount in a fish fauna inventory. As exposed above with studies in FN, focusing on distinct components of the local fish fauna, this may require a combination of different sampling methods, in order to achieve this. In this sense, all possible method-related limitations should be avoided, by also employing alternative methods (Willis & Babcock, 2000; Cappo et al., 2003). Baited remote baited underwater video systems (BRUVS) can offer such an alternative, non-destructive, non-lethal and efficient fish fauna sampling technique, that additionally bypasses the limitations and risks inherent to scuba diving (Willis & Babcock, 2000; Cappo et al., 2003; Lindfield et al., 2014). In this context, the present study provides an inventory of the ichthyofauna of the Fernando de Noronha Archipelago, using data from BRUVS sampling in different benthic habitats, and supplementary species images.

Material and Methods

1. Study Area

This study was conducted in the Fernando de Noronha Archipelago (FN), an isolated group of volcanic islands, located in the western tropical Atlantic 345 km off the north-eastern coast of Brazil (03°52'S; 32°25'W) (Figure 1). About 70% of the main island and the waters spanning its coastline to the 50 m isobath constitute as a no-take zone (Figure 1), declared a National Marine Park (corresponding to IUCN Category II) in 1988 (IBAMA, 1990, Maida, Ferreira, 1997, Dudley, 2008). The remaining portion of FN is an Environmental Protection Area (EPA) designated for sustainable use (corresponding to IUCN Category V) established in 1986 (IBAMA, 1990, Maida, Ferreira, 1997, Dudley, 2008). The archipelago is under the influence of the South Equatorial Current, with annual averages of water temperature and salinity of 26°C and 36‰, respectively. The archipelago has two main underwater landscapes: the windward side, characterized by extensive algal-vermetid reef barriers along rocky shorelines, and the leeward side, mainly composed of descending slopes along a rocky shoreline with large scattered boulders and sparse and small reefs (Maida, Ferreira, 1997).

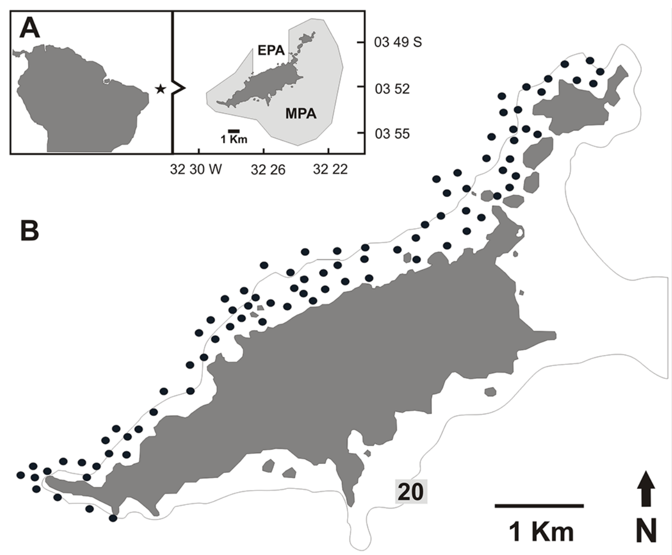

Figure 1. Study area map at the Fernando de Noronha Archipelago with sampling locations (black dots), 20 m depth isobaths (20) and delimitation of the areas inside (MPA) and outside (EPA) of the Marine National Park (PARNAMAR) in the right small window

2. BRUVS sampling

In August 2017, 81 single BRUVS (one camera) deployments were realized in order to sample the FN ichthyofauna. Deployments were made randomly over a variety of benthic habitats, in depths ranging from approximately 5 to 35 m. BRUVS sampling was conducted at least 1 hour after sunrise and 1 hour before sunset due to visibility conditions and to remove the effect of crepuscular behavior. Soak time for each deployment was approximately 90 min. BRUVS were equipped with high-definition (HD) GoPro Hero 3+ action cameras and baited with 1,000 g of a mix of crushed sardine and fish offal. Only the windward (northwestern) side of FN was sampled due to its calmer sea conditions at this time of the year.

3. Video and data analysis

All video samples were analyzed using the free VLC media player software (www.videolan.org). All fish were identified to species level, with few exceptions identified to genus level (e.g. *Halichoeres* spp.).

The maximum number of individuals within a paused still frame at any time of the video (MaxN) was adopted as relative abundance measure, in order to avoid recounting individual entering several times in the camera's field of view (Cappo et al., 2004). Total relative abundances (TMaxN), summed from all BRUVS samples, per species are presented in a matrix (Table 1) with information on the international and Brazilian conservation status (IUCN, 2019; ICMBio, 2018. Mean relative abundance and species richness per BRUVS deployment was also calculated. Four habitat types were visually identified: rocky reefs (RO), rocky bottom with macroalgae (MA) and rhodolith beds (RH), as well as the unconsolidated sandy bottom habitats (SA) (Figure 2). At last, species images were extracted from the video samples, in order to produce a catalog of underwater images of the species (Figures 3-28).

Table 1. Matrix of the fish inventory of Fernando de Noronha Archipelago obtained with Baited Remote Underwater Video Systems (BRUVS). TMaxN = Total (summed) relative abundance; Conservation status according to IUCN = The International Union for Conservation of Nature and ICMBio = Instituto Chico Mendes de Conservação da Biodiversidade; CR = Critically Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least concern; DD = Data Deficient; NE = Not Evaluated. Benthic habitats: SA = Sandy bottom; RO = Rocky bottom / rocky reefs; MA = Rocky bottom with macroalgae and RH = Rhodolith

Species	TMaxN	IUCN	ICMBio	Benthic habitats	Image
ANGUILLIFORMES					
Congridae					
Heteroconger camelopardalis (Lubbock 1980)	79			SA	
Muraenidae					
Gymnothorax funebris (Ranzani, 1839)	13	LC	NE	RO/MA	Figure 13 (a)
Gymnothorax moringa (Cuvier, 1829)	2	LC	DD	RO	Figure 13 (b)
BELONIFORMES					
Exocoetidae					
Hirundichthys speculiger (Valenciennes, 1847)	1	LC	LC	SA	
BERYCIFORMES					
Holocentridae					
Holocentrus adscensionis (Osbeck, 1765)	67	LC	LC	SA/RO/MA	Figure 22 (a)
CARCHARHINIFORMES					
Carcharhinidae					
Carcharhinus perezii (Poey, 1876)	45	NT	VU	SA/RO	Figure 3 (b)
Negaprion brevirostris (Poey, 1868)	45	NT	VU	SA/RO/MA/RH	Figure 3 (a)
MYLIOBATIFORMES					
Dasyatidae					
Hypanus berthalutzae Petean, Naylor & Lima, 2020	42	DD	DD	SA/RO/MA/RH	Figure 4 (a)
Myliobatidae					
Aetobatus narinari (Euphrasen, 1790)	1	NT	DD	RO	Figure 4 (b)
ORECTOLOBIFORMES					
Ginglymostomatidae					
Ginglymostoma cirratum (Bonnaterre, 1788)	39	DD	VU	SA/RO/MA	Figure 3 (c)
PERCIFORMES					
Acanthuridae					
Acanthurus bahianus Castelnau, 1855	112	LC	LC	SA/RO/MA/RH	Figure 16 (b)
Acanthurus chirurgus (Bloch, 1787)	133	LC	LC	SA/RO/MA	Figure 16 (a)
Acanthurus coeruleus Bloch & Schneider, 1801	98	LC	LC	SA/RO/MA	Figure 16 (c)
Carangidae					
Caranx bartholomaei Cuvier, 1833	67	LC		SA/RO/MA	Figure 11 (a)
Caranx crysos (Mitchill, 1815)	176	LC	LC	SA/RO/MA/RH	Figure 11 (b)
Caranx latus Agassiz, 1831	38	LC	LC	SA/RO/MA	Figure 11 (c)
Caranx lugubris Poey, 1860	20	LC	LC	RO	
Caranx ruber (Bloch, 1793)	80	LC		SA/RO/MA	Figure 12 (a)
Decapterus macarellus (Cuvier, 1833)	18	LC	LC	SA	
Elagatis bipinnulata (Quoy & Gaimard, 1825)	3	NA	LC	SA	
Seriola rivoliana (Valenciennes, 1833)	4	LC	LC	SA/RO	Figure 12 (b)
Trachinotus falcatus (Linnaeus, 1758)	1	LC	LC	RO	

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Species	TMaxN	IUCN	ICMBio	Benthic habitats	Image
Chaetodontidae					
Chaetodon ocellatus (Bloch, 1787)	50	LC	DD	SA/RO/MA	Figure 24 (b)
Echeneidae					
Echeneis naucrates Linnaeus, 1758	44		LC	SA/RO/MA	Figure 27 (a)
Echeneis neucratoides Zuiew, 1789	1	DD		SA	
Haemulidae					
Anisotremus surinamensis (Bloch, 1791)	107	DD	DD	SA/RO/MA/RH	Figure 14 (a)
Haemulon chrysargyreum (Günther, 1859)	117	LC	LC	RO/MA	Figure 14 (b)
Haemulon parra (Desmarest, 1823)	98	LC	LC	SA/RO/MA/RH	Figure 14 (c)
Kyphosidae					
Kyphosus bigibbus Lacepède, 1801	104	LC		SA/RO/MA/RH	Figure 15 (a)
Kyphosus spp.	5			RO	
Labridae					
Bodianus pulchellus (Poey, 1860)	14	LC	LC	RO	Figure 18 (a)
Bodianus rufus (Linnaeus, 1758)	5	LC	LC	RO	
Clepticus brasiliensis Heiser, Moura & Robertson, 2000	1	LC	LC	RO	
Halichoeres dimidiatus (Agassiz, 1831)	30	LC		SA/RO	
Halichoeres radiatus (Linnaeus, 1758)	83	LC	LC	SA/RO/MA	Figure 18 (b)
Halichoeres spp.	138			SA/RO/MA/RH	
Xyrichtys incandescens (Linnaeus, 1758)	1	LC	LC	SA	
Lutjanidae					
Lutjanus jocu (Bloch & Schneider, 1801)	74	DD	NT	SA/RO/MA/RH	Figure 7 (a)
Malacanthidae					
Malacanthus plumieri (Bloch, 1786)	42	LC	LC	SA/RO/MA/RH	Figure 21 (a)
Mullidae					
Mulloidichthys martinicus (Cuvier, 1829)	66	LC	LC	SA/RO	Figure 23 (a)
Pseudupeneus maculatus (Bloch, 1793)	61	LC	LC	SA/RO/MA	Figure 23 (b)
Pomacanthidae					
Pomacanthus paru (Bloch, 1787)	32	LC	DD	SA/RO/MA	Figure 25 (a)
Pomacentridae					
Abudefduf saxatilis (Linnaeus, 1758)	613	hLC	LC	SA/RO/MA/RH	Figure 17 (a)
Chromis multilineata (Guichenot, 1853)	263	LC	LC	SA/RO/MA	Figure 17 (b)
Stegastes pictus (Castelnau, 1855)	34		LC	SA/RO/MA	
Stegastes rocasensis[E] (Emery, 1972)	15		VU	RO/MA	Figure 17 (c)
Scaridae					
Sparisoma amplum (Ranzani, 1841)	43	LC	NT	SA/RO	Figure 9 (a, b)
Sparisoma axillare (Steindachner, 1878)	45	DD	VU	SA/RO/MA/RH	Figure 7 (b)
Sparisoma frondosum (Agassiz, 1831)	26	DD	VU	SA/RO/MA/RH	Figure 8 (a)
Sparisoma sp.	6			SA/RO	
Serranidae					
Cephalopholis fulva (Linnaeus, 1758)	254	LC	LC	SA/RO/MA/RH	Figure 5 (a)
Dermatolepis inermis (Valenciennes, 1833)	27	DD	DD	SA/RO	Figure 6 (b)
Epinephelus itajara (Lichtenstein, 1822)	1	VU	CR	RO	Figure 5 (b)
Paranthias furcifer (Valenciennes, 1828)	108	LC		SA/RO/MA	Figure 6 (a)
Rypticus saponaceus (Bloch & Schneider, 1801)	1	LC	LC	RO	

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Species	TMaxN	IUCN	ICMBio	Benthic habitats	Image
Sphyraenidae					
Sphyraena barracuda (Edwards, 1771)	68	LC	LC	SA/RO/MA/RH	Figure 10 (a)
PLEURONECTIFORMES					
Bothidae					
Bothus lunatus (Linnaeus, 1758)	1	LC	LC	MA	Figure 26 (a)
Bothus maculiferus (Poey, 1860)	2	LC	LC	SA/RO	
SCORPAENIFORMES					
Dactylopteridae					
Dactylopterus volitans (Linnaeus, 1758)	16	LC	LC	SA/MA	Figure 28 (a)
TETRAODONTIFORMES					
Balistidae					
Canthidermis sufflamen (Mitchill, 1815)	15	LC	LC	SA/RO/MA	
Melichthys niger (Bloch, 1786)	628	LC	LC	SA/RO/MA	Figure 19 (a)
Monacanthidae					
Aluterus scriptus (Osbeck, 1765)	5	LC	LC	RO/SA/MA	Figure 20 (a)
Cantherhines macrocerus (Hollard, 1853)	9	LC	LC	SA/RO/MA	Figure 20 (b)
Ostraciidae					
Lactophrys trigonus (Linnaeus, 1758)	61	LC	LC	SA/RO/MA	Figure 24 (a)

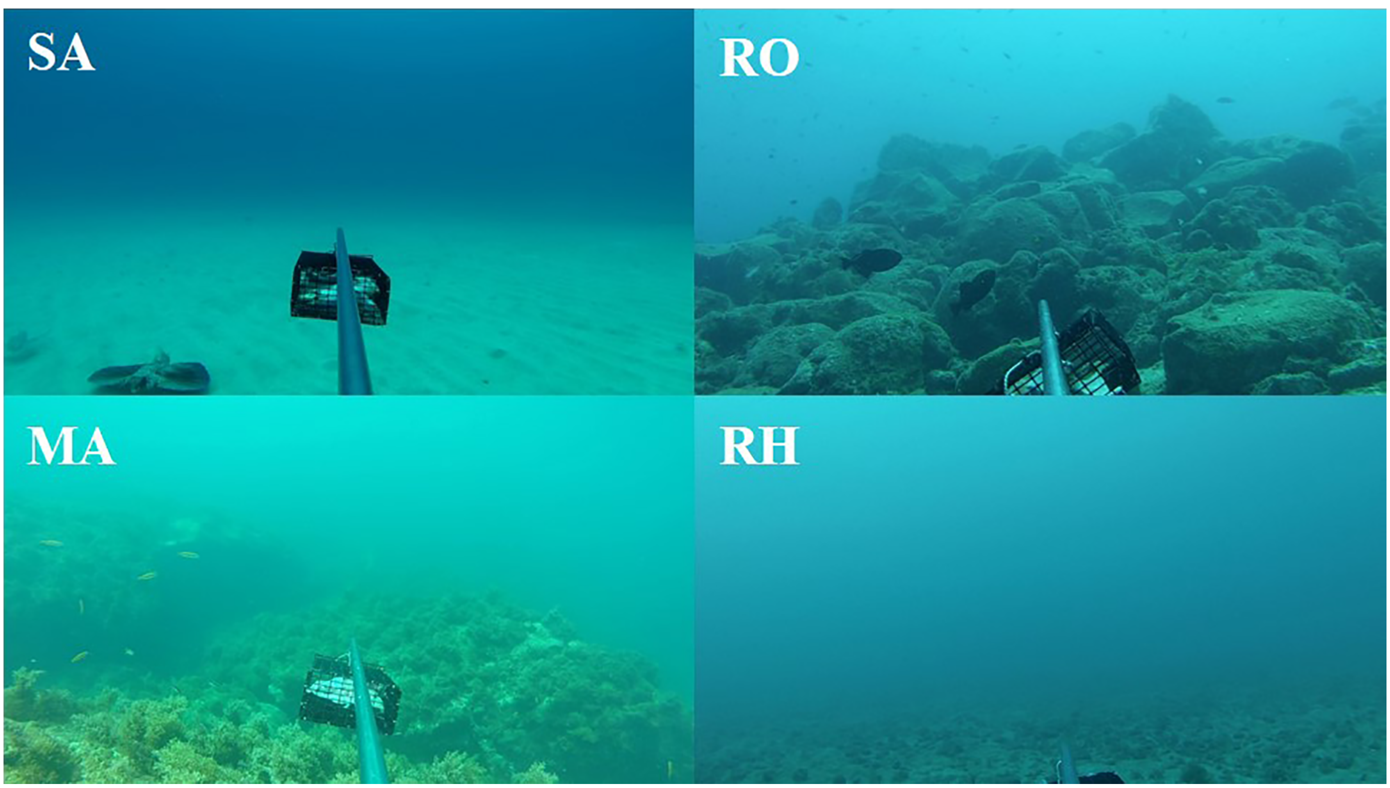

Figure 2. Benthic habitat types visually identified during video analysis from BRUVS (Baited Remote Underwater Video System) samples at the Fernando de Noronha Archipelago, Brazil. SA = Sandy bottom; RO = Rocky bottom / rocky reefs; MA = Rocky bottom with macroalgae and RH = Rhodolith

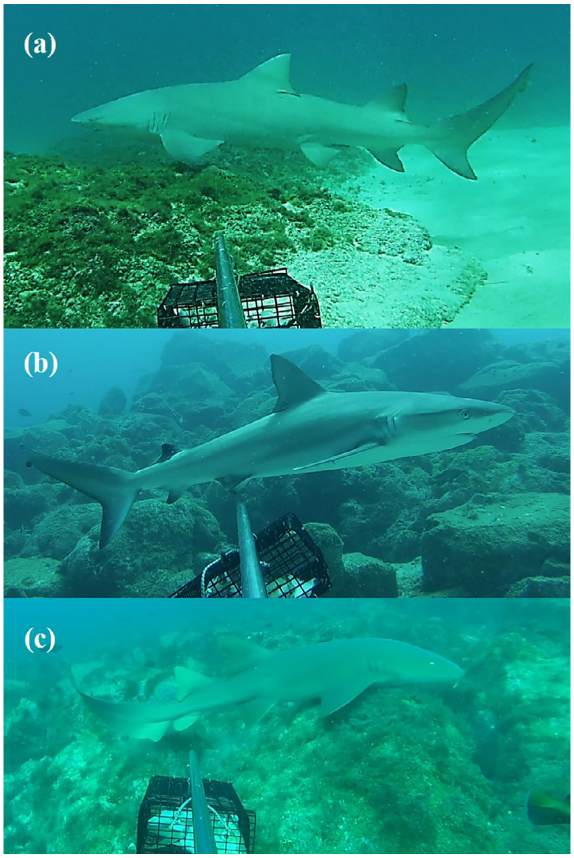

Figure 3. (a) *Negaprion brevirostris*; (b) *Carcharhinus perezii*; (c) *Ginglymostoma cirratum*

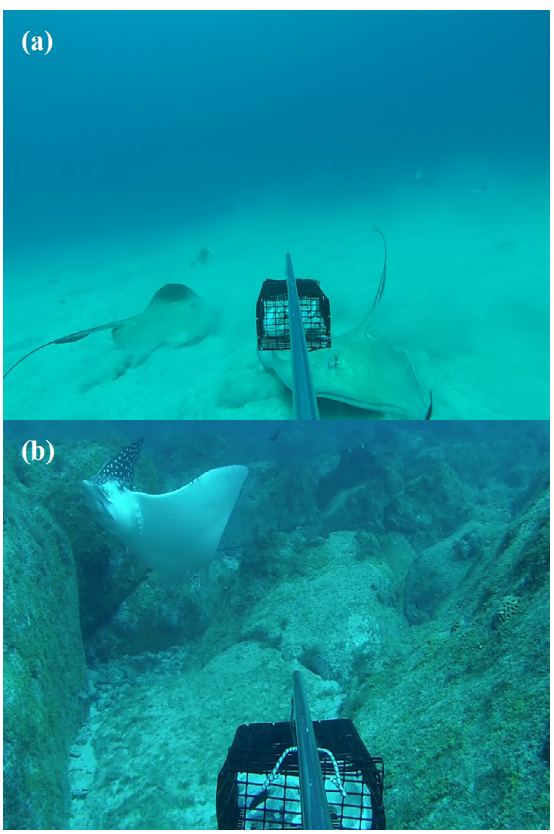

Figure 4. (a) *Hypanus americanus*; (b) *Aetobatus narinari*

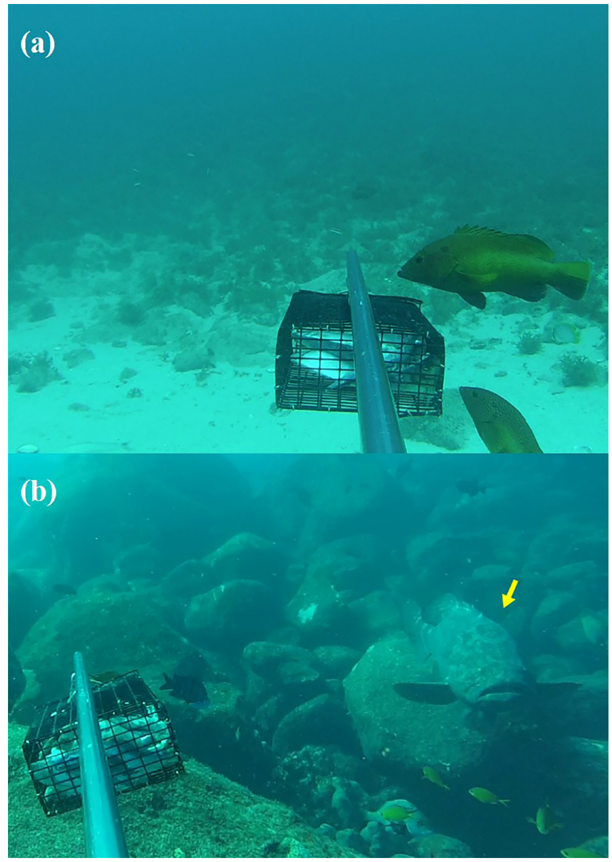

Figure 5. (a) *Cephalopholis fulva*; (b) *Epinephelus itajara*

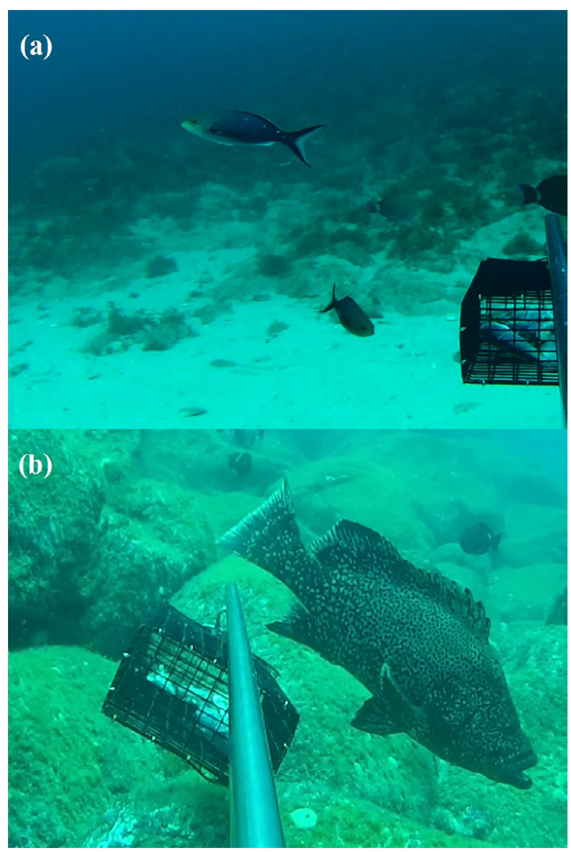

Figure 6. (a) *Paranthias furcifer*; (b) *Dermatolepis inermis*

Figure 7. (a) *Lutjanus jocu*

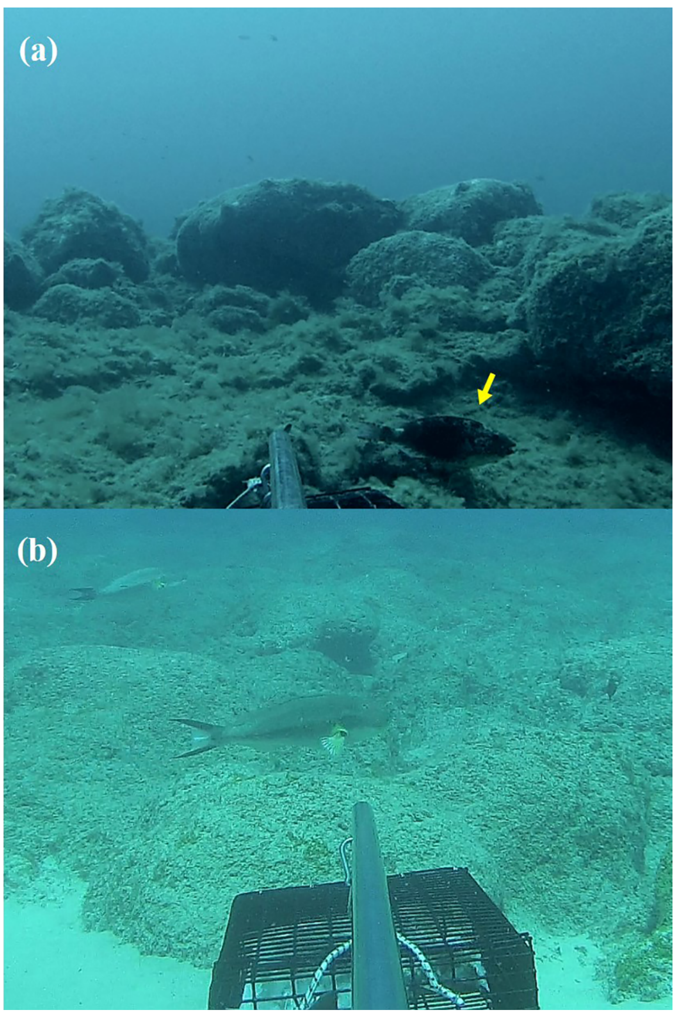

Figure 8. (a) *Sparisoma frondosum (intermediate phase)*; (b) *Sparisoma axillare (terminal phase)*

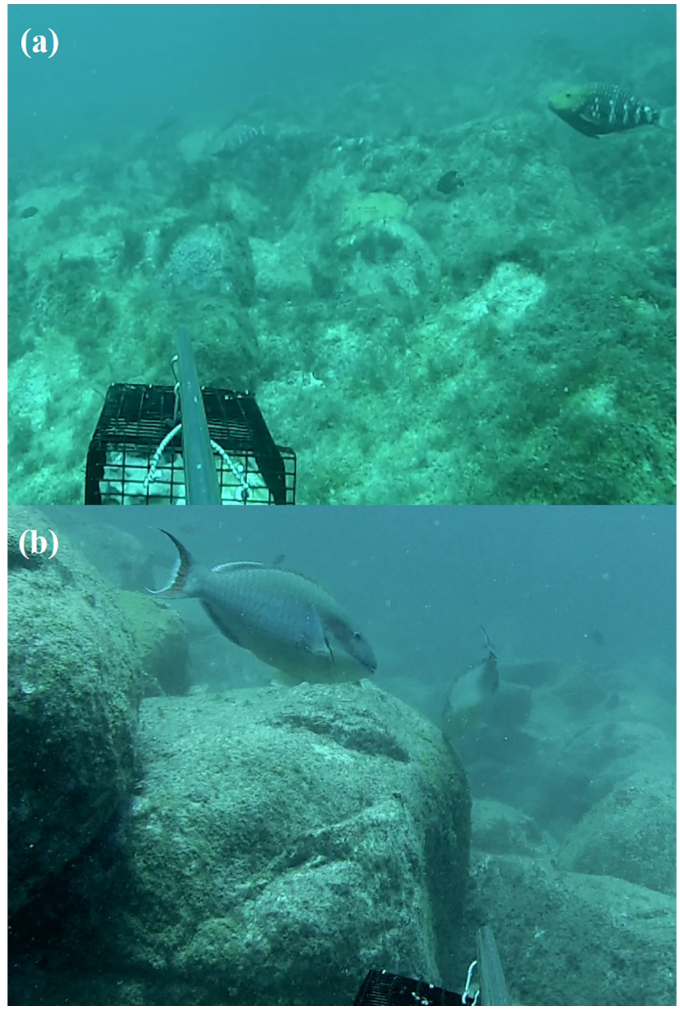

Figure 9. (a) *Sparisoma amplum (intermediate phase)*; (b) *Sparisoma amplum (terminal phase)*

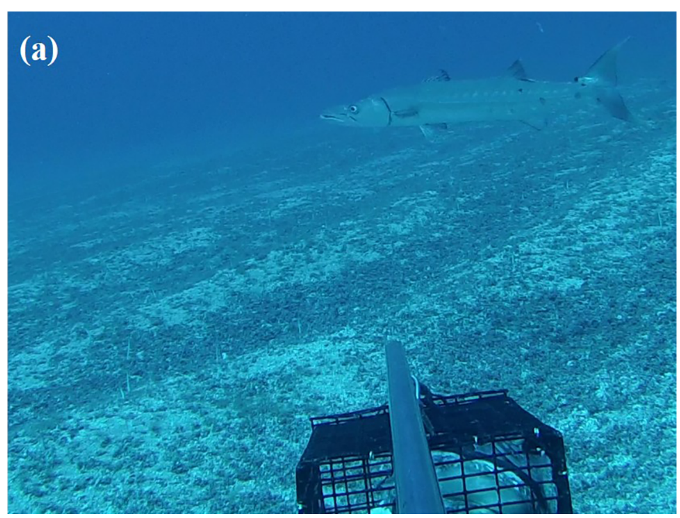

Figure 10. (a) *Sphyraena barracuda*

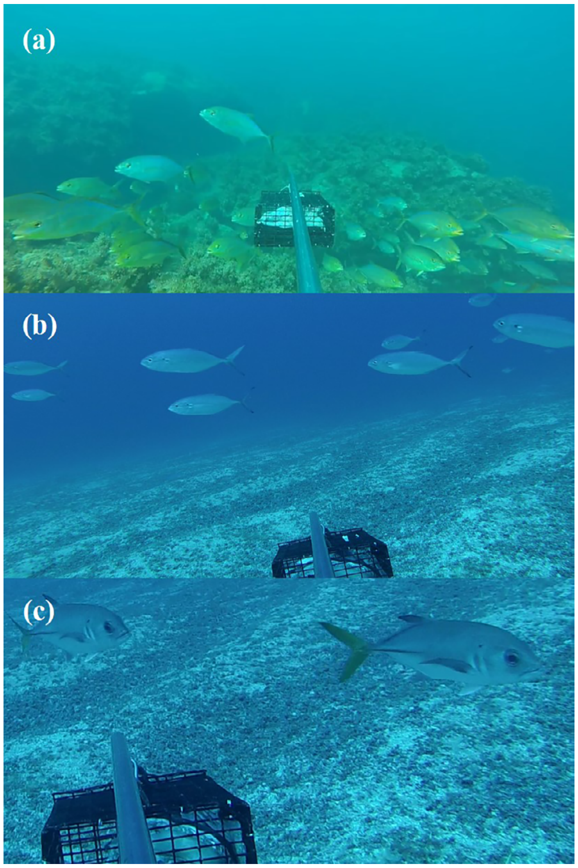

Figure 11. (a) *Caranx bartholomaei*; (b) *Caranx crysos*; (c) *Caranx latus*

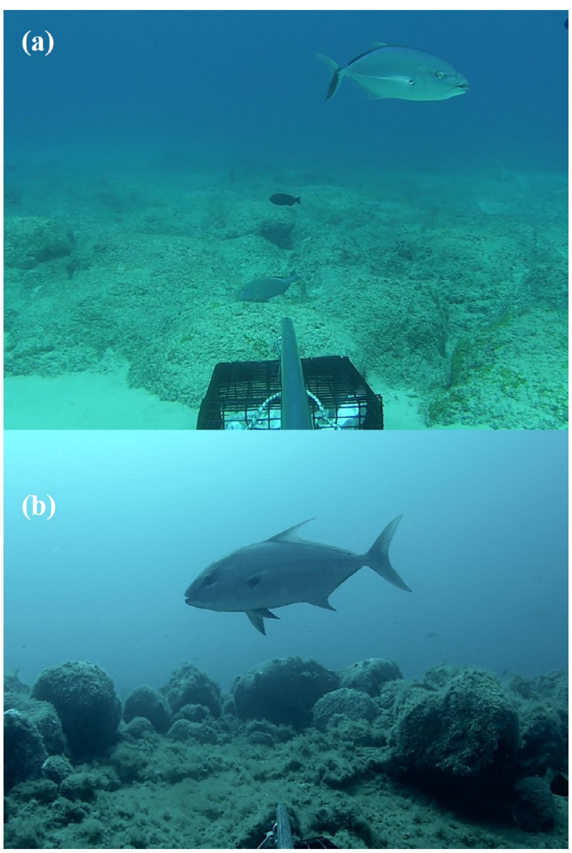

Figure 12. (a) *Caranx ruber*; (b) *Seriola rivoliana*

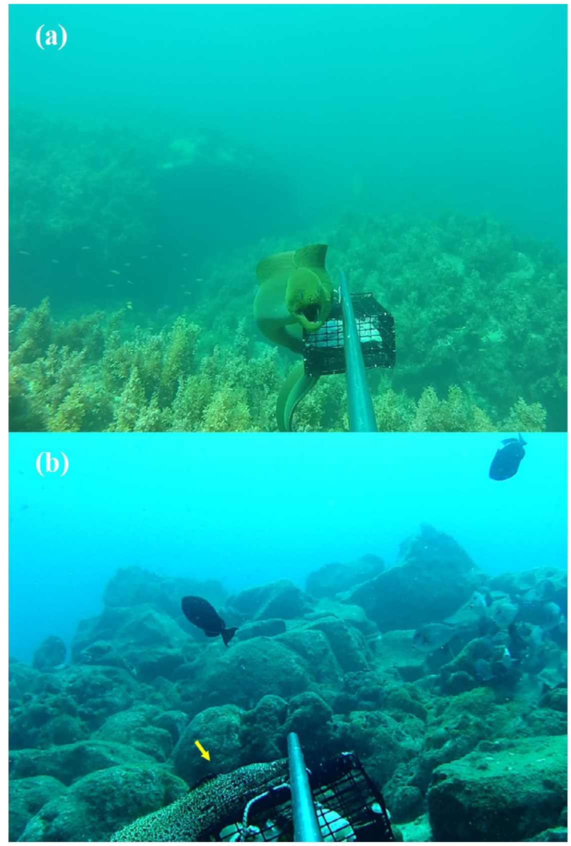

Figure 13. (a) *Gymnothorax funebris*; (b) *Gymnothorax moringa*

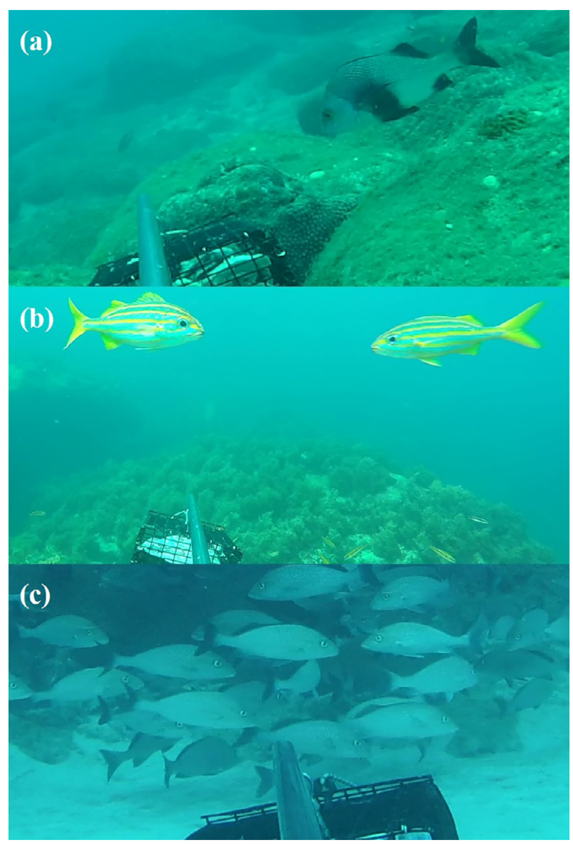

Figure 14. (a) *Anisotremus surinamensis*; (b) *Haemulon chrysargyreum* ; (c) *Haemulon parra*

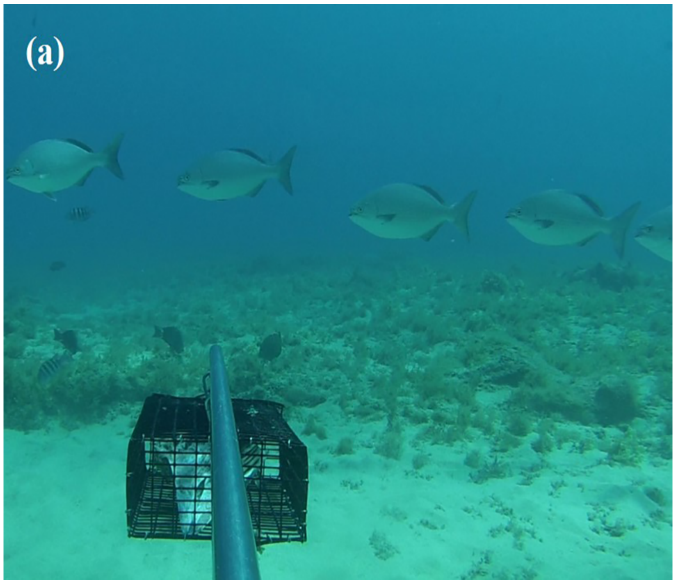

Figure 15. (a) *Kyphosus bigibbus*

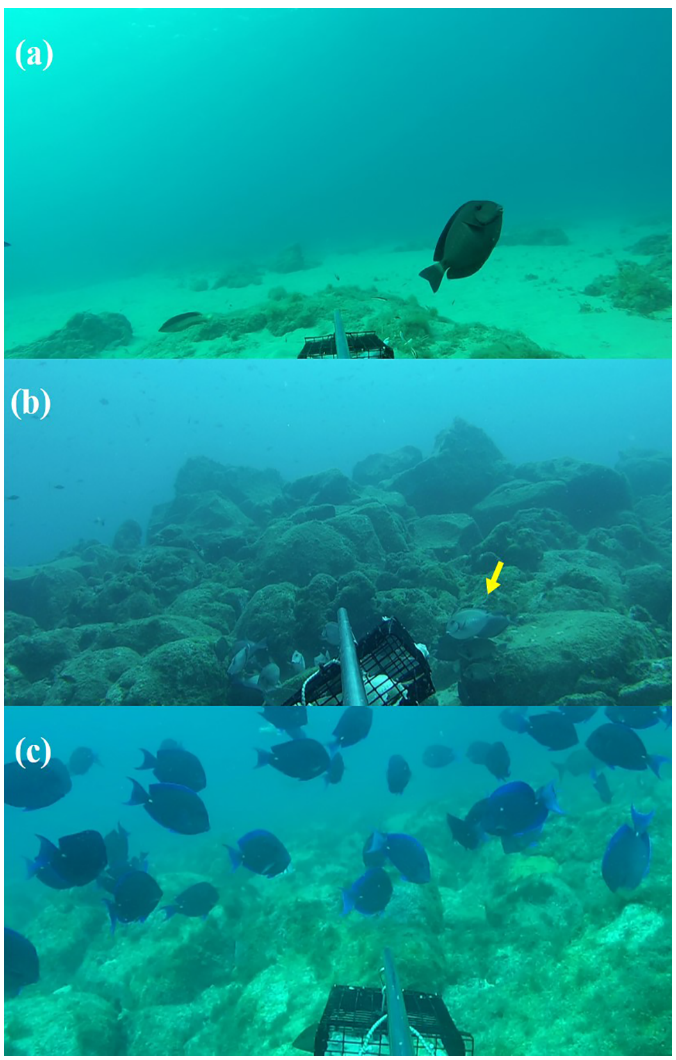

Figure 16. (a) *Acanthurus bahianus*; (b) *Acanthurus chirurgus*; (c) *Acanthurus coeruleus*

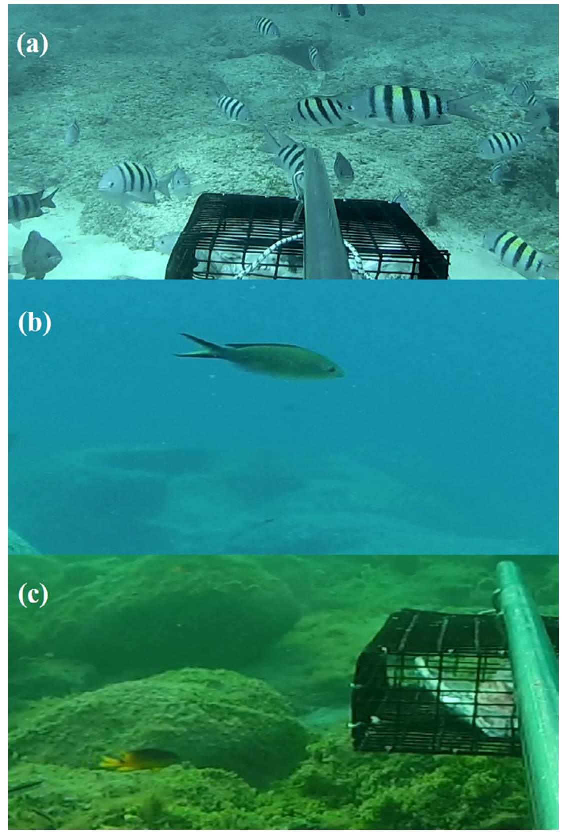

Figure 17. (a) *Abudefduf saxatilis*; (b) *Chromis multilineata*; (c) *Stegastes rocasensis*

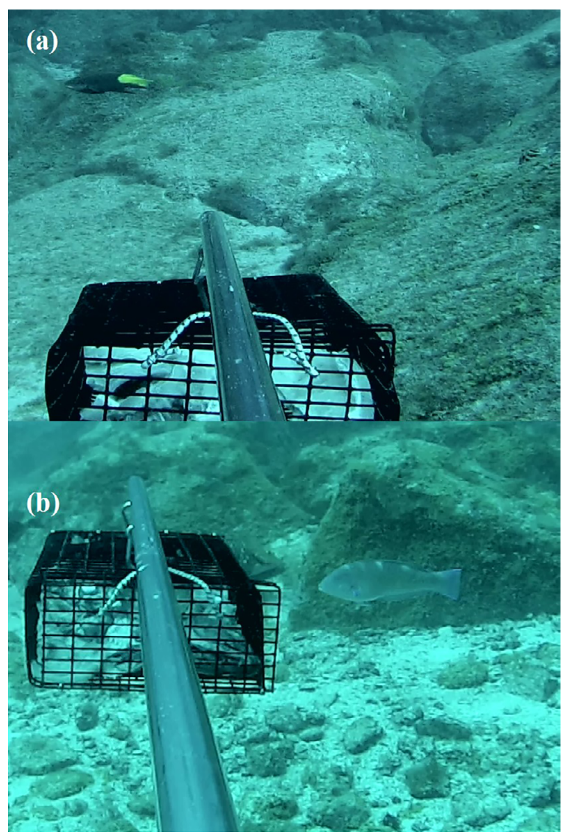

Figure 18. (a) *Bodianus pulchellus*; (b) *Halichoeres radiatus (terminal phase)*

Figure 19. (a) *Melichthys niger*

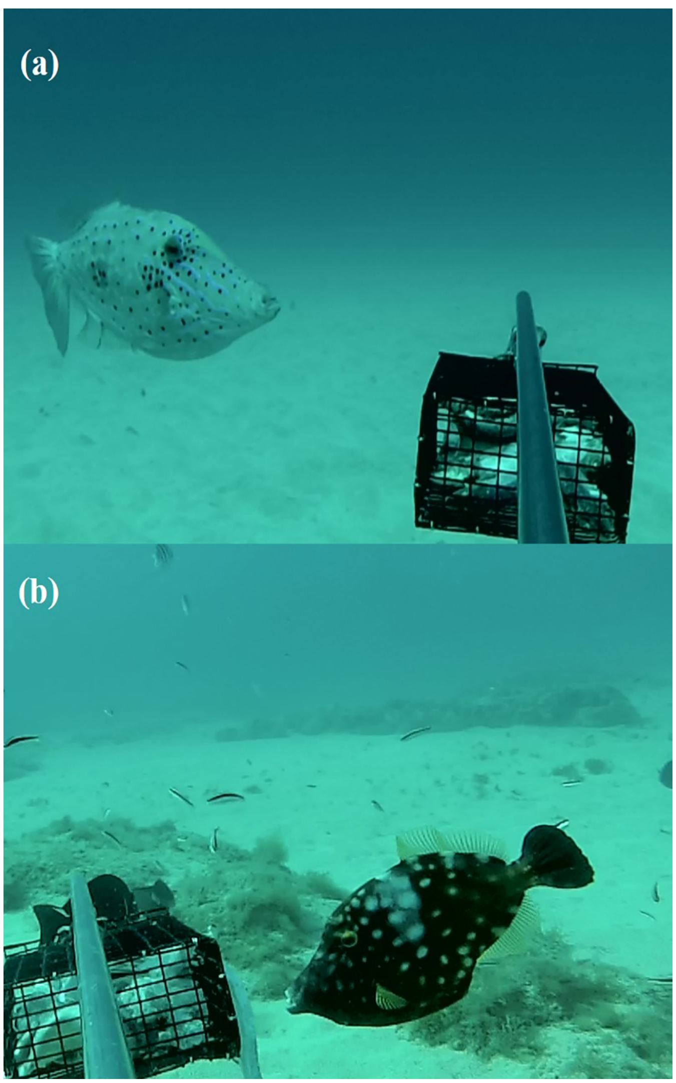

Figure 20. (a) *Aluterus scriptus*; (b) *Cantherhines macrocerus*

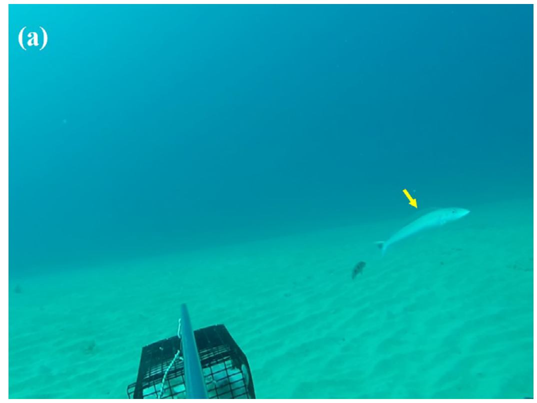

Figure 21. (a) *Malacanthus plumieri*

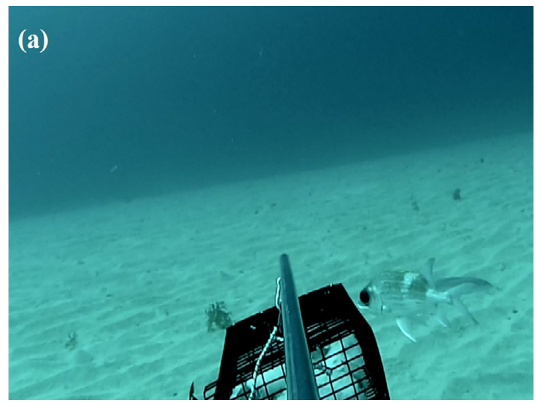

Figure 22. (a) *Holocentrus adscensionis*

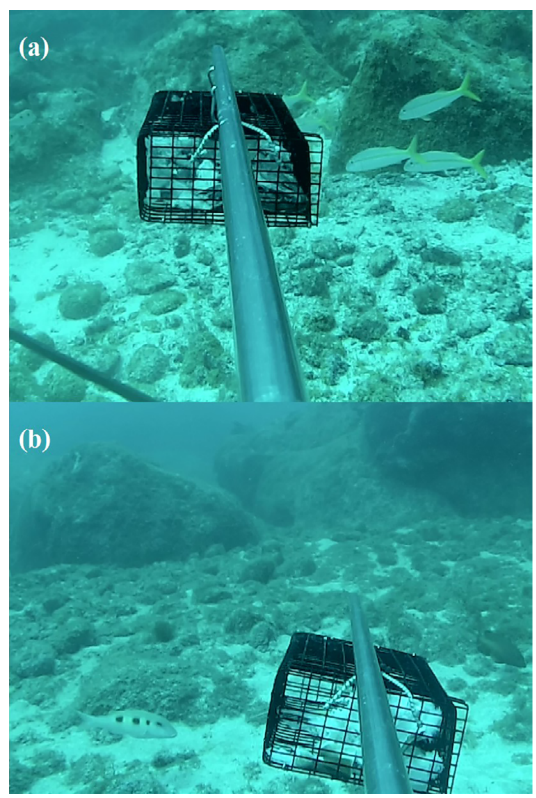

Figure 23. (a) *Mulloidichthys martinicus*; (b) *Pseudupeneus maculatus*

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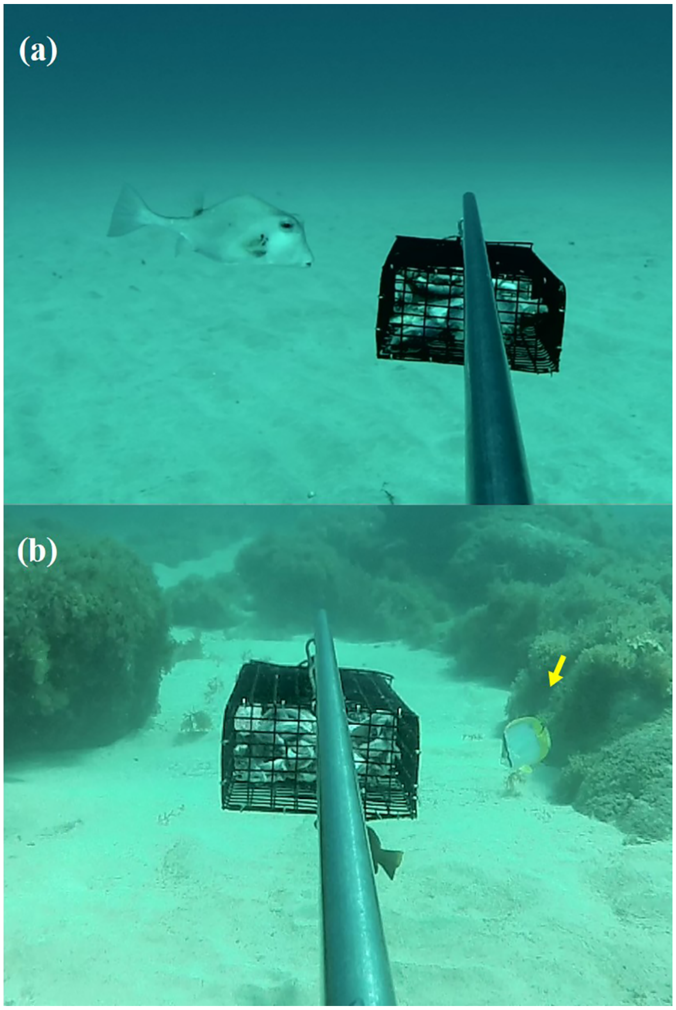

Figure 24. (a) *Lactophrys trigonus*; (b) *Chaetodon ocellatus*

Figure 25. (a) *Pomacanthus paru*

Figure 26. (a) *Bothus lunatus*

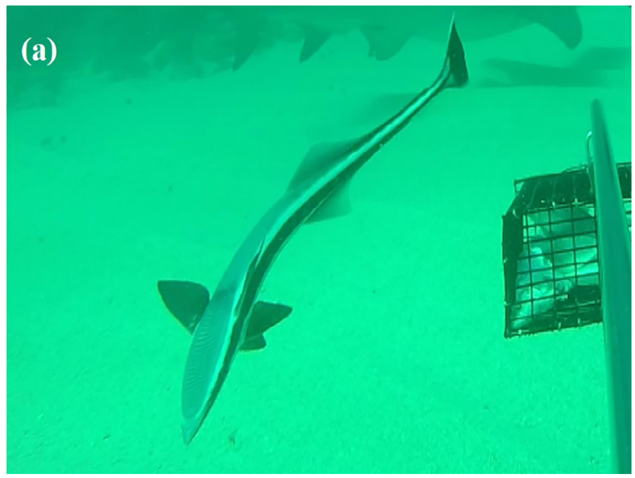

Figure 27. (a) *Echeneis naucrates*

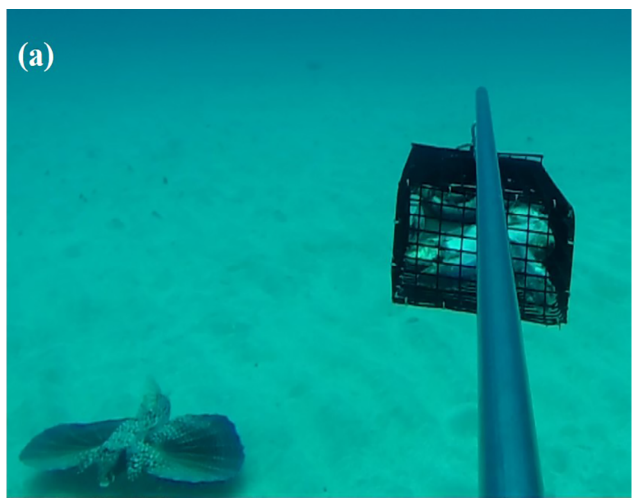

Figure 28. (a) *Dactylopterus volitans*

Results and Discussion

From the 81 BRUVS deployments, 4,398 individuals of 66 fish species, belonging to 28 families and 10 orders were identified. The overall mean relative abundance (mean MaxN ±SD) and species richness (mean S ±SD) sampled per BRUVS deployment were 54.3 ±46.2 and 13.9 ±8.8, respectively. In the rocky reefs, the mean relative abundance and species richness were 96.4 ±38.2 and 22.5 ±5.1, in rocky bottom with macroalgae 65.8 ±39.8 and 17.6 ±9.7, in rhodolith beds 32.5 ±40.3 and 7.5 ±6.4 and in sandy bottom habitats 25.3 ±25.9 and 8.0 ±5.3, respectively. BRUVS were deployed randomly, without prior identification of the habitat types at the sampling locations, which contributed to a highly unbalanced number of samples per habitat (SA: 44/ RO: 30 / MA: 5 / RH: 2), unsuitable for further statistical analysis and testing, yet still serving as an additional information, that may support future species-specific or habitat-related studies in the Archipelago.

Compared to former fish fauna inventories in this area (Soto, 2011; Krajewski & Floeter, 2011; Medeiros et al., 2011; Ilarri et al., 2017; Andrades et al., 2018), a considerably high number of species (66) was detected within the 81 BRUVS samples. Krajewski & Floeter (2011) detected 60 species in 91 belt transects with scuba, sampling both sides of FN and the same depth range as this study. Ilari et al. (2017) recorded 50 species from 27 families in a study employing an effort of 140 transects in waters up to 6 m depth. Soto (2001) recorded 167 species, including pelagic species in an inventory using visual census and fisheries surveys supplemented with literature records. Furthermore, seven species of six different families have been recorded with BRUVS in this study, which were not registered in the former, above mentioned, studies. Being them *Acanthurus bahianus* (Acanthuridae), *Bothus maculiferus* (Bothidae), *Caranx ruber* and *Trachinotus falcatus* (both Carangidae), *Hirundichthys speculiger* (Exocoetidae), *Clepticus brasiliensis* and *Halichoeres dimidiatus* (Labridae).

Based on these results, BRUVS have shown to be a valuable alternative sampling method, that may eventually complement or even partially substitute traditionally used methods, in FN and other tropical marine protected areas, depending on which portion of the fish assemblage is studied. In this study, notably large predatory fish such as sharks, groupers and snappers were registered in high abundances, e.g. C*archarinus perezii* and *Negaprion brevirostris*, each with 45 individuals, highlighting the efficiency of BRUVS to sample large-bodied, olfactory driven predatory fish. Studies developed with nonlethal methods are especially recommended for research on elasmobranchs, as this group includes some of the most vulnerable marine species (Musick et al., 2000).

The most representative families were Carangidae (407 individuals / 9 species), followed by Serranidae (385 individuals / 5 species), Labridae (272 individuals / 7 species) and Scaridae (120 individuals / 5 species). Twelve families were represented by a single species (Table 1). The most abundant species were *Melichthys niger* (TMaxN: 628), *Abudefduf saxatilis* (TMaxN: 613), *Chromis multilineata* (TMaxN: 263) and *Cephalopholis fulva* (TMaxN: 254). For 10 species only a single individual was recorded in all video samples (Table 1). Furthermore, five different species of elasmobranchs of three orders and four families were also recorded, being them: *Carcharinus perezii*, *Negaprion brevirostris*, *Ginglymostoma cirratum*, *Aetobatus narinari* and *Hypanus berthalutzae*. All elasmobranchs showed high total relative abundances (TMaxN) ranging from 39 to 45 individuals (Table 1), except for one single individual of *Aetobatus narinari* (Myliobatiformes). From the 66 fish species recorded, a total of 49 species images were suitable to produce an underwater image species catalog (Figures 3-27). The specific image number for each species is indicated in the main matrix (Table 1).

Several threatened fish species were recorded, including the Goliath grouper *Epinephelus itajara*, classified as "Vulnerable" by the IUCN and already "Critically Endangered" by the Brazilian environmental agency (ICMBio). Three shark species classified as "Vulnerable" by the ICMBio, the Caribbean reef shark *Carcharinus perezii*, Lemon shark *Negaprion brevirostris* and the Nurse shark *Ginglymostoma cirratum*, were registered in large numbers, with 45, 45 and 39 individuals, respectively. Overall, more than 17% of all species registered in the present study are threatened (CR, VU) or near threatened (NT) according to IUCN and/or ICMBio (Table 1). The relatively high numbers of large predatory fish, threatened along most of the Brazilian coast, are certainly a positive response to three decades of protection from fishing by the PARNAMAR.

Finally, we recommend future research, ideally with stereo-BRUVS that additionally enables fish length measurements, applied both in benthic and pelagic habitats of FN and surrounding areas. The information of species richness and relative abundance within FN provides a baseline for future monitoring efforts in order to evaluate the impact of long-term environmental changes. Yet, in order to achieve a much complete fish fauna inventory of FN, we still recommend employing a combination of BRUVS with other conventional sampling methods, to compensate for the BRUV's disadvantage in detecting, for instance, small cryptic living fish species.

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Conflict of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Ethics

No approval by the ethics committee of the authors research institution was required, as the present study does not involve any manipulation of any living being whatsoever. All fish fauna data (video footage) were exclusively acquired by independent underwater video systems (BRUVS).

Data availability

The raw data of this study are very large data volumes of high-resolution video footage and the summed data of the video analysis are already included in the submitted manuscript (Principal.doc)

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