ARTICLE IN PRESS

Ocean and Coastal Management xxx (xxxx) xxx

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: http://www.elsevier.com/locate/ocecoaman

Dynamics of artisanal fisheries performed with hook-and-line gear under different management regimes in Brazil

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ARTICLE INFO

Keywords:
Extractive reserve
Artificial reef
Production
Fishing effort
CPUE

ABSTRACT

Artisanal fisheries are a source of livelihood for small-scale fishermen around the world. The risk of overfishing is a constant concern. The establishment of conservation units is a strategy to alleviate the pressure on fishing stocks. In the State of Ceará, there are two conservation units in the category of extractive reserves (Resex)[1]. This study characterized the dynamics of the artisanal fishing of the hook-and-line fleet in three communities with different modes of use. Data were collected by monitoring the landings twice a month from 2017 to 2019 at Mucuripe beach, Batoque Resex and Prainha do Canto Verde[2] (PCV) Marine Resex, State of Ceará, Brazil. Data were collected for biomass (B), fishing effort (f), species composition, fishing ground and type of bottom habitat. A total of 234 vessels were sampled and 85 species were identified at the three sites, showing that the use of fisheries targets multiple species. The Kruskal-Wallis test was applied to analyze the production and fishing effort data. The largest landing was shown at Mucuripe (10.16 ton), which also had the highest mean production (224 kg). Mucuripe employed the highest mean effort (2711 hook*hour) and showed the highest number of species per boat, and Batoque the lowest (48 hook*h). Two-way ANOVA was used to test differences in richness and catch per unit effort[3] (CPUE) across sites and between seasons. There was no difference in CPUE across sites. The species richness was different across sites, with the highest average in Mucuripe (6.4 species per boat) and the lowest in PCV (3.6 species per boat). There was no variation in species richness between seasons. The correspondence analysis identified a strong association of the ballyhoo halfbeak, corocoro grunt, chere-chere grunt, Atlantic spadefish and Atlantic thread herring with the artificial hard bottom habitat, and a correlation of the guachanche barracuda and black grouper to the natural hard bottom. In both Resex, more specimens were caught in artificial structures and in Mucuripe in natural bottom habitats. The linear regression analysis indicated a significant relationship between effort (f) and biomass (B) in Batoque and PCV. There was no relationship between f and CPUE in both reserves. In this study, it was observed that the choice of fishing grounds and bottom habitat influenced the composition of species caught by the artisanal fleet. No difference in fishing production was found across the studied sites under different types of management.

1. Introduction

Artisanal fishing in Brazil is an important source of livelihood for local populations (Santos et al., 2012). The activity is generally autonomous and carried out by professional fishermen with their own fishing equipment. The fishermen use small boats, which according to Brazilian legislation are those with a gross tonnage of 20 or less (Brasil, 2009b). Various fishing gears are often used in the same region due the spatial distributions of different target species and type of bottom habitat (Punzon, 2016). Nevertheless, artisanal fishing provides jobs and supplies local markets with products of high nutritional value (Fonteles, 2011; Santos et al., 2012).

In the state of Ceará (Brazil), hook-and-line fishing is among the common fishing strategies and can be used for multiple pelagic or

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[1] Resex - Extractive reserve.
[2] PCV - Prainha do Canto Verde.
[3] CPUE - Catch per unit effort.

https://doi.org/10.1016/j.ocecoaman.2020.105403
Received 12 February 2020; Received in revised form 25 September 2020; Accepted 26 September 2020
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demersal target species (da Silva et al., 2007; Maia and Barreira, 2008; Gadig et al., 2017). Hook-and-line fishing is advantageous for the low costs and simplicity of the equipment, consisted of bait hooks of various sizes attached to nylon lines (Farias, 1988; De Freitas et al., 2017). However, "caçoeira" (gill net) fishing is more observed during the dry season. Winds are more intense during this season and can interfere with hook-and-line fishing. Hence, the ample use of two fishing strategies in the same region and climate conditions can influence the production of fishing and the richness of species caught by the hook-and-line gear.

Approximately 40 million people are estimated to depend on fishing as a means of subsistence and overfishing has been observed (FAO, 2018), justifying the need for proper management of fishing resources. Developed countries are improving their ways of managing fisheries, but developing countries are still not managing their fishing stocks efficiently (Ye and Gutierrez, 2017). Governments still have to work towards achieving target 14.4 of the Sustainable Development Goals (SDG) of 2030 Agenda. This target foresees that by this year (2020), overfishing and destructive and unregulated fishing practices should cease. In addition, UN expert bodies (Bindoff et al., 2019; FAO, 2018) suggest that fisheries resources may be affected by climate change, the degradation of ecosystems, and increased accumulation of microplastics in marine environments.

The creation of conservation units is a potential strategy to manage natural resources for anthropogenic use (Santos et al., 2012). In 2000, Brazil created a national law that establishes criteria and standards to create and manage conservation units through the National System of Conservation Units (Brasil, 2000). This law divides conservation units into two major groups, which are integral protection and sustainable use. Extractive Reserves (Resex) are conservation units for sustainable use by local extractivist communities to maintain their living standards and protect their mode of subsistence (Brasil, 2000). The state of Ceará has two extractive reserves, which are the Batoque Resex (Brasil, 2003) and Prainha do Canto Verde (PCV) Resex (Brasil, 2009a). The local populations near these reserves consist of fishermen. However, these reserves have different management agreements. The Prainha do Canto Verde Resex has a fisheries management agreement and the area protected by law covers both marine and land territory, whereas the Batoque Resex protected area pertains only to continental activities and has no fisheries management agreement.

Artisanal fishing is observed in many communities outside of the conservation units. However, it is unknown how the establishment of conservation units affects fisheries production when compared to unregulated areas. Furthermore, the influence of rainfall on artisanal fishing production is unknown Thus, the present study characterized the dynamics of the artisanal fishing of hook-and-line fleets in the three communities of: (1) a federal Resex with protected marine territory and a fisheries management agreement that regulates the fishing modalities and prohibits motorized vessels (PCV Resex) (ICMBIO - Instituto Chico Mendes de Conservação da Biodiversidade, 2012), (2) a federal Resex that has only a protected terrestrial area (Batoque Resex), and (3) a community that is outside of a conservation unit (Mucuripe beach).

2. Material and methods

2.1. Study area

The study sites sampled were Mucuripe Beach, Batoque Resex and Prainha do Canto Verde Resex, of which the latter two are federal extractive reserves. Mucuripe Beach is located at Mucuripe cove in the municipality of Fortaleza, State of Ceará, Brazil (Fig. 1). This site is considered as urbanized and has artisanal fishing activity. The Batoque Extractive Reserve is a federal Conservation Unit (CU) established by Decree on June 5, 2003, with the objective of protecting the local fishing population. It is located in the coastal region of the municipality of

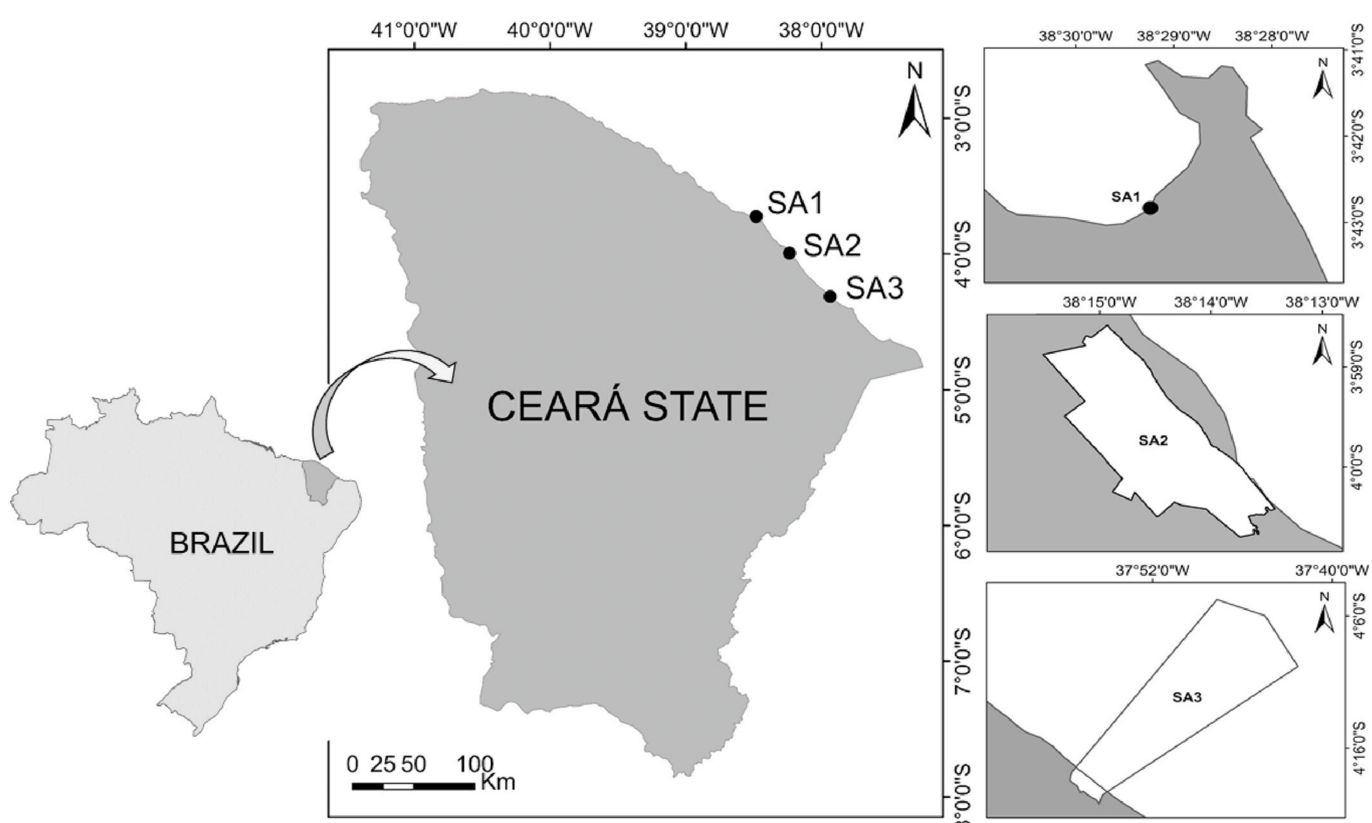

Fig. 1. Map of the study area showing Brazil, the State of Ceará and the three studied beaches. Legend: SA1: Mucuripe Beach, SA2: Batoque Extractive Reserve, SA3: Prainha do Canto Verde Marine Extractive Reserve.

Table 1
List of species sampled in order of evolution according to Nelson et al. (2016), common name and occurrence at Mucuripe beach, Batoque Resex and PCV Resex, State of Ceará, Brazil. Legend: M: Mucuripe, B: Batoque and P: Prainha do Canto Verde.

Family	Species	Local name	English common name	Ocurrence		
				M	B	P
Loliginidae	*Lolliguncula brevis* (Blainville, 1823)	Lula	Atlantic brief squid			x
Octopodidae	*Octopus insularis* Leite & Haimovici, 2008	Polvo	Brazil reef octopus		x	
Lamnidae	*Isurus oxyrinchus* Rafinesque, 1810	Tubarão cavala	Shortfin mako	x		
Carcharhinidae	*Carcharhinus falciformis* (Müller & Henle, 1839)	Tubarão lombo preto	Silky shark	x	x	x
Carcharhinidae	*Rhizoprionodon porosus* (Poey, 1861)	Cação	Caribbean sharpnose shark			x
Rhinobatidae	*Pseudobatos percellens* (Walbaum, 1792)	Arraia viola	Chola guitarfish		x	
Dasyatidae	*Hypanus americanus* (Hildebrand & Schroeder, 1928)	Arraia comum	Southern stingray	x	x	x
Dasyatidae	*Hypanus guttatus* (Bloch & Schneider, 1801)	Arraia bico de remo	Longnose stingray		x	x
Dasyatidae	*Hypanus* sp.	Arraia-pedra	–			x
Myliobatidae	*Aetobatus narinari* (Euphrasen, 1790)	Arraia pintada	Whitespotted eagle ray			x
Megalopidae	*Megalops atlanticus* Valenciennes, 1847	Camurupim	Tarpon	x	x	x
Albulidae	*Albula Vulpes* (Linnaeus, 1758)	Ubarana	Bonefish		x	x
Muraenidae	*Gymnothorax moringa* (Cuvier, 1829)	Moreia Pintada	Spotted moray	x	x	x
Muraenidae	*Gymnothorax vicinicus* (Castelnau, 1855)	Moreia	Purplemouth moray	x	x	x
Clupeidae	*Opisthonema oglinum* (Lesueur, 1818)	Sardinha	atlantic thread herring		x	x
Ariidae	*Bagre bagre* (Linnaeus, 1766)	Bagre fita	Coco sea catfish			x
Ariidae	*Bagre marinus* (Mitchill, 1815)	Bagre azul	Gafftopsail sea catfish		x	
Ariidae	*Genidens barbus* (Lacépède, 1803)	Bagre branco	White sea catfish		x	
Ariidae	*Genidens genidens* (Cuvier, 1829)	Bagre ariaçú	Guri sea catfish		x	
Ariidae	*Sciades herzbergii* (Bloch, 1794)	Bagre comum	Pemecou sea catfish			x
Holocentridae	*Holocentrus adscensionis* (Osbeck, 1765).	Mariquita	Squirrelfish	x	x	x
Holocentridae	*Myripristis jacobus* Cuvier, 1829	Olho de boi	Blackbar soldierfish	x	x	x
Balistidae	*Balistes capriscus* Gmelin, 1789	Cangulo comum	Grey triggerfish	x	x	x
Hemiramphidae	*Hemiramphus Brasiliensis* (Linnaeus, 1758)	Agulha	Ballyhoo halfbeak		x	x
Belonidae	*Ablennes hians* (Valenciennes, 1846)	Zambaia	Flat needlefish	x	x	x
Coryphaenidae	*Coryphaena hippurus* Linnaeus, 1758	Dourado	Common dolphinfish	x	x	x
Rachycentridae	*Rachycentron canadum* (Linnaeus, 1766)	Beijupirá	Cobia	x	x	x
Echeneidae	*Remora remora* (Linnaeus, 1758)	Rêmora	Shark sucker		x	x
Carangidae	*Carangoides bartholomaei* (Cuvier, 1833)	Guarajuba amarela	Yellow jack	x	x	x
Carangidae	*Caranx crysos* (Mitchill, 1815)	Guarajuba branca	Blue runner	x	x	x
Carangidae	*Caranx latus* Agassiz, 1831	Guarajuba Preta	Horse-eye jack	x	x	x
Carangidae	*Caranx lugubris* Poey, 1860	Xaréu	Black jack	x	x	x
Carangidae	*Chloroscombrus chrysurus* (Linnaeus, 1766)	Palombeta	Atlantic bumper		x	x
Carangidae	*Decapterus macarellus* (Cuvier, 1833)	Olhão cinza	Mackerel scad			x
Carangidae	*Selar crumenophthalmus* (Bloch, 1793).	Olhona	Bigeye scad			x
Carangidae	*Selene vomer* (Linnaeus, 1758)	Galo	Lookdown	x	x	x
Carangidae	*Seriola dumerili* (Risso, 1810)	Pitangola	Greater amberjack		x	
Carangidae	*Seriola lalandi* Valenciennes, 1833	Arabaiana ferreiro	Yellowtail amberjack	x		
Carangidae	*Seriola rivoliana* Valenciennes, 1833	Arabaiana	Longfin yellowtail	x	x	x
Carangidae	*Trachinotus falcatus* (Linnaeus, 1758)	Pampo	Permit		x	
Sphyraenidae	*Sphyraena guachancho* Cuvier, 1829	Bicuda	Guachanche barracuda			x
Sphyraenidae	*Sphyraena picudilla* Poey, 1860	Garapau	Southern sennet		x	x
Bothidae	*Bothus ocellatus* (Agassiz, 1831)	Solha	Eyed flounder		x	x
Scombridae	*Acanthocybium solandri* (Cuvier, 1832)	Cavala empinge	Wahoo			x
Scombridae	*Euthynnus alletteratus* (Rafinesque, 1810)	Bonito	Little tunny	x		x
Scombridae	*Katsuwonus pelamis* (Linnaeus, 1758)	Bonito listrado	Skipjack tuna	x		
Scombridae	*Scomberomorus brasiliensis* Collette, Russo &Zavala-Camin (1978)	Serra	Serra Spanish mackerel	x	x	x
Scombridae	*Scomberomorus cavalla* (Cuvier, 1829)	Cavala	King mackerel	x	x	x
Scombridae	*Thunnus obesus* (Lowe, 1839)	Albacora	Bigeye tuna	x		
Stromateidae	*Peprilus paru* (Linnaeus, 1758)	Mocinha	American harvestfish		x	
Scaridae	*Scarus trispinosus* Valenciennes, 1840	Bodião azul	Greenback parrotfish	x		
Scaridae	*Sparisoma frondosum* (Agassiz, 1831)	Batata vermelho	Agassiz's Parrotfish	x	x	
Scaridae	*Sparisoma rubripinne* (Valenciennes, 1840)	Batata azul	Redfin parrotfish	x		
Gerreidae	*Eucinostomus spp.*	Carapicu	–			x
Serranidae	*Cephalopholis fulva* (Linnaeus, 1758).	Piraúna	Coney	x	x	x
Serranidae	*Epinephelus adscensionis* (Osbeck, 1765)	Garoupa Gato	Rock hind	x		
Serranidae	*Epinephelus marginatus* (Lowe, 1834)	Garoupa	Dusky grouper	x		x
Serranidae	*Mycteroperca bonaci* (Poey, 1860)	Sirigado	Black grouper	x	x	
Serranidae	*Rypticus saponaceus* (Bloch & Schneider, 1801)	Sabão do mar	Greater soapfish		x	
Priacanthidae	*Priacanthus arenatus* Cuvier, 1829	Olhão	Atlantic bigeye			x
Pomacanthidae	*Holacanthus ciliaris* (Linnaeus, 1758)	Paru jandaia	Queen angelfish		x	
Pomacanthidae	*Pomacanthus paru* (Bloch, 1787)	Paru preto	French angelfish		x	x
Malacanthidae	*Malacanthus plumieri* (Bloch, 1786)	Pirá	Sand tilefish	x	x	x
Haemulidae	*Anisotremus virginicus* (Linnaeus, 1758)	Frade	Porkfish	x	x	x
Haemulidae	*Genyatremus luteus* (Bloch, 1790)	Golosa	Torroto grunt		x	
Haemulidae	*Haemulon aurolineatum* Cuvier, 1830	Xira	Tomtate grunt		x	
Haemulidae	*Haemulon melanurum* (Linnaeus, 1758).	Sapuruna	Cottonwick grunt	x		x
Haemulidae	*Haemulon parra* (Desmarest, 1823)	Cambuba	Sailor's grunt	x	x	x
Haemulidae	*Haemulon plumieri* (Lacepède, 1801)	Biquara	White grunt	x	x	x
Haemulidae	*Haemulon steindachneri* (Jordan and Gilberta, 1882)	Macasso	Chere-chere grunt		x	x
Haemulidae	*Orthopristis ruber* (Cuvier, 1830)	Cabeça dura	corocoro grunt		x	
Lutjanidae	*Lutjanus analis* (Cuvier, 1828)	Cioba	Mutton snapper	x	x	x

(*continued on next page*)

Table 1 (*continued*)

Family	Species	Local name	English common name	Ocurrence		
				M	B	P
Lutjanidae	*Lutjanus jocu* (Bloch & Schneider, 1801).	Dentão	Dog snapper	x	x	x
Lutjanidae	*Lutjanus purpureus* (Poey, 1866)	Pargo	Southern red snapper	x	x	
Lutjanidae	*Lutjanus synagris* (Linnaeus, 1758)	Ariacó	Lane snapper	x	x	x
Lutjanidae	*Ocyurus chrysurus* (Bloch, 1791)	Guaiuba	Yellowtail snapper	x	x	x
Ephippidae	*Chaetodipterus faber* (Broussonet, 1782)	Paru branco	Atlantic spadefish		x	x
Sciaenidae	*Cynoscion leiarchus* (Cuvier, 1830)	Pescada branca	Smooth weakfish			x
Acanthuridae	*Acanthurus chirurgus* (Bloch, 1787)	Cirurgião	Doctorfish	x	x	x
Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	Chancarona	Tripletail	x		
Sparidae	*Archosargus probatocephalus* (Walbaum, 1792)	Sargo	Sheepshead		x	
Sparidae	*Archosargus rhomboidalis* (Linnaeus, 1758)	Salema	Western Atlantic seabream		x	
Sparidae	*Calamus penna* (Valenciennes, 1830)	Pena	Sheepshead porgy	x	x	x
Sparidae	*Calamus pennatula* Guichenot, 1868	Pena bode	Pluma porgy		x	
Ostraciidae	*Lactophrys trigonus* (Linnaeus, 1758)	Baiacu caixão	Buffalo trunkfish		x	x
Batrachoididae	*Batrachoides surinamensis* (Bloch & Schneider, 1801)	Pacamon	Pacuma toadfish		x	
Monacanthidae	*Aluterus monoceros* (Linnaeus, 1758)	Cangulo velho	Unicorn leatherjacket filefish	x	x	x
Tetraodontidae	*Sphoeroides spp.*	Baiacu	–		x	

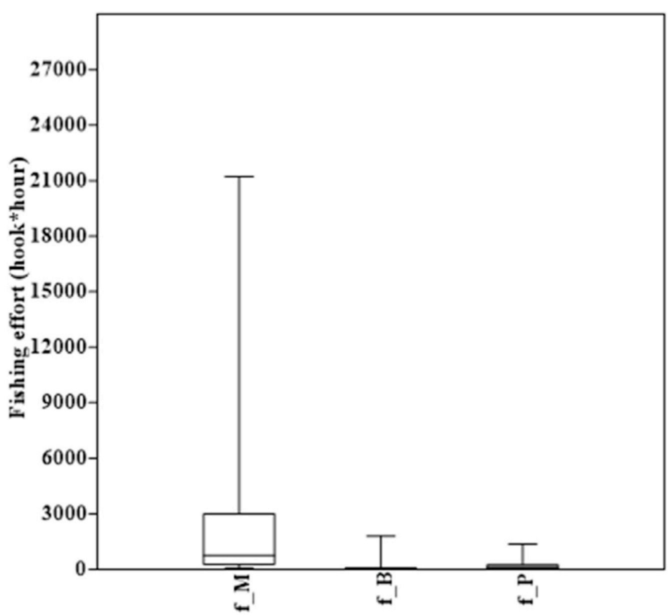

Fig. 2. Variation in fishing effort set on hook*hour in Mucuripe (M), Batoque (B) and Prainha do Canto Verde (P) beaches from 2017 to 2019.

Aquiraz, which is approximately 51 km southeast from Fortaleza and covers an area of approximately 601 ha in land territory (Fig. 1). The Prainha do Canto Verde Marine Extractive Reserve is a federal conservation unit that was established by Decree on June 5, 2009, and is located approximately 110 km southeast from Fortaleza in the municipality of Beberibe. It covers an area of approximately 29,794 ha of sea and land (Fig. 1). The objectives of this reserve focus on artisanal fishing activity as practiced by the community members, and fishing activity is regulated through Fisheries Management Agreements (ICMBIO - Instituto Chico Mendes de Conservação da Biodiversidade, 2012).

2.2. Data collection

Authorization for data collection in the two federal Conservation Units was obtained from the Chico Mendes Institute for Biodiversity Conservation Authorization and Information System (SISBIO-ICMBIO): licenses number 61552–1 and number 52552–2. The methods of data collection from local fishing populations was approved by the Ethics Committee at the Federal University of Ceará (Protocol of approval No. 3.913.236). Data were sampled biweekly from May 2017 to April 2018 at Mucuripe beach, from July 2018 to June 2019 at Batoque Resex, and from April 2017 to April 2018 at Prainha do Canto Verde Resex. The sampling period covered the dry and rainy seasons. In the State of Ceará, the rainy season is from December to June and the dry season from July to November (FUNCEME- Fundação Cearense de Meteorologia e Recursos Hídricos, 2009).

Fish landings were monitored through inquiries with the fishermen regarding various aspects of their activities (e.g. number of fishing gear used, number of fishermen, fishing hours, fishing grounds, type of bottom habitat at the at the fishing grounds). Specimens were counted and weighed (0.01 g). Individual specimens were identified at the species level when possible, based on previous research and with the aid of identification keys (e.g. Menezes and Figueiredo, 1978; Figueiredo and Menezes, 1980; Menezes and Figueiredo, 1980; Menezes and Figueiredo, 1985; Figueiredo and Menezes, 2000; Haimovici et al., 2009; Last et al., 2016).

Table 2
Main parameters of the artisanal fishing at the Mucuripe beach, Batoque Resex and PCV Resex, State of Ceará, Brazil, from 2017 to 2019 (mean ± standard error). Legend: M: Mucuripe, B: Batoque and P: Prainha do Canto Verde, H_A_B: Hard Artificial Bottom, H_N_B: Hard Natural Bottom.

Study sites	M	B	P
Number of vessels	2.09 ± 0.28	3.45 ± 0.38	2.42 ± 0.33
Number of motorized vessels	0.62 ± 0.14	0	0
Number of sailing boats	1.48 ± 0.23	3.45 ± 0.38	2.42 ± 0.33
Number of fisheries in H_A_B	0	3.45 ± 0.38	2.24 ± 0.33
Number of fisheries in H_N_B	2 ± 0.28	0	0.14 ± 0.07
Number of gravel fisheries	0.05 ± 0.05	0	0.04 ± 0.03
Number of sand fisheries	0.05 ± 0.05	0	0
Maximum distance from the coast (km)	46788.51 ± 2964.07	13469.23 ± 1296.99	2530.48 ± 2047.81
Biomass (ton)	483.89 ± 178.69	47.27 ± 7.39	58.43 ± 10.05
Production	223.76 ± 69.74	13.21 ± 1.53	33.75 ± 5.56
Fishing effort	2711.05 ± 759.19	105.29 ± 31.19	190.77 ± 15.17
Number of species	12.33 ± 1.21	13.25 ± 1.41	7.26 ± 0.86

2.3. Data analysis

The fishing effort and the CPUE were estimated for each vessel at the three study sites. The fishing effort (f) is the number of hooks used during the effective fishing time (f = hook*hours). The catch per unit effort (CPUE) is an index of the relative abundance of the stock and is measured as the weight of the catch (kg) per unit of fishing effort (kg/

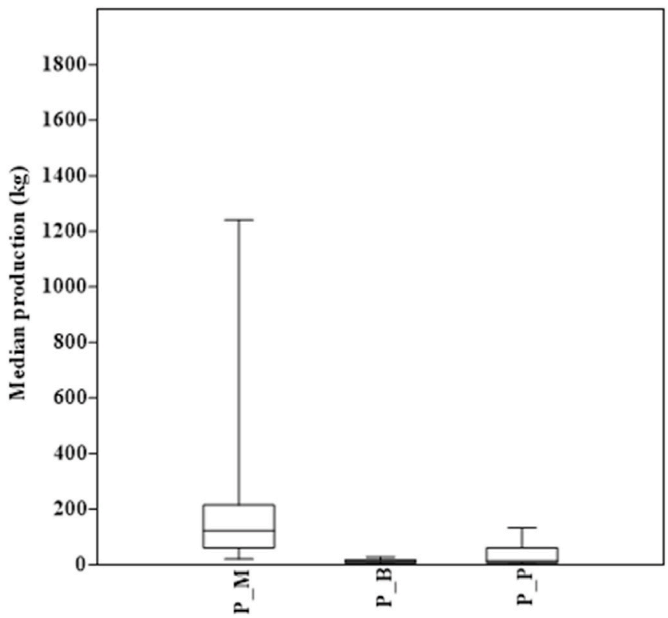

Fig. 3. Variation in production in kg in Mucuripe (M), Batoque (B) and Prainha do Canto Verde (P) beaches from 2017 to 2019.

hook*hours). The average production was the biomass (kg) of the total catch per number of vessels and was calculated monthly for each study site. The average number of species (species richness) at each site was estimated from the number of species recorded per number of vessels monitored for each month.

All data were tested for normality and homoscedasticity using the Shapiro-Wilk and Levene tests, respectively (Shapiro and Wilk, 1965). Data of the fishing effort and production did not present normal distribution even after logarithmic, square-root and fourth-root data transformations. Therefore, these data were tested by non-parametric Kruskal-Wallis test and statistical significance was tested by the Mann-Whitney test for pairwise comparison.

Species richness and CPUE of each site met the assumptions of normality after natural logarithmic transformation. These data were compared by site and seasonality using two-way ANOVA with repetitions. In the State of Ceará, the rainy season is from December to June and the dry season from July to November (FUNCEME- Fundação Cearense de Meteorologia e Recursos Hídricos, 2009).

The correspondence analysis (Fisher, 1940) was used to seek to correlate the occurrence and high abundance of a particular species in only one of the sampled sites according to the type of bottom. The species chosen for this analysis were those that had expressive abundances on landings in only one or two sampled sites. The bottom was classified as sand, gravel, natural hard bottom habitat (e.g. rock, reef and gully) and artificial hard bottom (e.g. "garajaus", a type of wooden structure, wreck, tires and stumps). A descriptive analysis of the bottom was also performed for the fishing activities at each site. The species selected for the correspondence analysis were ballyhoo halfbeak (*Hemiramphus brasiliensis*), guachanche barracuda (*Sphyraena guachancho*), corocoro grunt (*Orthopristis ruber*), chere-chere grunt (*Haemulon steindachneri*), Atlantic spadefish (*Chaetodipterus faber*), cottonwick grunt (*Haemulon melanurum*), Atlantic thread herring (*Opisthonema oglinum*) and black grouper (*Mycteroperca bonaci*).

Linear regression analyses were performed to determine the relationship between fishing effort (x) and biomass (y), and fishing effort (x) and CPUE (y). The model obtained was represented by a linear regression, with 95% confidence intervals. The series span a one-year period at the Batoque (July 2018–June 2019), Canto Verde (April 2017–April 2018), and Mucuripe (May 2017–April 2018) study sites. These multispecies analyses exclude fishing trips that showed no catch. Analyses and graphs were obtained in Microsoft Excel (2016) and the statistical software PAST® (Hammer et al., 2001). All analyses were performed with a significance level of 5%.

3. Results

A total of 234 vessels were sampled among the three study sites, of which the fishing was carried out only with hook-and-line gear. There were 85 species that were identified, belonging to 41 families and 67 genera. Some species with high abundance, such as ballyhoo halfbeak (*Hemiramphus Brasiliensis*), chere-chere grunt (*Haemulon steindachneri*), Atlantic spadefish (*Chaetodipterus faber*) and Atlantic thread herring (*Opisthonema oglinum*) occurred only at the Batoque and Prainha do Canto Verde Resex sites (Table 1). The most abundant species at the Mucuripe site were the coney (*Cephalopholis fulva*), white grunt (*Haemulon plumieri*), yellowtail snapper (*Ocyurus chrysurus*) and squirrelfish (*Holocentrus adscensionis*); lane snapper (*Lutjanus synagris*), chere-chere grunt, corocoro grunt (*Orthopristis ruber*) and Atlantic thread herring at the Batoque site; and white grunt, yellowtail snapper, guachanche barracuda (*Sphyraena guachancho*) and ballyhoo halfbeak at the Prainha do Canto Verde Resex site.

Significant difference was shown across the three sites (Kruskal-Wallis for the fishing effort, with the highest mean effort per trip at Mucuripe (2711.05 ± 759.19), followed by the PCV Resex (190.77 ±

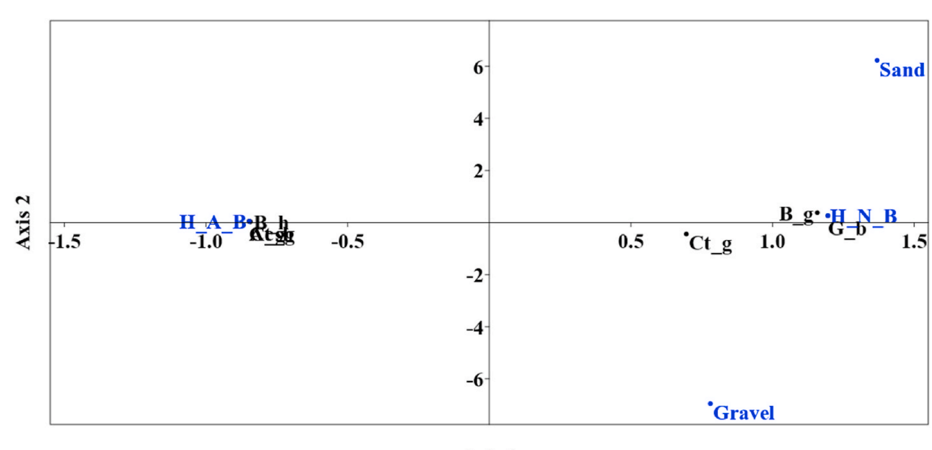

Fig. 4. Association of some fish species with different types of bottom habitats at the beaches of Mucuripe, Batoque and Prainha do Canto Verde from 2017 to 2019. Legend: H_A_B: Hard Artificial Bottom; H_N_B: Hard Natural Bottom; B_h: Ballyhoo halfbeak; G_b: Guachanche barracuda; C_g: Corocoro grunt; Cc_g: Chere-chere grunt; A_s: Atlantic spadefish; Ct_g: Cottonwick grunt; At_h: Atlantic thread herring; B_g: Black grouper.

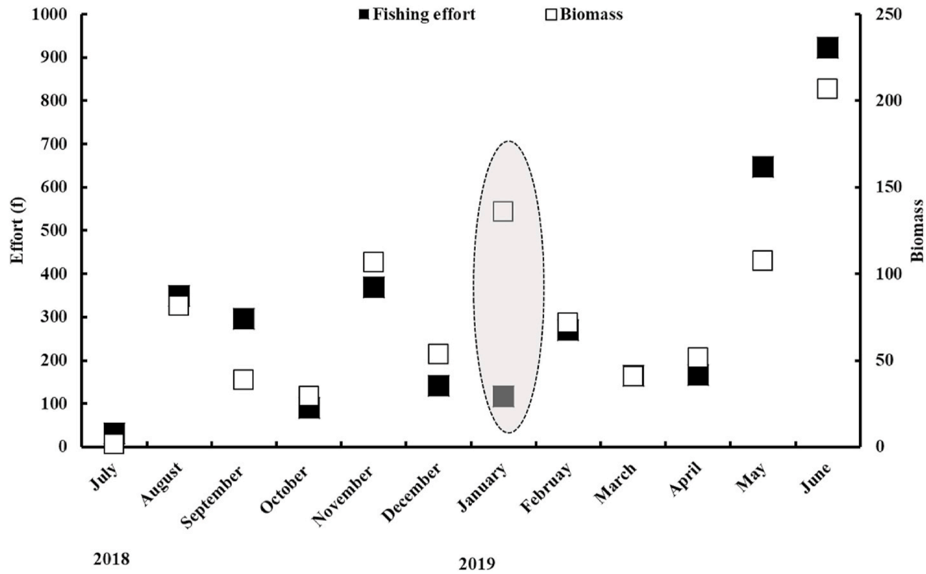

Fig. 5. Monthly variation in hook*hour fishing effort and biomass in kg at Batoque beach, from 2018 to 2019. The shaded spots represent an outlier.

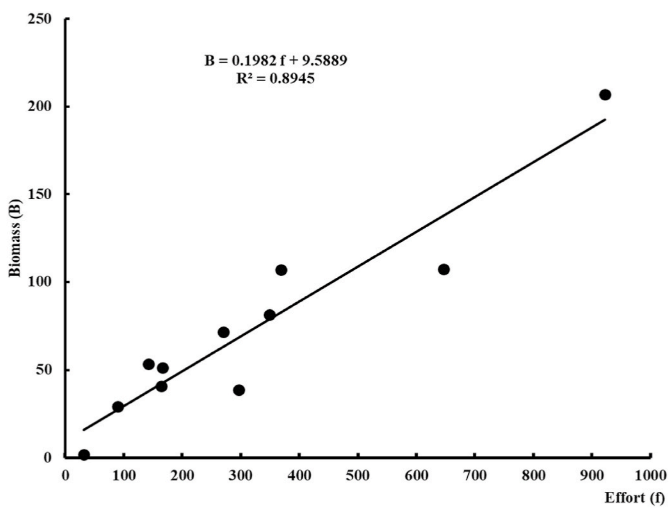

Fig. 6. Relationship between fishing effort (f) and biomass (B) in kg at Batoque beach, from 2018 to 2019.

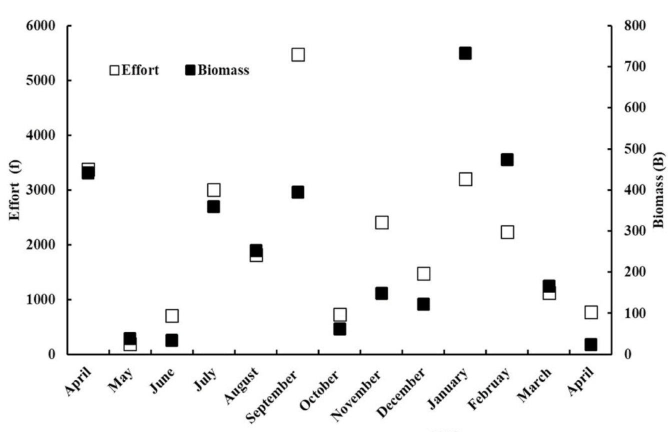

Fig. 7. Variation in fishing effort in hook*hour and biomass in kg in Prainha do Canto Verde, from 2017 to 2018.

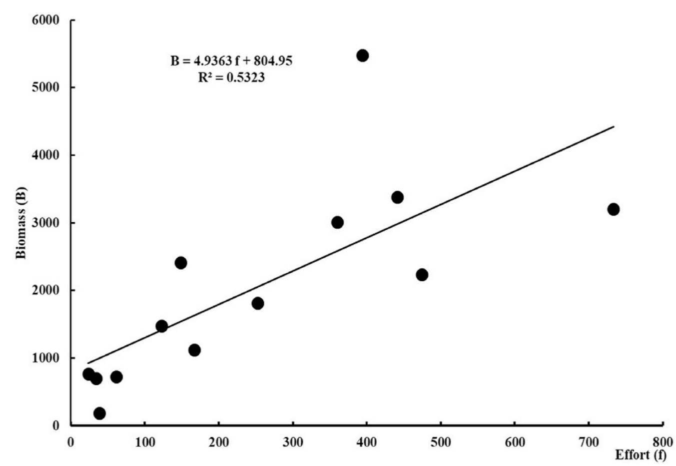

Fig. 8. Relationship between fishing effort (f) and biomass (B) in kg at Canto Verde beach, from 2018 to 2019.

15.17) and Batoque Resex sites (105.29 ± 31.19). The fishing effort at the Mucuripe site was significantly higher than those of the Batoque ($p < .001$) and PCV ($p < .001$), and the effort at the PCV Resex site was significantly higher than that of the Batoque ($p < .001$) (Fig. 2). Mucuripe was the only study site with that permitted motorized vessels (Table 2).

No significant difference in CPUE values was shown across sites (two-way ANOVA, $F = 2.28$, $p = .142$) and between seasons (two-way ANOVA, $F = 1.78$, $p = .186$). Furthermore, no interaction was detected between the sampling sites and the seasons for the CPUE (two-way ANOVA, $F = 0.15$, $p = .854$).

Mean production values of species caught by boat showed significant difference (Kruskal-Wallis, $H = 34.8$, $p < .001$), of which the production at the Mucuripe site (223. 76 ± 69.74) differed from the Batoque Resex ($p < .001$) (13.216 ± 1.53) and Prainha do Canto Verde Resex sites ($p < .001$) (33.74 ± 5.56). The Mucuripe site presented the highest mean production across the sites. No significant difference was shown between the Batoque and Prainha do Canto Verde sites (Fig. 3).

Significant difference was shown across the sites for the average number of recorded species (two-way ANOVA, $F = 11.12$, $p < .001$). No difference was observed between the average number of species per seasons (two-way ANOVA, $F = 1.40$, $p = .245$).

Regarding the habitat of the fishing grounds, a preference for the artificially hard bottom was observed in both Resex sites. The fishermen of the Batoque site carried out the fishing near artificial structures. Fishermen of the Mucuripe site performed 89% of their fishing on natural hard bottoms (Table 2).

The first axis of the correspondence analysis explained significantly 91.43% of the variance of the model with the first two axes presenting an eigenvalue of 0.845782 and 0.0612087, respectively. A strong association of the ballyhoo halfbeak, corocoro grunt, chere-chere grunt, atlantic spadefish and atlantic thread herring was observed with the artificial hard bottom habitat, as well as the guachanche barracuda and the black grouper with the natural hard bottom habitat (Fig. 4).

In this study, there was a problem suffered by artisanal fisheries around the world. The fact that they are fisheries working with numerous fishing gears, which are multi-species and has a fleet of variable boats, creates a certain difficulty to analyze the data sampled. It is necessary to consider the complexity of this type of fishing and the subjectivity of some of the data provided that may lead to some outliers, modifying the interpretation of some results. The Mucuripe site showed the highest number of outliers, which was expected given its proximity to an urban center and the difficulty in monitoring the landings. This site also showed a high dispersion of values for fishing effort (f) and biomass (B) ($R^2 = 0.0026$) and for f and CPUE ($R^2 = 0.0462$).

The relationship between fishing effort (f) and biomass (B) at the Batoque site showed the same monthly variation with exception for January 2019 (Fig. 5). However, the relationship between f and B shows significance (n 1p1, $R^2 = 0.8945$, $p < .001$) when considering this month as an outlier and excluding it from analysis (Fig. 6). The relationship for f and CPUE at this site showed a negative trend, but no significance was shown ($R^2 = 0.2693$).

The relationship between f and B at the Prainha do Canto Verde site showed the same monthly variation (Fig. 7). The relationship between f and B was significant ($n = 11$, $R^2 = 0.5323$, $p < .001$) (Fig. 8). This site showed a high dispersion of values for f and CPUE, but with no significance ($R^2 = 0.002$).

4. Discussion

Hook and line (HAL) fishing in tropical regions captures a wide diversity of species in the pelagic and demersal zones (Fonteles, 2011; Munga et al., 2014; De Freitas et al., 2017). This was verified herein and in other studies (Punzon, 2016; De Freitas et al., 2017; Previero and Gasalla, 2018). However, variation in the average number of species caught was observed between sites in the present study despite the high species richness shown across all sites, indicating that the fishing strategy used at each location influences the species richness of the landings.

The CPUE showed no variation across sites, contrary to the hypothesis that fisheries practiced within a Conservation Unit that has a protected marine area and has a fisheries management agreement has a higher production than other beaches. However, it is worth noting that the CPUE of small-scale fisheries is affected by several factors, such as climate, socio-economic conditions, ocean currents and displacement of fishermen to more attractive fishing grounds (Vølstad et al., 2014; Rochman et al., 2016). Rainfall was expected to affect the CPUE since it influences the ability of fishermen to go out to the sea and probably the abundance of species (Vilela et al., 2018). The three dry and rainy periods of the present study were within the historical rainfall average (FUNCEME - Fundação Cearense de Meteorologia e Recursos Hídricos, 2017; 2018, 2019). However, no interaction was shown between seasonality and CPUE. It is possible that a larger set of data may be required to detect these differences.

When comparing the two conservation units, the Batoque Resex site showed a lower mean effort and shorter distances travelled per vessel. However, its production was statistically equal to that of Prainha do Canto Verde Resex, indicating an advantage for the fishing strategy at the Batoque site. All fishing activities at the Batoque Resex were carried out near artificial habitats, which have been suggested to support high abundances of fish (Grossman et al., 1997). On the other hand, there were more fishermen exploiting the resources at the Prainha do Canto Verde Resex site, which could increase pressure on the stock.

The fishing activities at the Mucuripe site were carried out in areas with a natural bottom, which showed a different species composition when compared to that of artificial habitats. Hackradt et al. (2011) reported that the number of species in the natural environment is slightly higher than in the artificial reef, corroborating the results of this study. The Mucuripe site showed the highest average number of species caught per vessel. In addition, the increased fishing production in Mucuripe may be related to a higher variety of exploited habitats, since most vessels are motorized.

Regarding the association between species and bottoms, the correlation of the corocoro grunt (*Orthopristis ruber*) to artificial hard bottom is perhaps due to this species only being observed with fishing activities carried out in Batoque Resex, where 100% of the fishing occurred in this type of bottom. However, this species is known to occur in several types of bottoms such as sand, rock and mud bottoms, and inhabits coastal waters (Aizawa and Uyeno, 1983). Hence, the presence of this species only at the Batoque Resex is probably related to the fact that fishing at this site was performed with the least distance from the coast when compared to the other study sites. The other species associated with the artificial bottoms (e.g. ballyhoo halfbeak, chere-chere grunt, Atlantic spadefish and Atlantic thread herring) were shown at the Batoque and PCV Resex sites, of which these species are known to form shoals and occur mainly in coastal regions (Collette, 1978; Courtenay and Sahlman, 1978; Lieske and Myers, 1996; Smith, 1997).

The artificial hard bottom was predominant for fishing at the PCV Resex, but natural hard bottoms were targeted for fishing at this site as well. The guachanche barracuda was associated with the natural habitat and only occurred at this site and showed high catches. This species is known to inhabit muddy bottoms and coastal waters near estuaries and rivers rather than natural hard bottoms (De Sylva, 1990). However, the occurrence of this species may be due to the turbid waters off the coast of Ceará. Another species associated with the natural hard bottom was the black grouper. This species generally inhabits coral and rocky reefs (Lieske and Myers, 1994). The Atlantic thread herring also occurs in reef environments (Lieske and Myers, 1996), but in the present study they showed no direct association with any bottom. Nevertheless, Punzon (2016) suggested that the association of some species to certain habitats influences the spatial distribution of fishing activities.

For the relationship between fishing effort and biomass, artisanal fishermen at the Batoque Resex site directed their fishing effort towards areas with artificial refuges, resulting in a lower mean effort due to the concentration of fish biomass. The relationship between f and B at the Prainha do Canto Verde Resex was similar to that of the Batoque site, but effort was greater than that of the Batoque since the fishing was performed near natural and artificial habitats. The monthly biomass prediction is based on the fishing effort at the artificial reefs, where the variations in the abundance of the species are similar. Artificial reefs show abundances of various fish species because these structures provide refuge and food (Pickering and Whitmarsh, 1997). Thus, the presence of artificial habitats reduces the need to fish at various areas. When considering the Mucuripe site, more movement was required for the catch when compared to the two Resex sites, like due to the absence of artificial refuges in this region.

No relationship was established between fishing effort (f) and CPUE in the present study. Variations in CPUE are mainly associated with changes in fleet composition (Hilborn and Walters, 1992), as well as environmental factors (Sunden et al., 1981). However, the need to correct the CPUE (e.g., standardize the data) is not the only drawback in its interpretation as an index of relative abundance. The most common form of nonproportionality is that CPUE remains very high while abundance decreases, as defined by the equation $CPUE = q \times N\beta$ (Harley et al., 2001). "Hyper-stability" is suggested when $\beta < 1$ (Hilborn and

Walters, 1992) and therefore, relative CPUE is not proportional to abundance. Furthermore, it may lead to overestimation of biomass and underestimation of fishing mortality (F) (Crecco and Overholtz, 1990). Harley et al. (2001) found that $\beta < 1$ in more than 70% of the cases studied in three groups of fish (β values between 0.64 and 0.75). On the other hand, the proportionality between CPUE and N ($\beta = 1$) was satisfactory in artificial refuges used to capture lobster in the Cuban archipelago (Cruz and Borda, 2013), the results were different in lobster traps in the same area ($\beta = 0.37$).

5. Conclusions

Hook-and-line fishing at the three study sites targeted multiple species and the fishing grounds showed variation in bottom habitats and exploited by a variable fleet. The fish species showed associations with certain types of bottom habitats. Rainfall had no influence on the fishing production at any of the studied sites. Fishing at the Mucuripe showed the largest captured biomass, but also employed the greatest fishing effort and movement to fishing grounds. Fishing at the Batoque Resex was more efficient than fishing at the Prainha do Canto Verde Resex for obtaining a similar production but with a lower fishing effort. Fishing at the Batoque site was likely advantageous due to having artificial habitats, which attract high abundances of fish.

No conclusion was reached regarding if there is an advantage to fishing in conservation units. Further studies are needed to clarify if the relative abundance (CPUE) is proportional to the abundance of fish stocks derived from artisanal fisheries. Consequently, it is advisable to generate a monthly and annual, detailed and dynamic information base that makes it possible to incorporate data to those variables (environmental and fisheries) that may affect the catch per unit effort.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to the Cearense Foundation for Research Support (FUNCAP) for the scholarship granted to the first author, to the managers of extractive reserves for the approval of the research and to the fishermen for being so available.

References

Aizawa, M., Uyeno, T.T., 1983. Fishes Trawled off Suriname and French Guiana. Japan Marine Fishery Resource Research Center. Tokyo.

Bindoff, N.L., Cheung, W.W.L., Kairo, J.G., Arístegui, J., Guinder, V.A., Hallberg, R., Hilmi, N., Jiao, N., Karim, M., saiful, levin, L., O'Donoghue, S., Cuicapusa, S.R.P., Rinkevich, B., Suga, T., Tagliabu, A., Williamson, P., 2019. changing ocean, marine ecosystems, and dependent communities, in: IPCC special report on the ocean and Cryosphere in a changing climate, pp. 447–587.

Brasil, 2000. Diário Oficial da União. Lei nº 9.985, de 18 de julho de, vol. 2000. Poder Legislativo, Brasília, DF, p. 1, 19 jul. 2000. Seção 1. https://www2.camara.leg.br/legin/fed/lei/2000/lei-9985-18-julho-2000-359708-norma-pl.html/. (Accessed 1 May 2020).

Brasil, 2003. Diário Oficial da União. Decreto, de 05 de junho de, vol. 2003. Poder Executivo, Brasília, DF, p. 13, 06 jun. 2003. Seção 1. https://www.jusbrasil.com.br/diarios/572851/pg-13-secao-1-diario-oficial-da-uniao-dou-de-06-06-2003?ref=goto/. (Accessed 1 May 2020).

Brasil, 2009a. Diário Oficial da União. Decreto, de 05 de junho de, vol. 2009. Poder Executivo, Brasília, DF, pp. 5–6, 08 jun. 2009. Seção 1. https://www.jusbrasil.com.br/diarios/704723/pg-5-secao-1-diario-oficial-da-uniao-dou-de-08-06-2009/. (Accessed 1 May 2020).

Brasil, 2009b. Diário Oficial da União. Lei nº 11.959, de 29 de junho de, vol. 2009. Poder Legislativo, Brasília, DF, pp. 1–3, 30 jun. 2009. seção 1. https://www.jusbrasil.com.br/diarios/796732/pg-1-secao-1-diario-oficial-da-uniao-dou-de-30-06-2009?ref=goto/. (Accessed 1 May 2020).

Collette, B.B., 1978. Western Central Atlantic Fishing Area 31. FAO Species Identification Sheets for Fishery Purposes. Hemiramphidae. In: Fischer, W. (Ed.), vol. 2. Rome.

Courtenay, W.R., Sahlman, H.F., 1978. Western Central Atlantic Fishing Area 31. FAO Species Identification Sheets for Fishery Purposes. Pomadasyidae. In: Fischer, W. (Ed.), vol. 4. Rome.

Crecco, V., Overholtz, W.J., 1990. Causes of density-dependent catchability for Georges Bank haddock *Melanogrammus aeglefinus*. Can. J. Fish. Aquat. Sci. 47, 385–394. https://doi.org/10.1139/f90-040.

Cruz, R., Borda, C.A., 2013. Estimation of abundance and spatial distribution of *Panulirus argus* using different methodologies in artificial shelter, trap and coral reef fisheries. Crustaceana 86.2, 158–181. https://doi.org/10.1163/15685403-00003159.

Da Silva, G.B., Basílio, T.H., Nascimento, F.C.P., 2007. Distribuição de comprimento das raias *Dasyatis guttata* e *Dasyatis americana* no litoral do estado do Ceará, em função do aparelho-de-pesca. Arquivos de Ciência do Mar 40. https://doi.org/10.32360/acmar.v40i1.6141. http://periodicos.ufc.br/arquivosdecienciadomar/article/view/6141. (Accessed 14 April 2020).

De Freitas, R.R., Chamy, P., Dumith, R.D.C., 2017. Institutional design of small-scale fisheries in marine protected areas applied to sustainable territorial development on the Brazilian coast. Ocean Coast Manag. 139, 92–101. https://doi.org/10.1016/j.ocecoaman.2017.02.006.

De Sylva, D.P., 1990. Sphyraenidae. In: Quéro, J.C., Hureau, J.C., Karrer, C., Post, A., Saldanha, L. (Eds.), Check-List of the Fishes of the Eastern Tropical Atlantic. Unesco, Paris, pp. 860–864.

FAO, 2018. Food and agriculture organization of the united nations. El estado mundial de la pesca y la acuicultura 2018 (SOFIA): cumplir los objetivos de desarrollo sostenible. http://www.fao.org/state-of-fisheries-aquaculture/es/. (Accessed 14 April 2020).

Farias, J.O., 1988. Parte 6. Artes de pesca e tecnologia da captura, in: Manejo de reservatorios para a produção de peixes. FAO, Brasilia. http://www.fao.org/3/AB486P/AB486P06.htm#refparte6. (Accessed 1 February 2020).

Figueiredo, J.L., Menezes, N.A., 1980. Manual de peixes marinhos do sudeste do Brasil. Museu de Zoologia, Sao Paulo.

Figueiredo, J.L., Menezes, N.A., 2000. Manual de peixes marinhos do sudeste do Brasil. Museu de Zoologia, São Paulo.

Fisher, R.A., 1940. The precision of discriminant functions. Ann Eugenic 10, 422–429. https://doi.org/10.1111/j.1469-1809.1940.tb02264.x.

Fonteles, A.A., 2011. Oceanografia, biologia e dinâmica populacional de recursos pesqueiros. Expressão Gráfica e Editora, Fortaleza.

FUNCEME - Fundação Cearense de Meteorologia e Recursos Hídricos, 2017. Quadra chuvosa: Ceará fica dentro da média histórica em 2017. Newsletter. Publication date: 13 june 2017. http://www.funceme.br/?p=1533/(. (Accessed 10 January 2020).

FUNCEME - Fundação Cearense de Meteorologia e Recursos Hídricos, 2018. Avaliação da Quadra Chuvosa de 2018. http://saladeimprensa.ceara.gov.br/todospelaagua/wp-content/uploads/2017/arquivos/AVALIA%C3%87%C3%83O%20DA%20QUADRA%20CHUVOSA%20-%202018.pdf/. (Accessed 10 January 2020).

FUNCEME - Fundação Cearense de Meteorologia e Recursos Hídricos, 2019. Quadra chuvosa do Ceará em 2019 fica em torno da média. Newsletter. Publication date: 05 june 2019. http://www.funceme.br/?p=1533/. (Accessed 10 January 2020).

FUNCEME- Fundação Cearense de Meteorologia e Recursos Hídricos, 2009. Para entender melhor a previsão meteorológica para a estação chuvosa no ceará E glossário de Termos meteorológicos. http://www.funceme.br/produtos/manual/clima/Clima/boletins_clima_alerta/EntenderPrevisaoQuadraChuvosa.pdf./. (Accessed 17 February 2020).

Gadig, O.B.F., Bezerra, M.A., Feitosa, R.D., Furtado, M.A.A., 2017. Ictiofauna marinha do estado do ceará, brasil: I. Elasmobranchii. Arq. Ciencias do Mar 33. https://doi.org/10.32360/acmar.v33i1-2.11848. http://www.periodicos.ufc.br/arquivosdecienciadomar/article/view/11848/. (Accessed 1 February 2020).

Grossman, G.D., Jones, G.P., Seaman, W.J., 1997. Do artificial reefs increase regional fish production? A review of existing data. Fisheries 22, 17–23. https://doi.org/10.1577/1548-8446(1997)022<0017:DARIRF>2.0.CO;2.

Hackradt, C.W., Félix-Hackradt, F.C., García-Charton, J.A., 2011. Influence of habitat structure on fish assemblage of an artificial reef in southern Brazil. Mar. Environ. Res. 72, 235–247. https://doi.org/10.1016/j.marenvres.2011.09.006.

Haimovici, M., Dos Santos, R.A., Fischer, L., 2009. Class Cephalopoda, in: Compendium of Brazilian sea Shells. Evangraf. Rio Grande 610–658.

Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001. PAST: paleontological statistics software package for education and data analysis. Palaeontol Electron 4. https://palaeo-electronica.org/2001_1/past/issue1_01.htm.

Harley, S.J., Myers, R.A., Dunn, A., 2001. Is catch-per-unit-effort proportional to abundance? Can. J. Fish. Aquat. Sci. 58, 1760–1772. https://doi.org/10.1139/f01-112.

Hilborn, R., Walters, C.J., 1992. Quantitative Fisheries Stock Assessment Choice, Dynamics and Uncertainty. Chapman and Hall, New York.

ICMBIO - Instituto Chico Mendes de Conservação da Biodiversidade, 2012. Resolução Nº 02 de 31 de março de 2012. Portaria MMA nº 125/2010, Published in Diário Oficial da União de 15 de dezembro de 2010.

Last, P.R., White, W.T.R., Seret B, D.C.M., Stehmann, M., Naylor, G.J.P., 2016. Rays of the world. CSIRO publishing., Clayton, vic.

Lieske, E., Myers, R., 1994. Collins Pocket Guide. Coral Reef Fishes Indo-Pacific & Caribbean: Including the Red Sea. Haper Collins Publishers, London.

Lieske, E., Myers, R., 1996. Coral Reef Fishes Indo-Pacific & Caribbean: Including the Red Sea. Harper Collins Publishers, London.

Maia, I.C.C., Barreira, C.de A.R., 2008. Caracterização da atividade de captura de organismos da zona entre-marés, em recifes de arenito do litoral do Ceará, Brasil. Arq. Ciencias do Mar 41. https://doi.org/10.32360/acmar.v41i1.6077. http://www.periodicos.ufc.br/arquivosdecienciadomar/article/view/6077/(. (Accessed 1 February 2020).

Menezes, N.A., Figueiredo, J.L., 1978. Manual de peixes marinhos do sudeste do Brasil. Museu de Zoologia. São Paulo.
Menezes, N.A., Figueiredo, J.L., 1980. Manual de peixes marinhos do sudeste do Brasil. Museu de Zoologia, São Paulo.
Menezes, N.A., Figueiredo, J.L., 1985. Manual de peixes marinhos do sudeste do Brasil. Museu de Zoologia, São Paulo.
Munga, C.N., Omukoto, J.O., Kimani, E.N., Vanreusel, A., 2014. Propulsion-gear-based characterisation of artisanal fisheries in the Malindi-Ungwana Bay, Kenya and its use for fisheries management. Ocean Coast Manag. 98, 130–139. https://doi.org/10.1016/j.ocecoaman.2014.06.006.
Nelson, J.S., Grande, T., Wilson, M.V.H., 2016. Fishes of the World. John Wiley & Sons, Hoboken, NJ.
Pickering, H., Whitmarsh, D., 1997. Artificial reefs and fisheries exploitation: a review of the 'attraction versus production' debate, the influence of design and its significance for policy. Fish. Res. 31, 39–59. https://doi.org/10.1016/s0165-7836(97)00019-2.
Previero, M., Gasalla, M.A., 2018. Mapping fishing grounds, resource and fleet patterns to enhance management units in data-poor fisheries: the case of snappers and groupers in the Abrolhos Bank coral-reefs (South Atlantic). Ocean Coast Manag. 154, 83–95. https://doi.org/10.1016/j.ocecoaman.2018.01.007.
Punzon, A., 2016. Spatial characterization of the fisheries in the avilés Canyon System (Cantabrian sea, Spain). Cienc. Mar. 42, 237–260. https://doi.org/10.7773/cm.v42i4.2628.
Rochman, F., Jatmiko, I., Wujdi, A., 2016. Biology and CPUE spatial distribution of escolar *Lepidocybium flavobrunneum* (Smith, 1843) in eastern indian ocean (evolving fisheries: today's by-catch is tomorrow's target catch). Indonesian Fisheries Research Journal 22 (27). https://doi.org/10.15578/ifrj.22.1.2016.27-36.
Santos, M.P.N.D., Seixas, S., Aggio, R.B.M., Hanazaki, N., Costa, M., Schiavetti, A., Dias, J.A., Azeiteiro, U.M., 2012. A Pesca enquanto atividade humana: pesca artesanal e sustentabilidade. Revista de Gestão Costeira Integrada 12, 405–427. https://doi.org/10.5894/rgci385.
Shapiro, S.S., Wilk, M.B., 1965. An analysis of variance test for normality (complete samples). Biometrika 52, 591–611. https://www.jstor.org/stable/2333709/(. (Accessed 15 April 2020). http://doi.org/10.2307.
Smith, C.L., 1997. National audubon Society field guide to tropical marine fishes of the Caribbean, the gulf of Mexico, Florida, the Bahamas, and Bermuda. Alfred A. Knopf Inc., New York.
Sunden, P.N., Blackburn, M., Williams, F., 1981. Tunas and Their Environment in the Pacific Ocean: a Review. Aberdeen University Press, Aberdeen,UK.
Vilela, R., Conesa, D., Rio, J.D., López-Quílez, A., Portela, J., Bellido, J., 2018. Integrating fishing spatial patterns and strategies to improve high seas fisheries management. Mar. Pol. 94, 132–142. https://doi.org/10.1016/j.marpol.2018.04.016.
Vølstad, J.H., Afonso, P.S., Baloi, A.P., Premegi, N.D., Meisfjord, J., Cardinale, M., 2014. Probability-based survey to monitor catch and effort in coastal small-scale fisheries. Fish. Res. 151, 39–46. https://doi.org/10.1016/j.fishres.2013.11.016.
Ye, Y., Gutierrez, N.L., 2017. Ending fishery overexploitation by expanding from local successes to globalized solutions. Nature Ecology & Evolution 1. https://doi.org/10.1038/s41559-017-0179.