Lat. Am. J. Aquat. Res., 46(4): 765-778, 2018
DOI: 10.3856/vol46-issue4-fulltext-14

Research Article

The offshore recreational fisheries of northeastern Brazil

Kátia Meirelles Felizola-Freire[1], Ussif Rashid Sumaila[1], Daniel Pauly[2] & Gustavo Adelino[3]
[1]Fisheries Economics Research Unit, Institute for the Oceans and Fisheries
University of British Columbia, Vancouver, BC, Canada
[2]Sea Around Us, Institute for the Oceans and Fisheries, University of British Columbia
Vancouver, BC, Canada
[3]Zagaia Pesca Oceânica, João Pessoa, Paraíba, Brazil
Corresponding author: Kátia de Meirelles Felizola Freire (kmffreire2018@gmail.com)

ABSTRACT. This study was carried out to estimate total catches extracted from the offshore areas of northeastern Brazil by recreational fishers from offshore operations, daily activities, and fishing competitions. It also aimed at providing a first estimate of expenditure by anglers in the region. The basis for this analysis was the data supplied by the only offshore fishing operator established in Paraíba State. The available logbooks allowed for the first estimate of total catches by anglers in Paraíba State, which was extrapolated to the entire region using information provided in a database of recreational fishers' licenses. By combining these data with catch data from fishing competitions, we were able to estimate that a peak of about 90 t was extracted in 2011. This catch is low when compared with commercial catches, but the associated economic impacts, assessed via the expenditure by recreational fishers at US$1.5 million in 2014, is high. Moreover, catches are concentrated mainly on a small number of species, mostly *Thunnus* spp. and *Seriola* spp. in waters off Paraíba State. No information is available on the current status of these amberjacks (*Seriola* spp.). However, some of the snappers (Fam. Lutjanidae) included in the top species caught by recreational fishers are considered overexploited in the region.

Keywords: sports fishery, amateur fishery, oceanic, recreational fishery, northeastern Brazil.

INTRODUCTION

Offshore recreational fisheries of northeastern Brazil have increased in importance in recent years, even though offshore recreational fishing has been occurring for a long time along the southeastern Brazilian coast. There, fishing competitions targeting billfishes have been taking place annually since the 1960s (Arfelli *et al.*, 1994; Barroso, 2002; Paiva & Pires-Júnior, 1983). Cisneros-Montemayor & Sumaila (2010) noted gaps in the information available on Brazilian marine recreational fisheries, such as the absence of participation rate. Even though these authors presented one global estimate of expenditure by recreational fishers, estimates by country were not given. In the estimation process, Cisneros-Montemayor & Sumaila (2010) assumed that absence of data on recreational fisheries suggested that they do not exist, or were very small, but is not the case in Brazil where this activity is significant (Freire *et al.*, 2016a). However, concerning management, only a few measures are currently in place. The main ones being the requirement of a fishing license, a bag limit of 15 kg/fisher/day for marine waters (plus one specimen of any species and any size/weight, except for those prohibited by any additional legislation), and the prohibition to sell the catch (Freire *et al.*, 2012).

Freire (2005) was the first to describe recreational fisheries off northeastern Brazil and estimated annual catches at around 1150 t (not split between onshore and offshore fisheries). The offshore recreational fisheries expanded to the northeastern region (Bahia, Pernambuco and Rio Grande do Norte), but without being firmly established, probably due to economic constraints. Later, Freire (2010) and Freire *et al*. (2014) studied recreational fisheries off northeastern Brazil but concentrated their efforts on coastal fisheries due to their easier access to the members of fishing clubs targeting mainly coastal species. Therefore, the offshore recreational fisheries in this region remain mostly unknown to the scientific community, as there

Corresponding editor: Antônio Ávila da Silva

is no general understanding among stakeholders of the importance of data for future planning and assessment of the sustainability of this activity.

Brazil has no system of catch data collection for recreational fisheries as compared to, *e.g.*, Canada (Brownscombe *et al.*, 2014). There, biological, social, and economic data related to recreational fisheries have been collected nationally through mail survey every five years since 1975. On the other hand, much of the data estimated by Freire *et al.* (2016a) is based on local studies compiled in Freire *et al.* (2016b) and a database of anglers' licenses. More studies focusing on different regions and components of recreational fisheries are still required. Thus, this study aims to describe the offshore recreational fisheries of northeastern Brazil, based on a case study from Paraíba State, and to estimate their total annual catch and economic impacts.

Pauly (2016) makes a case for the importance of including all components responsible for the extraction of fish resources from their habitat, even in cases where bold assumptions are required. Otherwise, some trends could be overlooked, as it was the case for the Bahamas, *e.g.*, where 55% of catches were originating from recreational fisheries and were never included in national catch statistics (Smith & Zeller, 2016). Similarly, recreational catches for west Africa had never been estimated before Belhabib *et al.* (2016). These authors indicated a current high economic value of this activity for that region and stated the importance of catch the trend in the early development of this activity, what seems to be the case for the growing offshore recreational fisheries in northeastern Brazil.

MATERIALS AND METHODS

Offshore recreational fisheries in Paraíba State

To describe the pattern of offshore recreational fisheries in the northeastern region, we based our study in a fishing operation based in João Pessoa, the capital of Paraíba State (Fig. 1). This analysis was based on logbooks available for the period 2008-2015, which report on the location of the fishing operation, the number of recreational fishers (or 'anglers'), and the catch per species. These logbooks were used to estimate total offshore catches by anglers in the state and to describe the main features of fishing operations. No operator is required to report catch data for their operations in Brazil. João Pessoa is the only state where the operator reported catch data in private logbooks due to his interest. This operator reported information for all fishing trips.

The economic contribution of offshore recreational fisheries for the state was assessed using the mean expenditure reported by respondents of a questionnaire based on an adapted version of a testing manual provided by Southwick Associates (WECAFC/ OSPESCA/CRFM/CFMC, undated), distributed by e-mail to all clients (n = 110) of the only offshore fishing operation established in Paraíba State. This questionnaire contained 24 open- and close-ended questions including general socio-economic features of each angler, information on fishing habits, and expenses related to their last fishing trip to João Pessoa. Three reminders one-month apart were sent to each client, who answered the questionnaire between March and June 2014.

Offshore recreational fisheries in northeastern Brazil

The total recreational catch for northeastern Brazil was obtained by adding three components: catches by operators, daily catches by anglers and catches from fishing competitions (tournaments, championships, jamborees). The term 'operators' refers to entrepreneurs taking anglers offshore for recreational fishing, while fishing competitions refer to any event where anglers compete for an award (*e.g.*, money, car, motorcycle, boat or outboard motor). Daily catches refer to any anglers' fishing activity conducted neither during fishing competitions nor with a professional captain (operator).

The number of offshore fishing operators in the region was obtained through an online search. Each operator, identified online, was asked when their operation started (if this information was not readily available) and to name other operators in the region, *i.e.*, using a snowball strategy. Total catch from operators (considering that each of them owns only one boat) was then obtained by multiplying catches estimated in the previous section for the operator based in Paraíba State by the number of fishing operators in each year in the region (Table 1).

For daily catches, the starting point was the number of licenses issued for the northeastern region (2010-2014) (Table 1). Even though electronic databases are available since 2002, they represent an unknown fraction of the total number of licenses, as only permits issued online were included (*i.e.*, the hard copy licenses were not encoded). It was not until mid-2009 that all licenses started to be issued online and managed by the same institution, the Ministry of Fisheries and Aquaculture (MPA). All anglers are required to have a fishing license to go fishing in private boats and also with an operator (for-hire captain), except for children (younger than 18 years). Elderly anglers (65 years for men and 60 years for women) are also required to obtain a license, even though they do not pay the license

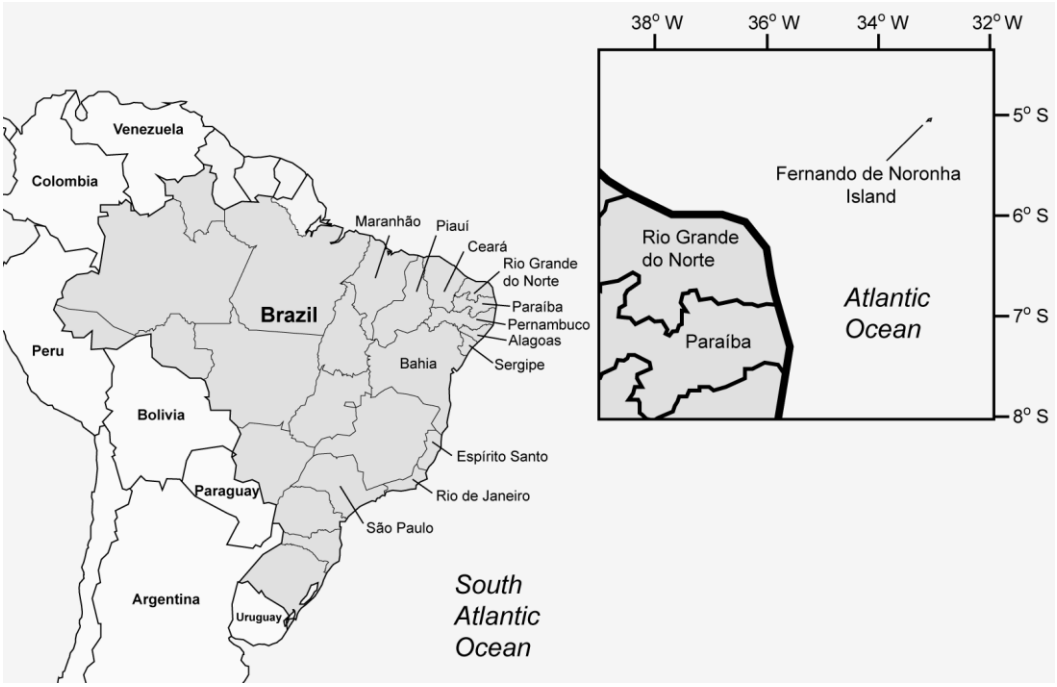

Figure 1. Study area indicating all states included in the northeastern region of Brazil (Maranhão to Bahia). The states of Espírito Santo, Rio de Janeiro, and São Paulo (southeastern region) are also shown. Fernando de Noronha Island location is presented in the right side.

fee. Catches were estimated using the license database for each year (built based on a questionnaire filled by anglers when acquiring their licenses). The CPUE values used were those estimated for the Paraíba State for each year (the only ones available after being assessed in this study). In the questionnaire associated with each license, anglers stated how many days they spent fishing in the state of residence and outside. Additionally, they were requested to name the most preferred state for fishing outside their state of residence. Here, we considered that half of these days were spent in the preferred state (if within the northeastern region), the only one that could be included here, as the others were not stated. Thus, the observed increase or decrease rate in the number of anglers and number of fishing days between 2010 and 2011 were applied for 2008 and 2009. In the absence of a better alternative, the trend between 2013 and 2014 was extrapolated to 2015.

For those anglers stating they ‘sometimes' released the fish they caught, based on the questionnaire of each license, we assumed a release fraction of 0.5 of their daily catch. Those anglers who ‘always' released their recreational catch were not included, and the catches of anglers who ‘never' released their fish were counted in their entirety. Only anglers stating they fish exclusively offshore were included in the estimation. Thus, last catches originating from daily activities (C_{DA}) were calculated as:

$$C_{DA} = pCR \times nfd \times na \times CPUE$$

where pCR: proportion of catch-and-release (0.5 or 1.0), nfd: number of fishing days in northeastern Brazil (also from the questionnaire of each license and included in the license database), na: number of anglers fishing only offshore (from the license database); and CPUE: mean catch per unit of effort (based on the logbooks previously mentioned for Paraíba State; see Table 1).

Finally, catches from fishing competitions in northeastern Brazil were obtained online (Pernambuco), by monitoring some events (Rio Grande do Norte and Fernando de Noronha Island), or from event organizers who kindly provided original catch records for some years (Fernando de Noronha Island) (Table 1).

Catches for Pernambuco State were estimated based on information available online. ‘Points' were converted into weight for some years, while photos for other events were used to identify all species caught, and estimate total catch based on the number of individuals caught per species and their mean weight as estimated for Paraíba State (obtained as described in the previous section).

Table 1. Data used to reconstruct catches for three components of offshore recreational fisheries of northeastern Brazil (2008-2015). PB: Paraíba State, NE: northeastern Brazil.

Component	Feature	Year	Locality	Source/comment
Operators	Number of operators (NO)	2008-2015	Northeastern	• Started with internet and snowball strategy • Assumption: 1 boat per operator
	The total annual catch for PB (CPB)	2008-2015	Paraíba in NE	• Based on the logbooks of the operator in PB • Catch by species
	The total annual catch for NE	2008-2015	Northeastern	• The total annual catch for NE = NO × CPB • No detail by species included to account for possible local differences
Daily activities	CPUE (kg angler^{-1} d^{-1}) from operator in PB	2008-2015	Paraíba in NE	• CPUE from Paraíba extrapolated to northeastern Brazil (NE) - considering one single Large Marine Ecosystem (east Brazil).
	Number of anglers (from the national license database)	2010-2014	Residents in the states of NE	• The direct number of licenses for each year (selected anglers fishing only offshore, inhabi-ting one of the states in NE, releasing fish sometimes or never and boat owners).
		2010-2014	Non-residents	• The direct number of licenses for each year (selected anglers fishing only offshore, inhabiting outside NE, but declaring any state in NE as local of preference for fishing, or inhabiting in NE and fishing in another state in NE, releasing fish sometimes or never and boat owners or not).
		2008-2009	Residents and non-residents	• Increasing trend for 2010-2011 used to estimate the number of anglers in 2008 and 2009 and then applied the proportion between boat owners and a total number of anglers for 2010 to 2008 and 2009 (Assumption: only boat owners practice daily activities; otherwise anglers will use operators).
		2015	Residents and non-residents	• Increasing trend for 2013-2014 used to estimate the number of anglers and proportion between boat owners and a total number of anglers used to 2014-2015.
	Number of fishing days (only those fishing offshore)	2010-2014	Residents in NE	• Directly from the license database for each year, but multiplied by 0.5 if angler releases fish sometimes and by 1.0 if never releases (Mean value per year).
		2010-2014	Non-residents	• Directly from the license database for each year, but multiplied by 0.5 if angler releases fish sometimes and by 1.0 if never releases (Mean value per year).
		2008-2009	Residents and non-residents	• Decreasing trend for 2010-2011 used to estimate the number of fishing days in 2008 and 2009.
		2015	Residents and non-residents	• Decreasing trend for 2013-2014 used to estimate the number of fishing days in 2015.

Continuation

Component	Feature	Year	Locality	Source/comment
	Final catch originating from daily activities (C_{DA})	2010-2015	Residents and non-residents	• C_{DA} = pCR×nfd×na×CPUE [pCR = proportion of catch-and-release (0.5 or 1.0); nfd = number of fishing days in NE (from the license database); na = number of anglers fishing only offshore (from the license database); and CPUE = mean catch per unit of effort (based on the logbooks for PB)].
Competitions	Total catch per year	1996-2015	• Rio Grande do Norte	• Direct observation
			• Pernambuco	• From internet (number estimated based on photos and mean individual weight from operation in PB)
			• Bahia	• No data provided by organizers or available online
			• Fernando de Noronha Island	• Catch data by species provided by the organizer

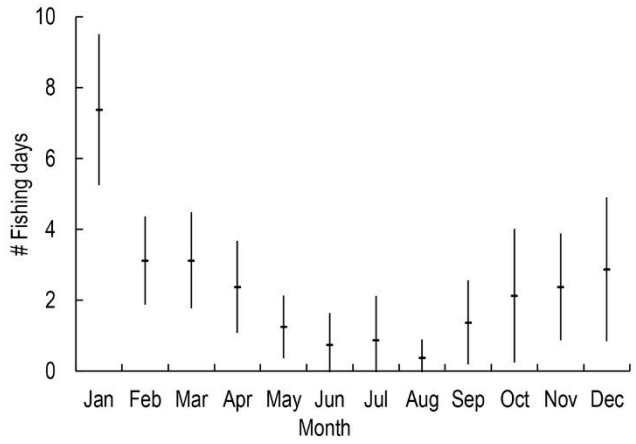

Figure 2. Mean ± SD number of fishing days per month for the offshore fishing operation based in Paraíba State (2008-2015).

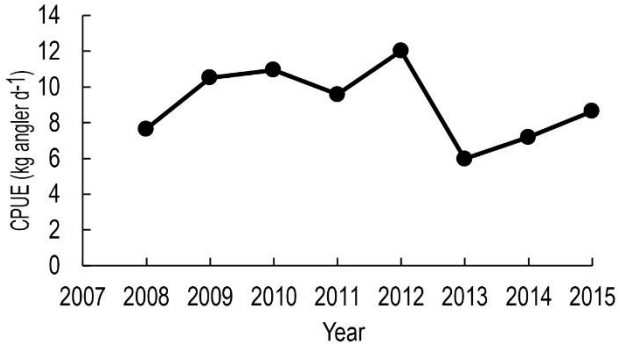

Figure 3. Catch-per-unit-of-effort (CPUE) per year for the offshore recreational fishing operation based on Paraíba State.

The economic importance of offshore recreational fisheries for the northeastern region was assessed using the mean expenditure reported by respondents of the questionnaire based on the testing manual provided by Southwick Associates mentioned in the previous section and applied to clients of the operator in Paraíba State. The mean expenditure reported by the respondents was extrapolated for the entire northeastern region considering the proportionality between expenditure (estimated here) and monthly income (stated in the license database) for residents and non-residents, separately. For this, we also considered the number of anglers that declared fishing only offshore and the number of days fishing in their state of residence. For visitors, we considered that half of the stated numbers of fishing-days were spent in the preferred state outside the area of residence (if in northeastern Brazil), the only such information in the online questionnaire.

RESULTS

Offshore recreational fisheries in Paraíba State

An average of 227 ± 11 recreational fishing licenses were issued annually for Paraíba State in the last three years for which data were available, representing 4-10% of all licenses issued in the nine states of the northeastern region. About 5% of those 227 license holders declared fishing only offshore. Even though offshore recreational fisheries have been practiced in Paraíba State for at least 30 years, the first and only business catering to this activity began in 2004. Moreover, complete daily logbooks were kept only from 2008 onwards, and it is the only longtime series

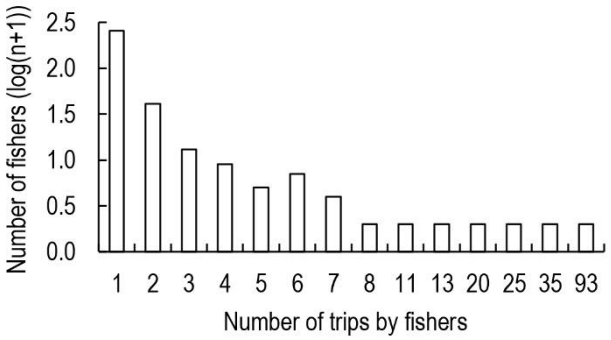

Figure 4. The number of offshore fishing trips for recreational fishers off Paraíba State (2008-2015).

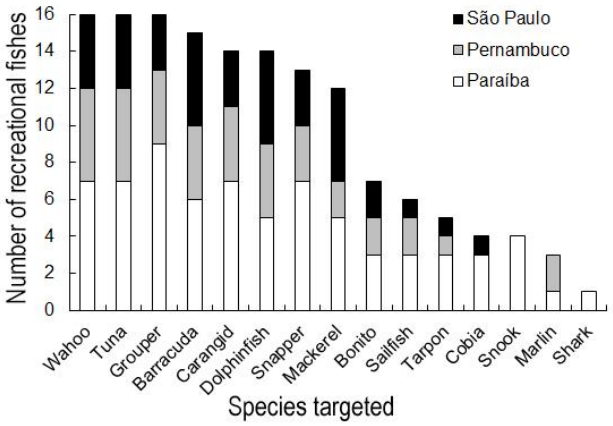

Figure 5. Main species targeted by respondents fishing offshore in Paraíba State based on a questionnaire circulated by e-mail (11 respondents from Paraíba, 6 from São Paulo, and 5 from Pernambuco).

available for northeastern Brazil. These logbooks indicate that each fishing trip usually runs from 06:00 h to 18:00 h, throughout the year, but mainly in January (Fig. 2). The number of trips in January was the highest (7 day-long trips on average), as it corresponds to the austral summer and the usual vacation period. August is the worst month to go fishing, as rains and strong winds beset it. There was less than one trip on average for that month, and also for June and July for the several years we had data. Most of the fishing trips took place during the weekends (72% on Saturdays or Sundays).

The average annual catch-per-unit-of-effort (CPUE) for 2008-2015 ranged from about 6 to 12 kg angler^{-1} day^{-1} (Fig. 3). This result should be viewed cautiously as the number of days used here does not represent the number of days spent fishing, but the actual duration of the trip, *i.e.*, from the day the boat left the harbor until its return. Also, not all persons listed in the logbooks may have been fishing during that trip. This information should be improved in the future to capture effective fishing days and the actual number of anglers, not all passengers. Most of the catches were tunas and bonitos (*Thunnus* spp. and *Euthynnus alletteratus*), amberjacks (*Seriola rivoliana* and other *Seriola* species), barracuda (*Sphyraena barracuda*), snappers (*Lutjanus vivanus* and *L. analis*), mackerels (*Scomberomorus cavalla* and *S. brasiliensis*), dolphinfish (*Coryphaena hippurus*), and horse-eye jack (*Caranx latus*) (about 80% of all specimens caught; Table 2). Catches also included one unidentified shark. It is worth pointing out that the name of the species caught and their number (or weight) was not reported in the logbooks analyzed here, especially in the first years of operation. Instead, only total catches were reported, with about 36% being reported as 'marine fishes nei'. This category was followed by Scombridae (22.8% in weight), Carangidae (20.7%), Lutjanidae (7.3%), Sphyraenidae (4.9%), Serranidae (4.8%), Coryphaenidae (1.2%), Istiophoridae (1.2%) and other species (1.1%), out of a total catch of 4055 kg over the entire period we analyzed. Thus, the number of specimens presented in Table 2 represents an underestimation of catch per species.

We found that most of the anglers that fished in offshore waters off Paraíba were males (96%), with ages between 5 and 81 years (average = 42 years), and overwhelmingly Brazilian (94%), even though there were anglers from Sweden, Italy, the United States of America, and Germany.

Among the Brazilians, most of them were residents (about 70%), followed by anglers from Pernambuco (neighbor state) and São Paulo (in southeastern Brazil) states. However, there were also anglers from the states of Rio Grande do Sul and Paraná (southern region), Espírito Santo, Rio de Janeiro, and Minas Gerais (southeastern region), and Mato Grosso and Mato Grosso do Sul (center-western region), including the Federal District (*i.e.*, Brasília). Most of the fishers (80%) only fished once, but some of them have taken part in 2-93 trips (Fig. 4). The highest number of recurrent trips was associated with operators, their relatives, or residents.

The response rate for the 110 questionnaires used to assess the expenditure with offshore fishing operation in Paraíba State was 21%. The responses were mainly sent by resident anglers, as well as some from Pernambuco and São Paulo states. These states correspond to the residence of most of the clients recorded in the logbooks analyzed above (additionally, there was a response from one Italian angler). The respondents target mainly wahoo, tuna, grouper, barracuda, carangid, and dolphinfish (Fig. 5).

Table 2. Total catch (in numbers) and mean individual weight per species for the offshore fishing operation established in Paraíba State (2008-2015). [1]Includes *Tylosurus* sp., *Thunnus atlanticus*, *Rachycentron canadum*, *Lutjanus cyanopterus*, *Alectis ciliares*, and *Panulirus* sp., [2]English common name for each species as in FishBase (Froese & Pauly, 2017), [3]Nei: not elsewhere included. Dashes (-) indicate species for which the operator did not report individual weight.

Portuguese common name	English common name[2]	Species	Number	Mean individual weight (kg)
Albacora, atum	Tuna	*Thunnus* spp.	134	2.6
Pitangola, arabaiana chata	Longfin yellowtail	*Seriola rivoliana*	65	3.5
Barracuda, bicuda	Great barracuda	*Sphyraena barracuda*	59	5.8
Espécies não identificadas	Marine fishes nei[3]	Marine fishes nei	50	-
Bonito	Little tunny	*Euthynnus alletteratus*	44	2.8
Pargo olho amarelo, pargo	Silk snapper	*Lutjanus vivanus*	38	1.1
Cavala branca, cavala	King mackerel	*Scomberomorus cavalla*	33	7.9
Serra	Serra Spanish mackerel	*Scomberomorus brasiliensis*	31	2.4
Arabaiana	Amberjacks	*Seriola* spp.	27	14.5
Dourado	Common dolphinfish	*Coryphaena hippurus*	22	4.4
Cioba	Mutton snapper	*Lutjanus analis*	21	3.6
Xaréu olhudo, garacimbora	Horse-eye jack	*Caranx latus*	21	5.8
Cavala wahoo, aipim	Wahoo	*Acanthocybium solandri*	17	13.7
Badejo, sirigado	Black grouper	*Mycteroperca bonaci*	16	13.9
Ariocó	Lane snapper	*Lutjanus synagris*	14	0.5
Guaiúba	Yellowtail snapper	*Ocyurus chrysurus*	14	4.0
Dentão	Dog snapper	*Lutjanus jocu*	11	-
Pargo ferreiro	Blackjack	*Caranx lugubris*	9	1.5
Garajuba, guarajuba	Yellow jack	*Carangoides bartholomaei*	8	5.5
Olho de boi, arabaiana verdadeira	Greater amberjack	*Seriola dumerili*	8	21.0
Olho de vidro, olho de cão	Grasseye	*Heteropriacanthus cruentatus*	6	2.8
Cherne	Groupers	*Hyporthodus* sp.	4	7.7
Agulhão vela, sailfish	Sailfish	*Istiophorus platypterus*	3	23.5
Albacora de laje	Yellowfin tuna	*Thunnus albacares*	3	34.3
Biquara	White grunt	*Haemulon plumierii*	2	-
Bonito listrado	Skipjack	*Katsuwonus pelamis*	2	2.5
Peixe rei	Rainbow runner	*Elagatis bipinnulata*	2	1.0
Piraúna	Coney	*Cephalopholis fulva*	2	-
Xixarro	Blue runner	*Caranx crysos*	2	-
Outras espécies[1]	Other species	Fish and lobster	7	-

All these species are effectively caught as shown in Table 2. In general, the target species are similar for residents and non-residents from São Paulo and Pernambuco states. However, residents tend to target groupers, snappers, and carangids preferentially.

The respondents stated an average expenditure of R$647 per angler (US$276) before leaving to João Pessoa in travel agency fees, airplane tickets, and bus tickets. Average spending while in João Pessoa was R$1302 (US$555), mainly related to boat services, including fishing guides, and hotel, with a total expenditure per trip of R$1949 (US$831). The average trip duration is about 1.8 days, which results in daily expenditure of R$1264 (US$539). Considering only States of origin of anglers with more than one respondent, daily total expenditure per angler is much higher for the State of São Paulo (R$ 2580 = US$ 1109) than for the States of Paraíba (RS 820 = US$ 353) and Pernambuco (R$ 433 = US$ 186; Table 3).

Offshore recreational fisheries in northeastern Brazil

The total recreational catch for northeastern Brazil was obtained adding three components: catches from operators, from anglers' daily activities, and from competitions. Twenty-two offshore fishing operators were found in the region, with the earliest operation starting in 1996 in Bahia State. Information on the year of establishment was not found for some operators, but data available indicate a steady increase (Fig. 6). Catches estimated for all offshore operators, based on data collected for Paraíba State, added to a maximum of about 13 t in 2011 (Fig. 7). This extrapolation was done considering that marine waters off all nine states of the northeastern region are included in the East

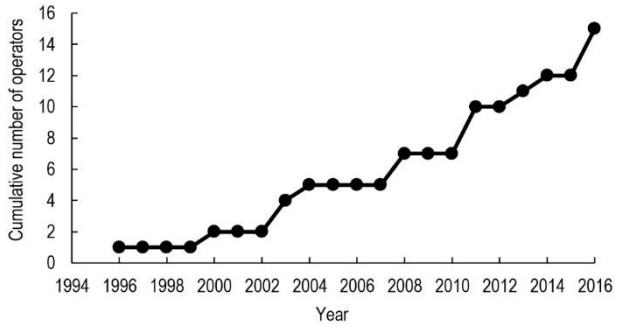

Figure 6. The number of operators working on offshore fisheries in northeastern Brazil.

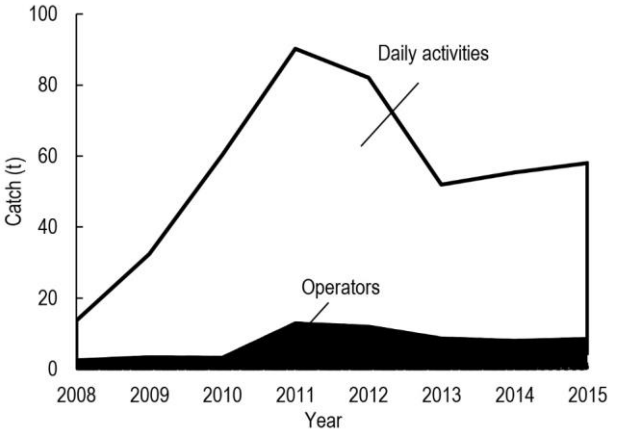

Figure 7. Total offshore recreational catch estimated for northeastern Brazil considering operators and daily catches, and fishing competitions. Catches from competitions are not shown due to their small value (annual catch smaller than 0.5 t).

Brazil Large Marine Ecosystem (Heileman, 2008) and, as such, share common features.

Within the component daily catches, a maximum annual catch of over 77 t was estimated for 2011, based on the yearly CPUE estimated for the only offshore operation established in Paraíba State (Fig. 3) and the number of licenses issued for anglers living in this region (Table 4) and of visitors (Fig. 7; see also Table 1).

Offshore competitions have been promoted in northeastern Brazil at least since 1996. These events only took place off Rio Grande do Norte, Pernambuco, and Bahia states as well as the oceanic Fernando de Noronha Island (administratively dependent on Pernambuco). The results of these competitions are not widely disseminated, and thus Table 5 has gaps. Based on the catch data available, the highest catches were observed in 1998 when almost 1.9 t were landed (Table 5). Catches declined in later years due to the introduction of catch-and-release in the events promoted in the region. Thus, the total extraction represents a crude estimate. The species composition was only partially available for Fernando de Noronha Island and Rio Grande do Norte State. The composition is similar in terms of species but with different proportions: *Istiophorus platypterus*, *Sphyraena barracuda* and *Thunnus* spp. are abundant around the oceanic Fernando de Noronha Island (78.6% of total catches), and *Acanthocybium solandri*, *Coryphaena hippurus* and *Istiophorus platypterus* (85.4%) off Rio Grande do Norte State (Table 6).

Table 3. Mean total daily expenditure stated by anglers fishing off the coast of Paraíba State (R$1 = US$0.43 in 2014).

State	Total expenditure (US$) Mean ± SD	Number of respondents
São Paulo	1109 ± 1328	6
Pernambuco	186 ± 145	5
Paraíba	353 ± 364	8

Adding the three components of catches (from operators, daily activities, and competitions) yields a peak of 99 t in 2011, followed by a decline onwards (Fig. 7). For 2013 to 2015, the average annual catch amounted to 55 t. The main component of the catch originated from daily activities and catches from competitions were too low (and indeed underestimated).

The expenditure data estimated for Paraíba State, and presented in Table 3, was extrapolated to the entire northeastern region and suggests that offshore anglers may have spent about US$1.5 million in 2014 (including expenses before and after leaving the state of residence). A total of 80% of the expenditure was associated with anglers from the Espírito Santo, São Paulo, and Rio de Janeiro states. It is worth pointing out that, based on the information provided together with the license databases, anglers from the northeastern region, who prefer fishing in their state of residence, had a monthly income corresponding to half of the ones who declared mainly fishing elsewhere in northeastern Brazil. This information was used here to estimate some missing values for the region.

DISCUSSION

A comprehensive description of offshore recreational fisheries in northeastern Brazil depends on the willingness of stakeholders to share information. Thus, much of the results presented here had to be estimated

Table 4. The number of recreational fishing licenses issued for each state of northeastern Brazil in 2014, corresponding to anglers who stated fishing offshore among other areas (# O. licenses) and only offshore (# OO. licenses). Relative frequency corresponds to the percentage of anglers of each state in relation to the total for northeastern Brazil fishing offshore among other areas.

State	# O. licenses	Rel. freq. (%)	# OO. licenses
Maranhão	30	2.6	2
Piauí	8	0.7	0
Ceará	144	12.3	25
Rio Grande do Norte	113	9.6	38
Paraíba	46	3.9	6
Pernambuco	196	16.7	64
Alagoas	98	8.4	29
Sergipe	48	4.1	10
Bahia	488	41.7	177
Total	1171	100.0	351

based only on limited available local information and/or by using data from neighboring states, but all included in the same Large Marine Ecosystem: east Brazil (Heileman, 2008).

There are still many aspects of the three components of offshore recreational fisheries (operators, daily catches, and competitions) in northeastern Brazil that should be described. However, based on the information available, we were able to estimate total catches for the region amounting to about 60 t in 2015. This estimate was based on the CPUE observed for Paraíba State of 8.6 kg angler^{-1} d^{-1} in the same year. The mean CPUE for that state was much lower than the mean value of about 30 kg angler d^{-1} estimated for some countries in West Africa (Belhabib *et al.*, 2016). This difference in CPUE for these two areas probably reflects the relatively "pristine" status of coastal game fish in some West African countries (Belhabib *et al.*, 2016). Also, the area studied here is part of the East Brazil Large Marine Ecosystem, which is oligotrophic, with low nutrient load and phytoplankton production (Gaeta *et al.*, 1999). The total estimated catch was relatively small, finally, also due to us considering only licensed anglers, as there is no information available on the ratio between licensed and non-licensed offshore anglers for northeastern Brazil. Moreover, only those anglers who stated that they fish exclusively offshore were included here. Thus, our catch most probably represents an underestimation of the total impact of recreational fisheries in the region. On the other hand, we used data from operators to extrapolate to the daily activities of recreational fishers, which could be a source of overestimation, which hopefully could compensate for the underestimation previously discussed. This issue could only be solved when studies are carried out in the region to estimate the ratio between licensed and non-licensed oceanic fishers, and also to estimate the possible source of bias related to the use of CPUE for operators as a proxy for daily activities of fishers.

Even though recreational catches are small, compared to commercial catches (based on an updated version of the database compiled by Freire *et al.*, 2016a), one should note that the number of operators is steadily increasing. The effort of offshore anglers is concentrated in a smaller number of species with life histories that render them readily susceptible to overexploitation (*e.g.*, Coleman *et al.*, 2004). Also, 18 of the species reported here were also targeted by spearfishers in the state of Bahia (Costa-Nunes *et al.*, 2012). Amongst scombrids, most of the catches were of *Thunnus* spp. Even though local anglers did not identify tunas, they may be represented mostly by *Thunnus atlanticus*, as this is the most coastal tuna species, subjected nearby to an artisanal fishery targeting this species from September to January (Freire *et al.*, 2005). Indeed, the highest recreational catches for *Thunnus* spp. off Paraíba were reported from September to March (data not shown). IBAMA (2007) reported the catches of *Thunnus albacares*, *T. alalunga* and *T. obesus* of an industrial fleet based on Paraíba State, but this fleet operates in a much more extensive area than used by the recreational fishing operator.

For the carangids, most of the catch was represented by amberjacks, mainly *S. rivoliana*. Even though this species was one of the most commonly caught off Paraíba State, Feitoza *et al.* (2005) considered that *S. rivoliana* occurs only occasionally over the deep-reefs of our study area. *Seriola* spp. was also reported by Brusher *et al.* (1984) as caught by anglers in the southeastern US, even though in very low numbers. No information was found on the exploitation status of *Seriola* in Brazil. However, this group, which has a high market value, is commercially caught in some states of northeastern Brazil, such as Sergipe, where annual catches amounted to 22 t in 2013 (Thomé-Souza *et al.*, 2014).

Catches of snappers were represented by *Lutjanus vivanus, L. analis, L. synagris, Ocyurus chrysurus*, and *L. jocu*. According to Frédou *et al.* (2009), except for *L. vivanus*, which was considered 'fully exploited,' all other species are overexploited in northeastern Brazil. A reduction in fishing effort of 80-90% was recommended for these species even before considering the additional effect of recreational fisheries. Thus, catch-and-release for this group may be promoted, but keeping in mind that survival of released fish will be

Table 5. Catches (kg) from offshore fishing competitions in northeastern Brazil. No event occurred in the other six states. Bold entries are reported data, and the others are estimated using photos or number of specimens caught available on the internet. Question marks indicate the occurrence of events but unknown catches.

Year	Rio Grande do Norte	Pernambuco	Bahia	Fernando de Noronha Island	Total
1996	**437**	**0**	**0**	**806**	**1243**
1997	**231**	**0**	?	**1236**	**1468**
1998	?	**0**	?	**1851**	**1851**
1999	**0**	?	?	**1688**	**1688**
2000	**0**	321	?	**682**	**1004**
2001	**0**	?	?	**909**	**909**
2002	**0**	**0**	?	?	**0**
2003	**0**	**0**	?	?	**0**
2004	**0**	**0**	?	?	**0**
2005	**0**	**0**	?	?	**0**
2006	**0**	**0**	?	?	**0**
2007	**0**	**0**	?	?	**0**
2008	**0**	?	?	?	**0**
2009	**0**	**0**	?	?	**0**
2010	?	**0**	?	**0**	**0**
2011	?	**0**	?	**0**	**0**
2012	?	**0**	?	**0**	**0**
2013	?	**0**	?	**0**	**0**
2014	?	191	?	**0**	**191**
2015	**63**	439	?	**0**	**502**

highly dependent on capture depth (*e.g.*, Gitschlag & Renaud, 1994; Brown *et al.*, 2010).

One group that attracts many anglers is billfish. Only three specimens of *Istiophorus platypterus* were caught from 2008 to 2015 in waters off Paraíba State (20 and 27 kg; no information for the third), from December to early February. Catches in Fernando de Noronha Island were much higher, where 123 specimens were caught in competitions from 1996 to 2001, which may be considered a hotspot for this species in Brazilian waters. Commercial fisheries around that island also captures this species but in a low proportion (Lessa *et al.*, 1998); it could be cited as one case were recreational catches might have surpassed commercial catches, considering only competitions. Another area that attracts anglers after large billfishes is Bahia State, in the southernmost part of the study area considered here. However, no information was available to quantify its importance, except for anecdotal evidence (http://www.bahiapescaesportiva.com.br//pesca-na-bahia/marlin-azul.asp). Results presented by Mourato *et al.* (2016) indicate that a slight decline in CPUE of sailfish in competitions is occurring in waters off Bahia State from 2009 to 2014. The assessment of the status of these stocks, as well as other large pelagics, is hampered by incomplete records and by their aggregation with other species (Collette *et al.*, 2011).

Mahon (1999) called attention on the lack of catch reports for *Coryphaena hippurus* originating from recreational fisheries in some countries, including Brazil, from 1970-1997. Here we were able to partially fill this gap, indicating that anglers caught this species in Fernando de Noronha Island (peaking at about 240 kg during a competition in 2001), as well as in the Sates of Rio Grande do Norte (approximately 184 kg in a tournament in 1996) and Paraíba (about 97 kg in 2008-2015).

Offshore recreational catches in northeastern Brazil seem to have reached a peak in 2011. The last three years indicated a stable total catch, but the collection of information on fishing licenses for 2015 onwards will be very important to follow this trend, together with the increasing collaboration of fishing operators currently established in the region.

In comparison with other South American countries such as Venezuela, which have been reporting catch data in some areas since the 1960s (Gaertner & Alió, 1994), Brazil is falling behind in collecting information for this very important sector which is continuously growing, particularly in northeastern Brazil. However, it is ahead of Colombia, which does not present any structured data collection system for recreational fishe-

Table 6. Catch (in kg) and species composition of offshore fishing competitions in Fernando de Noronha Island and Rio Grande do Norte State (1996 to 2001). Question marks indicate the occurrence of events but unknown catches. Dash (-) represents 'not applicable.'

Species	1996	1997	1998	1999	2000	2001	Total catch (kg)	%
Fernando de Noronha Island								
Istiophorus platypterus	49	324	1148	816	364	203	2904	40.5
Sphyraena barracuda	398	540	334	311	124	119	1826	25.5
Thunnus spp.	139	144	189	182	103	144	901	12.6
Acanthocybium solandri	39	118	108	252	27	146	690	9.6
Coryphaena hippurus	106	88	3	118	14	240	569	7.9
Marine fishes nei	32	22	18	8	38	36	154	2.1
Carangidae	43	0	50	0	13	20	126	1.8
Released fish	0	0	0	0	744	0	744	-
Rio Grande do Norte								
Acanthocybium solandri	129	95	?	0	0	0	224	33.6
Coryphaena hippurus	184	18	?	0	0	0	202	30.2
Istiophorus platypterus	65	79	?	0	0	0	144	21.6
Thunnus atlanticus	40	18	?	0	0	0	58	8.7
Sphyraena barracuda	18	15	?	0	0	0	33	5.0
Thunnus alalunga	0	4	?	0	0	0	4	0.6
Katsuwonus pelamis	0	2	?	0	0	0	2	0.3

ries (Alió, 2012). The same holds true for the Equator, even though it is well known that recreational fisheries occur off the coast of that country and some of the species caught are the same reported here for northeastern Brazil (Alava *et al.*, 2015). Chile, on the other hand, started collecting information on catches by sports spearfishers due to increasing interest by commercial spearfishes, resulting in high landings in the last years (Godoy *et al.*, 2010).

The mean expenditure of US$1.5 million by offshore anglers estimated here for northeastern Brazil in 2014 cannot be neglected. If compared to the US$383 million generated by the ex-vessel value of commercial catches in 2007 (IBAMA, 2007), the recreational value seems to be low. However, one should consider that this value is related to the value of both artisanal and industrial commercial fisheries. There are not many studies related to the economic value of recreational fisheries in Brazil, except for Venturieri (2002), Shrestha *et al.* (2002), and Angelo & Carvalho (2007), all related to freshwater recreational fisheries. No information is available for comparison with coastal recreational fisheries in northeastern Brazil up to this moment.

This study, carried out in very close collaboration with one of the operators in the region, is expected to trigger further partnership with other local operators to widen the results obtained in this study. Even though the Ministry of Fisheries and Aquaculture was abolished in late 2015, with its mandate being transferred to the Ministry of Agriculture, Livestock, and Supply, and to the Ministry of Industry, Foreign Commerce and Services in 2017, we hope that some of the initiatives already in place like online issuance of fishing licenses with an appended questionnaire, and other efforts supporting the activity, are not lost, but instead will be further improved and extended to allow for better management of fisheries in Brazil. Thus, many of the recommendations presented by Arlinghaus *et al.* (2016) after the 7th World Recreational Fishing Conference held in Campinas-São Paulo-Brazil may be accomplished for Brazilian waters soon.

CONCLUSIONS

Our results clearly show that catches originating from offshore recreational fisheries in northeastern Brazil are small concerning commercial fisheries. However, the effort is concentrated over a small number of species (against 46 caught in industrial fisheries in the same region), some of which (snappers) considered overexploited in the region. *Seriola rivoliana* is one of the species with the highest catches by anglers, but not much is known about the status of the species. Thus, it is recommended that more information is collected on catches and biological variables for this species in the near future.

Our preliminary assessment of the economic value of recreational fishing suggests that efforts should be directed towards comparisons between recreational and

commercial fisheries. It is also essential that information on the offshore recreational fisheries is made widely available before being lost, as it usually happens with the results of fishing competitions occurring in Brazil. It should be noted that the information provided here is still sparse and several gaps remain. Thus, a joint effort among anglers, scientists, fishing operators, and managers is required to complete the description of offshore recreational fisheries in Brazil and to move towards the analysis of other aspects of this activity as done in other parts of the world. Finally, some limitations of this study should be addressed in other initiatives comparing, for example, catch rates by operators and anglers using their boats, and also the proportion of license holders and non-holders which is currently unknown for northeastern Brazil. This study represents an important benchmark in recording catch data and estimating economic importance of a growing sector in northeastern Brazil. Keeping a thorough collection system of data related to recreational fisheries such as the one in Canada is still far from the local reality, considering that the collection system even for commercial fisheries for Brazil ended in 2007. However, keeping and improving the questionnaire accompanying the fishing license could help to reach a minimum understanding of the recreational sector, complemented with some necessary information to be provided by local studies, as pointed above. Moreover, rigorously implementing the obligation of tournament promoters to report detailed catch data could provide a cheap, plentiful source of information.

ACKNOWLEDGMENTS

We want to thank Michel Machado for providing data on fishing licenses. Samara Cristina for encoding part of the data used in this study. Rodolfo Aureliano Melo for making available all results of oceanic fishing competitions for Fernando de Noronha Island, and Bruna Suellen and Priscila Lopes for providing data for competitions in Rio Grande do Norte State, and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for providing an Estágio Sênior fellowship for the first author (CAPES Fellowship n. 99999.00577 3/2015-06).

REFERENCES

Alava, J.J., A. Lindop & J. Jacquet. 2015. Marine fisheries catch reconstructions for continental Ecuador: 1950-2010. Fisheries Centre Working Paper 2015, 34: 1-25.

Alió, J.J. 2012. Recreational fishery component of the Caribbean Large Marine Ecosystem, large pelagic fisheries case study: southern Caribbean area (Venezuela with notes from Colombia). Caribbean Regional Fisheries Mechanism Secretariat, Belize, CRFM Research Paper Collection, 7: 1-26.

Angelo, P.G. & A.R. Carvalho. 2007. Valor recreativo do rio Araguaia, região de Aruanã, estimado pelo método do custo de viagem. Acta Sci. Biol. Sci., 29: 421-428.

Arfelli, C.A., A.F. Amorim & R. Graça-Lopes. 1994. Billfish sport fishery off Brazilian coast. Col. Vol. Sci. Pap. ICCAT, 41: 214-217.

Arlinghaus, R., S.J. Cooke, S.G. Sutton, A.J. Danylchuk, W. Potts, K.M.F. Freire, J. Alós, E.T. da Silva & I.G. Cowx. 2016. Recommendations for the future of recreational fisheries to prepare the social-ecological system to cope with change. Fish. Manage. Ecol., 23: 177-186.

Barroso, H. 2002. Tempos da pesca. Ediouro, Rio de Janeiro, 248 pp.

Belhabib, D., P. Campredon, N. Lazar, U.R. Sumaila, B.C. Baye, E.A. Kane & D. Pauly. 2016. Best for pleasure, not for business: evaluating recreational marine fisheries in West Africa using unconventional sources of data. Palgrave Commun., 2. doi: 10.1057/palcomms.2015.50.

Brown, I., W. Sumpton, M. McLennan, D. Mayer, M. Campbell, J. Kirkwood, A. Butcher, I. Halliday, A. Mapleston, D. Welch, G.A. Begg & B. Sawynok. 2010. An improved technique for estimating short-term survival of released line-caught fish, and an application comparing barotrauma-relief methods in red emperor (*Lutjanus sebae* Cuvier, 1816). J. Exp. Mar. Biol. Ecol., 385: 1-7.

Brownscombe, J.W., S.D. Bower, W. Bowden, L. Nowell, J.D. Midwood, N. Johnson & S.J. Cooke. 2014. Canadian recreational fisheries: 35 years of social, biological, and economic dynamics from a national survey. Fisheries, 39(6): 251-260.

Brusher, H.A., M.L. Williams, L. Trent & B.J. Palko. 1984. Using charterboat catch records for fisheries management. Mar. Fish. Rev., 46(3): 48-55.

Cisneros-Montemayor, A.M. & U.R. Sumaila. 2010. A global estimate of benefits from ecosystem-based marine recreation: potential impacts and implications for management. J. Bioecon., 12: 245-268.

Coleman, F.C., W.F. Figueira, J.S. Ueland & L.B. Crowder. 2004. The impact of the United States recreational fisheries on marine fish populations. Science, 305: 1958-1960.

Collette, B.B., K.E. Carpenter, B.A. Polidoro, M.J. Juan-Jordá, A. Boustany, D.J. Die, C. Elfes, *et al*. 2011. High value and long life-double jeopardy for tunas and billfishes. Science, 333(6040): 291-292.

Costa-Nunes, J.A.C., D.V. Medeiros, J.A. Reis-Filho, C.L.S. Sampaio & F. Barros. 2012. Reef fishes captured by recreational spearfishing on reefs of Bahia State, northeast Brazil. Biota Neotrop., 12(1): 179-185.

Feitoza, B.M., R.S. Rosa & L.A. Rocha. 2005. Ecology and zoogeography of deep reef fishes in northeastern Brazil. Bull. Mar. Sci., 76(3): 725-742.

Frédou, T., B.P. Ferreira & Y. Letourneur. 2009. Assessing the stocks of the primary snappers caught in northeastern Brazilian reef systems. 1. Traditional modeling approaches. Fish. Res., 99: 90-96.

Freire, K.M.F. 2005. Recreational fisheries of north-eastern Brazil: inferences from data provided by anglers. In: G.H. Kruse, V.F. Gallucci, D.E. Hay, R.I. Perry, R.M. Peterman, T.C. Shirley, P.D. Spencer, B. Wilson & D. Woodby (eds.). Fisheries assessment and management in data-limited situations. University of Alaska Fairbanks, Alaska Sea Grant College Program, Fairbanks, pp. 377-394.

Freire, K.M.F. 2010. Unregulated catches from recreational fisheries off northeastern Brazil. Atlântica, 32: 87-93.

Freire, K.M.F., M.C.S. Bispo & R.M.C.A. Luz. 2014. Competitive marine fishery in the state of Sergipe. Actapesca, 2: 59-72.

Freire, K.M.F., R.P. Lessa & J.E.L. Oliveira. 2005. Fishery and biology of blackfin tuna *Thunnus atlanticus* off northeastern Brazil. Gulf Caribb. Res., 17: 15-24.

Freire, K.M.F., M.L. Machado & D. Crepaldi. 2012. Overview of inland recreational fisheries in Brazil. Fisheries, 37: 484-494.

Freire, K.M.F., J.A.N. Aragão, A.R.R. Araújo, A.O. Ávila-da-Silva, M.C.S. Bispo, G.V. Canziani, M.H. Carneiro, *et al.* 2016a. Brazil. In: D. Pauly & D. Zeller (eds.). Global atlas of marine fisheries. A critical appraisal of catches and ecosystems impacts. Island Press, Washington, 206 pp.

Freire, K.M.F., R.A. Tubino, C. Monteiro-Neto, M.F. Andrade-Tubino, C.G. Belruss, A.R.G. Tomás, S.L.S. Tutui, *et al.* 2016b. Brazilian recreational fisheries: current status, challenges, and future direction. Fish. Manage. Ecol., 23: 276-290.

Froese, R. & D. Pauly. 2017. FishBase. World Wide Web electronic publication. Version (10/2017). [www.fish-base.org]. Reviewed: 20 December 2017.

Gaeta, A.S., J.A. Lorenzetti, L.B. Miranda, S.M.M. Susini-Ribeiro, M. Pompeu & C.E.S. de Araújo. 1999. The Victoria eddy and its relation to the phytoplankton biomass and primary productivity during the austral fall of 1995. Arch. Fish. Mar. Res., 47(2/3): 253-270.

Gaertner, D. & J.J. Alió. 1994. Changes in the apparent abundance indices of billfishes in the Venezuelan recreational fishery off Playa Grande (1961-1990), central Venezuelan coast. Col. Vol. Sci. Pap. ICCAT, 41: 473-489.

Gitschlag, G.R. & M.L. Renaud. 1994. Field experiments on survival rates of caged and released red snapper. N. Am. J. Fish Manage., 14(1): 131-136.

Godoy, N., S. Gelcich, J.A. Vásquez & J.C. Castilla. 2010. Spearfishing to depletion: evidence from temperate reef fishes in Chile. Ecol. Appl., 20(6): 1504-1511.

Heileman, S. 2008. East Brazil shelf large marine ecosystem. In: K. Sherman & G. Hempel (eds.). The UNEP large marine ecosystem report: a perspective on changing conditions in LMEs of the world's regional seas. Nairobi, Kenya, UNEP regional seas reports and studies, 182: 711-722.

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA). 2007. Estatística da Pesca. 2007. Grandes regiões e unidades da federação. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, Brasília, 113 pp.

Lessa, R., L. Sales, M.R. Coimbra, D. Guedes & T. Vaske Jr. 1998. Analysis of landings from the Fernando de Noronha fishery (Brazil). Arq. Ciênc. Mar., 31(1-2): 47-56.

Mahon, R. 1999. Dolphinfish fisheries in the Caribbean region. Sci. Mar., 63(3-4): 411-420.

Mourato, B.L., H. Hazin, F. Hazin, F. Carvalho & A.F. Amorim. 2016. Assessing Atlantic sailfish catch rates based on Brazilian sport fishing tournaments (1996-2014). Bol. Inst. Pesca, 42(3): 625-634.

Paiva, M.P. & O.C. Pires-Júnior. 1983. Temporadas de pesca esportiva e oceânica, ao largo do estado do Rio de Janeiro. Bol. Ciênc. Mar., 38: 1-12.

Pauly, D. 2016. On the importance of fisheries catches with a rationale for their reconstruction. In: D. Pauly & D. Zeller (eds.). Global atlas of marine fisheries. A critical appraisal of catches and ecosystems impacts. Island Press, Washington, pp. 1-11.

Shrestha, R.K., A.F. Seidl & A.S. Moraes. 2002. Value of recreational fishing in the Brazilian Pantanal: a travel cost analysis using count data models. Ecol. Econ., 42: 289-299.

Smith, N.S. & D. Zeller. 2016. Unreported catch and tourist demand on local fisheries of small island Sates: the case of The Bahamas, 1950-2010. Fish. Bull., 114: 117-131.

Thomé-Souza, M.J.F., B.L.F. Carvalho, E.B. Garciov Filho, C.O. Silva, M.S. Deda, D.C.F. Félix & J.C.

Santos. 2014. Estatística pesqueira da costa do Estado de Sergipe e extremo norte da Bahia 2013. Universidade Federal de Sergipe, São Cristóvão, 107 pp.

Venturieri, R. 2000. "Pesque-pague" no Estado de São Paulo: vetor de desenvolvimento da piscicultura e opção de turismo e lazer. Relatório Final. Programa Nacional de Desenvolvimento de Pesca Amadora-PNDPA-Projeto PNUD BRA/97/012. EMBRATUR, MMA, 165 pp.

Received: 21 August 2017; Accepted: 23 March 2018