



# Brazilian recreational fisheries: current status, challenges and future direction

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**Abstract** Recreational fisheries in Brazil have increased in importance and attracted many foreign recreational fishers. The objectives of this article were to summarise the available data on Brazilian recreational fisheries, to discuss some of their features and to analyse how they are performing in different regions compared with international trends. A review of published and unpublished sources together with data from recreational fishing licences was used. The participation rate was low (0.9%). Overall, there was a high diversity of fish species, with the following species/group of species repeatedly reported: *Menticirrhus* spp., *Centropomus* spp., *Cynoscion* spp., and *Micropogonias furnieri* (marine/estuarine water), and *Cichla* spp., *Hoplias malabaricus*, and *Piaractus mesopotamicus*, together with the introduced *Oreochromis niloticus* and *Coptodon rendalli* (fresh water). The north-eastern region differs from the other regions: fishing occurs mostly in marine waters and fishers acquire mainly shore-based licences, have minimum fishing expenditures and rarely release fishes. There is no estimate of the total harvest or economic value. Conflicts include catch-and-release-oriented freshwater and marine recreational fishers vs consumption-oriented coastal fishers, tournament participants vs non-participants, commercial fishers and other leisure activities, pollution, ports, species introductions and translocations, protected areas, and federal and state laws. Cases of smooth shifts from artisanal to recreational fishing were detected, possibly associated with changes in the societal relationship with natural resources.

**KEY WORDS:** angling, competitive events, fisheries management, sport fisheries, tourism, tournaments.

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**Introduction**

Brazil's ichthyofauna includes 3290 freshwater species and 1209 marine species (Froese & Pauly 2015) representing 14% of global fish diversity. This high diversity

is strongly related to the heterogeneity of habitats and climate and provides considerable recreational fishing opportunities. Zeinad and Prado (2012) listed 114 freshwater fish species of some interest for recreational fishers throughout the country. For marine waters, at least 60

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recreational fish species are reported (Anon 2015). The recreational fishery (recreational fisheries) is locally defined as 'the one practiced by Brazilians or foreigners, with gears defined by specific law, for leisure or sport' (MPA 2009).

Recreational fisheries is largely recognised as a socio-economically important activity in countries, such as the USA and Canada (e.g. Ihde *et al.* 2011), but is not fully recognised by governments in many emerging economies, including Brazil, despite its growing reputation as an international fishing destination. Thus, recreational fisheries remain mostly unmanaged or mismanaged in these regions.

The practice of recreational fisheries as a leisure activity in Brazil goes back to at least the 1800s, with the first citation in the book '*Viagem ao Araguaia*' (Magalhães 1863). Fishing clubs have been active for many years. The first shore-based fishing events took place in the 1960s (Freire *et al.* 2014a,b) and oceanic competitive events have been promoted since 1962 off the state of Rio de Janeiro, including an international tournament in 1972 (Barroso 2002). Recreational spearfishing has also been practiced since at least 1970 (Anon 1970). The magazine *Pescatur* was the first one specialising in recreational fisheries and was launched in the early 1970s. The first scientific publications on recreational fisheries in Brazil came out in the 1990s (Arfelli *et al.* 1994; Lewis *et al.* 1999), which corresponded to the period when the visibility of this activity improved. Recently, recreational fisheries have increased in importance in Brazil and recreational catches have surpassed commercial catches in some areas (see, e.g., Catella *et al.* 2008).

Although studies on recreational fisheries have increased in the last few years, this information is dispersed and has not been collated. This contribution summarises available data on Brazilian freshwater and marine recreational fisheries, discusses some of their features and conflicts, and analyses how Brazilian recreational fisheries is performing in different regions compared with international trends.

## Methods

In this study, two components of recreational fisheries are considered: non-competitive and competitive fishing (tournaments, jamborees and championships). For the former, Brazilian recreational fisheries were reviewed based on published and unpublished information (theses, reports and personal communications) in different habitats: freshwater (rivers, lakes and reservoirs) and marine (estuarine, coastal and oceanic). The region is divided into twelve basins as defined by the National Agency of Waters ([www.ana.gov.br](http://www.ana.gov.br)) and this division was used when

referring to freshwater fisheries (Fig. 1): Amazonia (3 869 953 km<sup>2</sup>), Tocantins-Araguaia (918 822 km<sup>2</sup>), Paraná (879 873 km<sup>2</sup>), São Francisco (638 576 km<sup>2</sup>), eastern Atlantic (388 160 km<sup>2</sup>), Paraguay (363 446 km<sup>2</sup>), Parnaíba (333 056 km<sup>2</sup>), eastern north-east Atlantic (286 802 km<sup>2</sup>), western north-east Atlantic (274 301 km<sup>2</sup>), south-eastern Atlantic (214 629 km<sup>2</sup>), southern Atlantic (187 522 km<sup>2</sup>) and Uruguay (174 533 km<sup>2</sup>). To include marine fisheries, information was presented by administrative region (five) and all states within these regions (total of 25 states). Information on the characteristics of recreational fisheries, including a description of the marine and freshwater fisheries, demographic characteristics of licensed anglers, catch composition and catch rates, was collated. Froese and Pauly (2015) was consulted for scientific and English common names as well as species authority.

An updated version of the database originally compiled by Freire (2005) for marine events from 1970 to 2013 was used for competitive events. The database encoded by Santos and Freire (2014) for all Brazilian states was utilized for fresh waters.

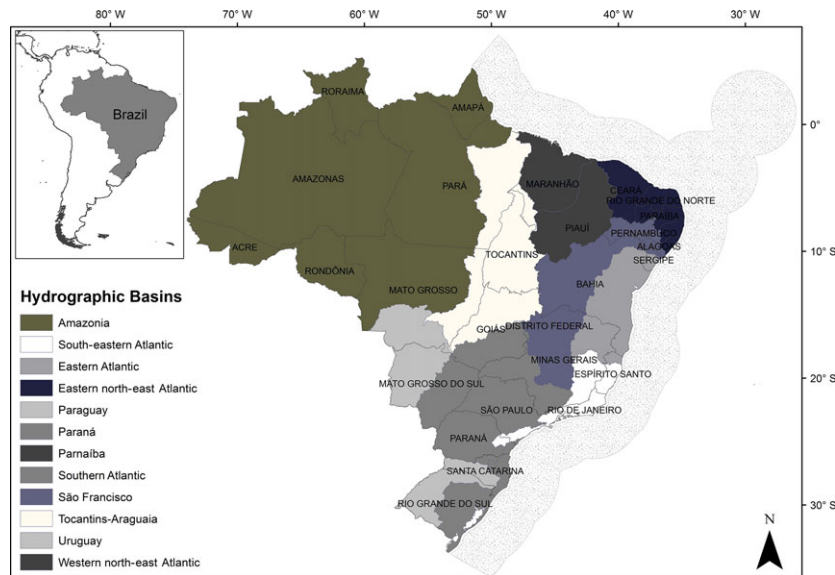
The 2013 database of the Ministry of Fisheries and Aquaculture (MPA) was used for analysis of licences, with the following selected variables: region (north, centre-west, north-east, south-east and south), state, sex, use of natural and/or artificial bait, catch-and-release habits, expenditure, licence type (according to Freire *et al.* 2012), boat ownership, use of fishing guides, fishing habitats (estuarine, coastal, oceanic, mangrove, lake, reservoir, river and fish-and-pay) and hosting location. The licence database was analysed using a multivariate correspondence analysis – CA (Greenacre & Blasius 1994) performed in R software (R Core Team 2014). The relationship between catch-and-release habits (proportion of licensed fishers that usually or sometimes release fishes from the 2013 licence database) and the human development index (HDI) (PNUD/IPEA/FJP 2013) was analysed for all Brazilian states.

Finally, the general legal framework for recreational fisheries in Brazil was described, and some conflicting issues were analysed. Based on comparison of all information presented, future directions for this sector are discussed.

## Characteristics of recreational fisheries in Brazil

*Northern region (states of Amazonas, Pará, Roraima, Amapá, Rondônia, Acre and Tocantins)*

This region, mostly included in the Brazilian Amazonia, emerged as a more recent destination for recreational fisheries in Brazil, which led to the promotion of the



**Figure 1.** Twelve Brazilian basins, as defined by the National Agency of Waters ([www.ana.gov.br](http://www.ana.gov.br)), all of Brazilian states and the Exclusive Economic Zone (EEZ; greyish dotted area).

First Workshop on Recreational Fishery in the state of Amazonas in 2000 (IPAAM 2001). The main target species is the peacock bass (*Cichla* spp.; see Table S1). The average expenditure by visiting fishers is US\$ 3000 for a 7-day trip (October to March) (Freitas & Rivas 2006). Other target species are the following: *Osteoglossum* spp., *Hypophthalmus* spp., *Brycon cephalus* (Günther), *Brachyplatystoma* spp., *Pellona* spp., *Boulengerella* spp., *Hydrolycus scomberoides* (Cuvier) and *Raphiodon vulpinus* Spix & Agassiz (IPAAM 2001). Most of the operations in the region are based on hotel boats, but in some areas with difficult access, fishers arrive by hydroplanes and stay overnight in tents mounted on floating structures. Hotels and jungle lodges are also used (Barra & Crepaldi 2014). Catch-and-release is the dominant practice among national and foreign recreational fishers in the region. Thomé-Souza *et al.* (2014) estimated very low mortality rates for three species of *Cichla*, including *C. temensis* Humboldt (3.5%), *C. orinocensis* Humboldt (2.3%) and *C. monoculus* Agassiz (5.2%), in the basin of the Negro River, which is the largest tributary of the Amazon River.

According to the Amazon State Enterprise for Tourism (Amazonastur), the number of fishing tourists visiting the state of Amazonas has been increasing and reached 7293 in 2011 (Santos undated). A total of 33 recreational fisheries operators were identified in 2013–2014 in all tributaries of the Negro River, according to the Participative Fishery Monitoring Project developed by the Social and Environmental Institute (ISA 2013). Groups are usually formed of 6–15 fishers and 11% are

foreigners. Approximately 50% of these fishers complain about the lack of local infrastructure and surveillance (Barra & Dias 2013).

Despite the high catch-per-unit-effort (CPUE) that is usually reported for the Brazilian Amazonia, fishing pressure has been very intense due to the lack of planning, monitoring and surveillance. The lack of planning leads to a massive exploitation in some areas while others remain under-utilised. The lack of monitoring induces a high fishing effort that can result in over-exploitation of some stocks (decreasing CPUE and fish size). Local recreational fishers have continuously complained about both decreasing CPUE and fish size (Daniel Crepaldi, personal observation), although this effect has not been quantified. Since the 1990s, this has led to the search for unexploited regions in the so-called Legal Amazon and in Protected Natural Areas (PNAs, both Conservation Units and Indigenous Lands) when conflicts arose due to the lack of proper regulation. Since 2009, the Brazilian Institute for the Environment and Renewable Resources (IBAMA) has begun standardised fish stock assessments for the dominant recreational fisheries species in five rivers to propose rules for sustainable use of their resources (see Crepaldi & Machado 2010). These studies confirmed that fish stocks in the PNAs were healthier than those outside the PNAs.

In the state of Pará (Fig. 1), both marine and freshwater recreational fisheries take place and the main target species/groups of species are: *Cichla* spp., *Hoplias malabaricus* (Bloch), Characidae, *Micropogonias furnieri* (Desmarest), *Cynoscion acoupa* (Lacepède) and

*Plagioscion squamosissimus* (Heckel) (Frédou *et al.* 2008). A study with 114 marine and freshwater recreational fishers showed that 70% live in the state of Pará and none was foreigner (Frédou *et al.* 2008). This study also indicated that the state of recreational fisheries was satisfactory with many unexploited areas. Spearfishing was reported in fresh waters with up to 100 kg caught by one fishing group over a single night. According to that study, the lack of infrastructure, including roads, is one of the main obstacles to the development of recreational fisheries. There is also an increasing demand for fish-and-pay operations and the establishment of areas reserved for recreational fisheries may become an important source of conflicts.

For the state of Roraima, Salazar Filho *et al.* (2005) found potential for development of recreational fisheries along the lower Branco River: Água Boa do Univini, Xeruíni and Itapará rivers. They caught mainly *Cichla* spp., *Boulengerella* spp., *Serrasalmus* spp. and *Hoplias* spp. and reported the existence of six lodges already operating with recreational fishers. No information was found for the other four states.

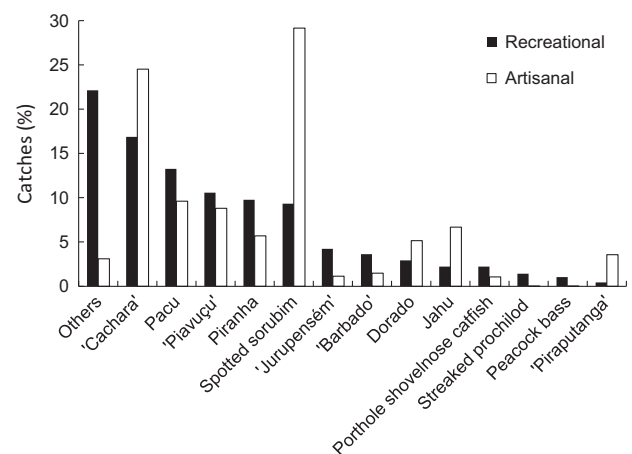
#### Centre-western region (states of Mato Grosso, Mato Grosso do Sul and Goiás)

The Pantanal is an extensive alluvial plain that encompasses 138 183 km<sup>2</sup> and is split between the states of Mato Grosso (48 865 km<sup>2</sup>) and Mato Grosso do Sul (89 318 km<sup>2</sup>), where fishing is a traditional activity of high socio-economic importance. Recreational fisheries are greater in the state of Mato Grosso do Sul (Southern Pantanal), for which most information is available since 1994, based on the Mato Grosso do Sul Fishing Control System (SCPESCA/MS) (Catella *et al.* 2008). Many local artisanal fishers have become fishing guides. Most of the recreational fishers are tourists from the southeastern and southern regions (Albuquerque *et al.* 2013), who use transportation and lodging services offered by regional tourism agencies including the services of luxurious hotel boats. The number of registered recreational fishers reached 59 000 in 1999 but has declined to 14 000 in recent years (Albuquerque *et al.* 2013).

Landing areas for recreational and artisanal fishers are widely spread over the southern Pantanal and thus are difficult to quantify. From 2007 to 2012, under a fishing quota of 10 kg per recreational fisher per trip plus one specimen, the annual median CPUE was 2.7 kg fisher<sup>-1</sup> day<sup>-1</sup> (1.7–3.9 kg) (see Table S1). During the same period, under a monthly fishing quota of 400 kg per artisanal fisher, the annual median CPUE was 8.3 kg fisher<sup>-1</sup> day<sup>-1</sup> (4.7–14.6 kg). In 2012, a total of 173 t (51%) and 165 t (49%) were caught by artisanal and

recreational fishers, respectively. The main species caught by the latter were *Pseudoplatystoma reticulatum* Eigenmann & Eigenmann, *Piaractus mesopotamicus* (Holmberg), *Leporinus macrocephalus* Garavello & Britski, *Pygocentrus nattereri* Kner, *Serrasalmus* spp. and *Pseudoplatystoma corruscans* (Spix & Agassiz). The overlap of species caught by recreational and artisanal fishers is complete, but recreational landings surpass artisanal landings for most species (Fig. 2). From 1980 onwards, some gears were prohibited to artisanal fishers and they started using hooks targeting larger species with higher market value, leading to the overlap with recreational fisheries and ultimately to conflicts (Catella 2007). Another conflict observed is the exclusion of both recreational and artisanal fishers from long stretches of protected areas in local rivers. There has also been an increasing demand for live bait by recreational fisheries, generating a new sector of specialised artisanal fishery and a certain degree of cooperation between artisanal and recreational fishers.

The rivers of the Amazon basin that drain the central and northern regions of the state of Mato Grosso are also an important destination for Brazilian and foreign recreational fishers, but there is little information available about this activity (Arrolho & Muniz 2011). Teles Pires and Juruena rivers are among the main fishing destinations of the region. A survey conducted in 2010 by the City Hall of Alta Floresta, near the Teles Pires River,



**Figure 2.** Proportion of each of the main species caught by recreational (black columns) and artisanal (white columns) fishers in Southern Pantanal in 2012 (based on Albuquerque *et al.* 2013). 'Cachara' = *Pseudoplatystoma reticulatum* (Eigenmann & Eigenmann), 'Piavuçu' = *Leporinus macrocephalus* (Garavello & Britski), 'Jurupensém' = *Sorubim lima* (Bloch & Schneider), 'Barbado' = *Piniirampus pirinampu* (Spix & Agassiz) and *Luciopimelodus pati* (Valenciennes), 'Jurupoca' = Porthole shovelnose catfish = *Hemisorubim platyrhynchos* (Valenciennes), and 'Piraputanga' = *Brycon hilarii* (Valenciennes).

indicated the existence of 18 recreational fisheries-related projects, generating approximately 1250 direct and indirect jobs and accounting for about 14% of the municipal revenues (Arrolho & Muniz 2011). These authors conducted a monitoring programme of fish populations in the Teles Pires River over 3 years using the same gears locally used by recreational fishermen. The most common species/group of species caught were *Cichla* spp. (53.0%), *Zungaro zungaro* (18.3%), *Phractocephalus hemiiopterus* (Bloch & Schneider) (9.3%) and *Pseudoplatystoma tigrinum* (Valenciennes) (3.0%).

Some indigenous lands have become fishing destinations in the Amazon basin of Mato Grosso, generating many conflicts between government institutions (e.g. IBAMA), indigenous populations (e.g. Bakairi and Kayabi) and tourism agencies. Some recreational fishers, tourism agencies and irregular hostels have been fined and prohibited fishing gears and boats have been seized after complaints from indigenous people (IBAMA 2012, 2014). Three hydroelectric plants are under construction in the Teles Pires River in Alta Floresta, which will probably affect its fishing potential (Arrolho & Muniz 2011).

For the state of Goiás, Carvalho and Medeiros (2005) interviewed 40 recreational fishermen in 2003–2004 along the Araguaia River and found a CPUE of 3.2 kg fisherman<sup>-1</sup> day<sup>-1</sup> (SD = 1.7 kg). Twenty one fish species/groups of species were caught and the main ones were: *Pimelodus maculatus* Lacepède, *Triportheus angulatus* (Spix & Agassiz), *Leporinus* spp., *Plagioscion* spp. and *Tetragonopterus argenteus* Cuvier. All of the fishes caught are consumed by fishers, indicating that catch-and-release is not a popular practice. The estimated economic value of this river in terms of recreational fisheries was US\$ 6.3 billion (Angelo & Carvalho 2007), which is probably an overestimate.

*North-eastern region (states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia)*

Freire (2005), using questionnaires distributed among recreational fishers in fishing clubs/associations and shops, found that none of the respondents fished only in fresh waters, 38% were restricted to marine waters, and most of them fished in both areas. Thus, marine recreational fisheries are predominant, with most fishers engaged in coastal/estuarine fisheries.

There is no information on catch composition for non-competitive fishing. Nunes *et al.* (2012) analysed information on catch composition of spearfishing activities off the state of Bahia in 2006–2008. Forty-eight

species were caught with dominance of *Scomberomorus brasiliensis* Collette, Russo & Zavala-Camin, *Sphyaena barracuda* (Edwards), *Lutjanus jocu* (Bloch & Schneider) and *Caranx bartholomaei* Cuvier (56% of total catches). More recently, oceanic fisheries have increased in popularity in the states of Rio Grande do Norte, Paraíba, Pernambuco, Sergipe and Bahia (Gustavo Adelino, Zagaia Pesca Oceânica, personal communication).

Only one charter operation in fresh water was found in north-eastern Brazil, which recently started activities in the state of Sergipe and targets mainly snooks (Marcos Seabra, Sport Fishing Sergipe, personal communication). Another area that has attracted recreational fishers is the Castanhão Dam in the Jaguaribe River (state of Ceará). Its construction began in 1995 and took 8 years to be completed (Oliveira *et al.* 2014).

Many coastal and oceanic fishing events occur in the region and detailed information is provided below.

*South-eastern Region (states of Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo)*

The importance of recreational fisheries in the state of Minas Gerais has increased in recent years (Freire *et al.* 2012). However, no information on the characteristics of recreational fisheries in this state was found, except for the impact of the translocation of some species, such as *Plagioscion squamosissimus* (Sciaenidae) and *Parachromis managuensis* into the Doce River, which are expected to affect the native biodiversity negatively similar to other introduced species listed in Barros *et al.* (2012).

For the state of Espírito Santo, the only study found referred to coastal fisheries (Chiappani 2006). In 2005–2006, two of the 25 species caught were responsible for most of the catches, *Conodon nobilis* (L.) (17%) and *M. littoralis* (14%), despite the main target being *Trachinotus* spp. The mean CPUE reported was 2.3 and 36.6 g fisher<sup>-1</sup> h<sup>-1</sup> on the beach and a pier, respectively, and shrimp was the main bait (52%).

Most of the information available for the region refers to the states of São Paulo and Rio de Janeiro. With the growing crisis in commercial fisheries, some artisanal fishers have become fishing guides. Previous studies reported a strong overlap of target species between recreational and artisanal fishers in Guanabara Bay (*M. furnieri*, *Cynoscion* spp., *Pomatomus saltatrix* (L.), *Caranx* spp. and *Priacanthus arenatus* Cuvier, Tubino *et al.* 2007). However, considering the ten top species targeted by commercial fishers in the state of Rio de Janeiro (FIPERJ/MPA/UFRJ undated), only *M. furnieri* is of any interest for recreational fishers.

In the state of São Paulo, catch statistics originating from industrial and artisanal fisheries have been reported since the 1940s (DPA 1946). Currently, the Fisheries Institute (*Instituto de Pesca*) is responsible for collecting information on commercial catches for the entire state. However, there is no collection system for recreational catches, except for some isolated initiatives. The Iguape and Cananéia Lagoon-Estuarine Complex (LEC), located in the southern part of the state of São Paulo where the highest number of artisanal fishers is found (Mendonça & Cordeiro 2010), has attracted a growing number of recreational fishers. The target species are *Centropomus undecimalis* (Bloch), *C. parallelus* Poey, *Cynoscion leiarchus* (Cuvier) and *C. acoupa*, with a mean CPUE of 2.8 kg fisher<sup>-1</sup> day<sup>-1</sup> (Moro *et al.* 2010). There is no management plan for recreational fisheries in this region, which has caused increasing conflicts (Mendonça & Parada 2014). Only half of the recreational fishers have fishing licences and many of them are not aware of catch quotas and minimum size limits (Barcellini *et al.* 2013).

Recreational fisheries are also important in the coastal area adjacent to this LEC. Based on 16 recreational fishing operations monitored in 2009, 29 species were caught, but only a few represented most of the catches: *Cynoscion microlepidotus* (Cuvier), *Scomberomorus brasiliensis*, and *Centropomus parallelus*. Recreational fisheries are boat-based and usually involve three people (one guide plus two recreational fishers using rod-and-reel) (Garrone-Neto *et al.* 2014). Sardine (Clupeidae), squid (Loliginidae) and shrimp (Penaeidae) are the most commonly used bait in association with artificial lures.

Most of the marine recreational fishers in the southeastern region are elder males (41–50 years old) with monthly incomes of US\$ 1111–2222 (Barcellini *et al.* 2013; Tsuruda *et al.* 2013; Tubino *et al.* 2013; Belruss 2014). They go fishing for 6–24 h and spend US\$ 8.40–83.12 per fishing day (Table 1 in the Supplementary Material). Usually, more than 25% of the recreational fishers do not have fishing licences.

Freshwater fishing in the state of São Paulo is practiced mainly in reservoirs and free stretches of major rivers. The number of recreational fishers has been increasing in reservoirs and rivers such as Paraná, Grande, Paranapanema, Tietê, Mogi-Guaçu and Pardo (Santos *et al.* 1995; Castro *et al.* 2006). Freshwater recreational fisheries are shore or boat-based. For boat-based activities, fishers rent boats and tackle, and hire fishing guides to fish in the former three rivers. In large dams (Jupiá, Barra Bonita and Promissão), commercial fishing is dominant, although recreational fishers are found over the weekends (Petreire *et al.* 2002). Fish-and-pay is practiced in privately owned tanks or ponds (Castro *et al.* 2006) and represents an alternative for

areas with intensive fishing pressure (Venturieri 2002). However, fish escapement may lead to the spread of non-native species (Fernandes *et al.* 2003). Agostinho *et al.* (2003) reported the occurrence of recreational fisheries throughout the year in the Upper Paraná River Basin where fishers target mainly *Salminus maxillosus* (Cuvier), *Brycon orbignyanus* (Valenciennes), *P. mesopotamicus*, *Leporinus elongatus* Valenciennes, *Leporinus obtusidens* (Valenciennes), *P. corruscans* and *Zungaro zungaro* (Humboldt). However, there are no data available on the yield of these fisheries.

According to Adalberto F. de Oliveira Filho (personal communication), a member of the Federation of Sport Fishing of the State of São Paulo (<http://www.fppl.com.br/>), peacock bass (*Cichla* spp.) is targeted by recreational fishers along the Tietê River and many other large rivers in 19 municipalities of the state of São Paulo. In this area, there are 211 lodges and recreational fisheries generate revenues of US\$ 305–570 million per year with over 4000 people directly employed (April/2014 survey). Information on catch composition is available for some reservoirs, such as Lobo-Broa and Emas Waterfall (Mogi-Guaçu), as well as Tietê, Paraná, Paranapanema and Grande rivers: *Cichla* spp., *Geophagus brasiliensis* (Quoy & Gaimard), *Coptodon rendalli* (Boulenger), *Oreochromis niloticus* (L.), *Gymnotus carapo* L., *H. malabaricus*, *Serrasalmus marginatus* Valenciennes, *Rhamdia quelen* (Quoy & Gaimard), *Plagioscion squamosissimus* (Heckel) and *Salminus brasiliensis* (Cuvier) (Peixer 2008; Pereira *et al.* 2008; Castro *et al.* 2009; AES-Tietê 2011; Maruyama *et al.* 2014).

Fisheries targeting live bait occur in flooded, shallow areas covered with vegetation along the slopes of rivers and reservoirs of the state of São Paulo. A total of 60–80 fishers are involved in catching at least 17 bait types along the Middle Tietê River but mostly *Gymnotus* spp., snail and shrimp (Castro *et al.* 2014). Fishers catch 200 specimens per day (US\$ 1.00–1.50 specimen<sup>-1</sup>) and all specimens are sold alive directly to recreational fishers, indirectly through middlemen or even in live-bait shops.

The main problems are pollution (garbage, industrial and domestic sewage, and pesticides), the change in water level, a decline of fish stocks caused by high fishing effort, dam construction, unsustainable practices (such as capture of individuals below maturity size), and conflicts between commercial and recreational fishers, fishers vs the environmental police, and professional artisanal vs illegal fishers (Paula Gênova, personal observation).

#### *Southern Region (states of Paraná, Santa Catarina and Rio Grande do Sul)*

No published study was found dealing specifically with recreational fisheries in the state of Paraná. Nonetheless,

in the estuarine region, boat-based fishers are observed with similar characteristics of neighbouring states (São Paulo and Santa Catarina). Thus, based on the similar catch composition in these states (Menezes *et al.* 2012; Barcellini *et al.* 2013), one expects that snooks (*C. undecimalis* and *C. parallelus*) and weakfishes (*Cynoscion* spp.) are also the main species caught in the estuaries of Paraná. Several competitive fishing events targeting snooks support this hypothesis (Moro 2008).

According to Deodato Pereira and Edson Deconto (personal communication), co-founders of the Association of Fishers with Artificial Lures from Paraná (APIA-PAR) in the 1980s, boat-based recreational fisheries are also practiced in dams along the Iguazu River. In these dams, *H. malabaricus*, *O. niloticus* and *C. rendalli* are the main target species. *Cichla* spp. are targeted in the Itaipu Dam.

For the state of Santa Catarina, Schork *et al.* (2010) reported information on boat-based recreational fishers off the northern coast, who catch *Menticirrhus* spp., *Coryphaena hippurus* L., *Orthopristis ruber* (Cuvier), *Sphyraena guachancho* Cuvier, *P. saltatrix* and *Trichiurus lepturus* L. Fishers are mainly men, fish for 6–24 h, and most do not have a fishing licence (75%). According to Menezes *et al.* (2012), 30 species were caught in estuaries by boat-based fishers, mainly *C. undecimalis*, *C. parallelus* and *Cynoscion* spp. Approximately 40% of these fishermen did not have a fishing licence.

The earliest published information on recreational fisheries for the state of Rio Grande do Sul was Lewis *et al.* (1999), who reported catches of 31 fish species/groups of species off the Cidreira Pier, mainly *M. littoralis*, *M. americanus* (L.), *Paralichthys brasiliensis* (Steindachner), *M. furnieri*, sharks and rays (Carcharhinidae, Myliobatidae, Rhinobatidae, Rhinopteridae and Sphyrnidae). According to Peres and Klippel (2005), recreational fisheries are mainly shore-based and fishers use mostly a rod-and-reel, with some similarities between the northern and southernmost regions, where catches are dominated by juvenile *Menticirrhus* spp., with total annual recreational fisheries catches of 1.0–2.5 t in the latter (Basaglia & Vieira 2005). The middle area is the least known and includes the Lagoa do Peixe National Park where recreational fisheries is not allowed, but it is very intense in the surf zone next to the park. Harayashiki *et al.* (2011) also included *M. furnieri* in the list of target species. Moreover, there are groups targeting rays and sharks during the night. Condini *et al.* (2007) found that *Epinephelus marginatus* (Lowe), a species included in the IUCN list, is caught by both recreational (19%) and artisanal (81%) fishers off the Patos Lagoon jetties (73% of all specimens that were caught with a handline in Jan-Feb 2006 were juvenile females).

### Marine and freshwater competitive fishing events

For marine events, which are usually promoted by fishing clubs/associations, the results are currently reported on their web pages and include the number of specimens caught, their total weight, and the number of points per fisher. Catches amounted to 6.5–7.9 t yr<sup>-1</sup> during the period of higher catches (2002–2007) (Fig. 3). Most of the recreational competitions ( $n = 123$ ) were held in 2007 (Fig. 4), which is certainly an underestimate. The results presented here are partial because the missing values were not estimated, except for events in the state of Sergipe (Freire *et al.* 2014a). Catch-and-kill is the main feature of these events, but there is no information on catches per species. However, organisers report the weight of the heaviest fish (168 common names, although 85% of the heaviest specimens had no associated name). Species/families with more than 100 records were as follows: Rajiformes, Tetraodontiformes, Ariidae, *Polydactylus* spp., Haemulidae, *Menticirrhus* spp., Carangidae, *Trachinotus* spp. and *Eucinostomus* spp.

Catches from oceanic competitive events targeting tuna and tuna-like fishes off the coasts of Rio de Janeiro, São Paulo and Espírito Santo include mainly *Istiophorus platypterus* (Shaw), *C. hippurus*, *Thunnus albacares* (Bonnaterre), *Katsuwonus pelamis* (L.), *Makaira nigricans* Lacepède, *Acanthocybium solandri* (Cuvier) and *Kajikia albida* (Poey) (Arfelli *et al.* 1994; Amorim & Silva 2005; Amorim *et al.* 2009). Oceanic events have also been organised off the coasts of the states of Rio Grande do Norte, Pernambuco (including Fernando de Noronha Island) and Bahia (Freire *et al.* 2014a,b). However, no details on species composition have been reported.

A few studies were conducted to provide details on the catch composition of coastal competitive events. Only marine shore-based competitive fishing events are promoted in the municipality of Ilhéus (southern Bahia).

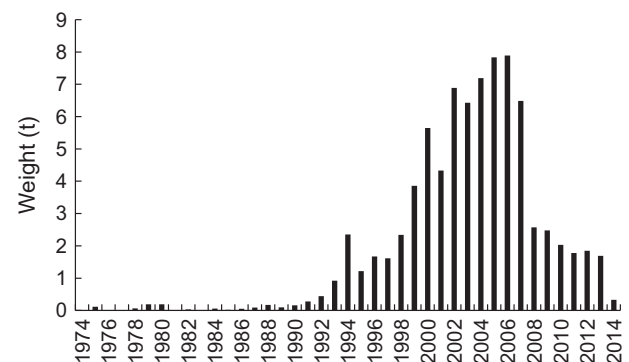
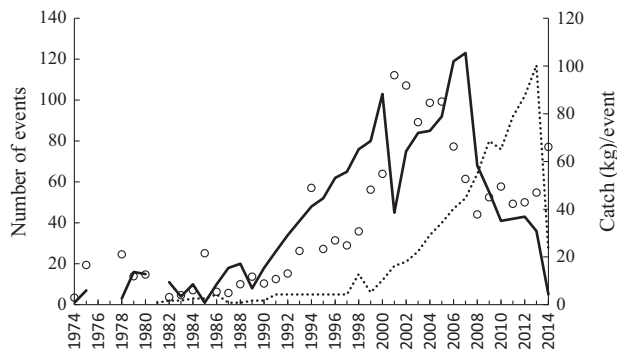


Figure 3. Weight of all of the specimens caught in fishing events conducted in marine waters off Brazil.





**Figure 4.** Number of fishing events in marine water (black line) and fresh water (dotted line), and catch (kg)/event (white circles) in 1974–2014 off Brazilian waters.

Nascimento (2008) analysed the catch composition of all of these events in 2007 and found that approximately 180 kg of *Cathorops* spp., *Eucinostomus melanopterus* (Bleeker), *Trachinotus goodei* Jordan & Evermann, *Menticirrhus littoralis* (Holbrook), *Atherinella brasiliensis* (Quoy & Gaimard), *Genidens genidens* (Cuvier) and *Trachinotus carolinus* (L.) among others, were caught (6043 specimens). In the state of Rio Grande do Norte, competitive events were promoted along the entire coast. According to Alves (2011), a total of 326 kg (6998 specimens) were caught in 2009 and were mainly represented by *Pomadasys corvinaeformis* (Steindachner), *Sciaedes couma* (Valenciennes), *Dasyatis guttata* (Bloch & Schneider), *M. littoralis* and *Colomesus psittacus* (Bloch & Schneider). Freire *et al.* (2014a) found that 1.8 t were caught in coastal competitive fishing events off Sergipe in 1998. However, details on the catch composition were not provided by recreational fishers, except for the heaviest specimens caught: Rajiformes, Ariidae, Tetraodontidae, *Diapterus* spp., *Caranx hippos* (L.), *Conodon nobilis* (L.), *Centropomus* spp., *Trachinotus* spp. and *Lobotes surinamensis* (Bloch).

Moro (2008) estimated a CPUE for snooks caught in competitive fishing events in the state of Paraná of about 328 g boat<sup>-1</sup> h<sup>-1</sup>. Based on specimens sampled in these events, it was also possible to estimate growth parameters for *C. parallelus*. In the state of Rio Grande do Sul, the Mampituba River has also been attracting recreational fishers targeting snooks, which include catches during competitive fishing events (UGAPE 2015).

A total of 117 events occurred in fresh waters in 2013, which were mostly promoted by government institutions. Missing values are more common for these events, which are mostly catch-and-release (82%), use artificial bait (89%) and are boat-based (71%). The maximum number of fishes is set at 3–12 per fisher, depending on the event, which is a feature that is never observed in marine events. For most events, 1–5 species

are defined as the target: *Cichla* spp., *Micropterus salmoides* (Lacepède), *P. mesopotamicus*, *Plagioscion* spp., *H. malabaricus*, *C. rendalli* and/or *O. niloticus*, *Salminus* spp., *Astyanax* spp., *Serralmus* spp., *Oncorhynchus mykiss* (Walbaum) and *Pseudoplatystoma fasciatum* (L.). A total of 10–2400 recreational fishers have participated in these events (1–4 fishers per team).

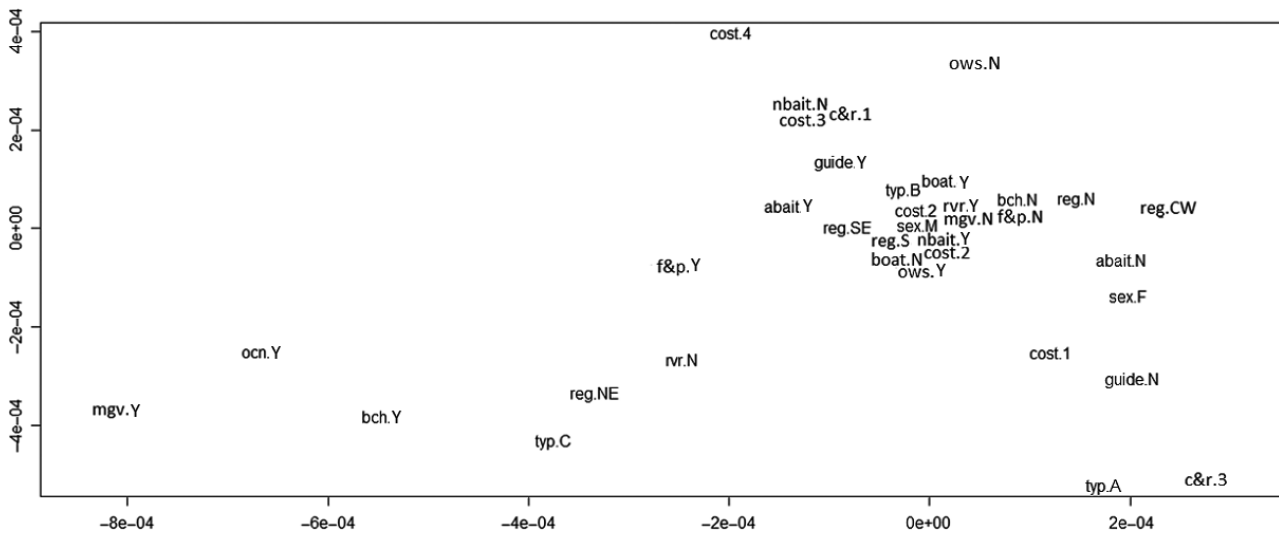
#### Patterns among licensed recreational fishers

A total of 401 550 licences were issued in 2013 for foreigner and Brazilian recreational fishers (263 222 records after eliminating errors in the licence database). The CA analysis separated the north-eastern region from the other four regions due to the following characteristics (Fig. 5): fishers fish mostly in the ocean, mangroves and beaches, but less in rivers; they acquire mainly type A licences (shore-based), and thus, fishing guides are not necessary; fishing expenditures are minimal (US\$ 111 in average); and most fishers never release the fishes. A total of 78 type-C licences were issued in 2013 despite being eliminated in 2012.

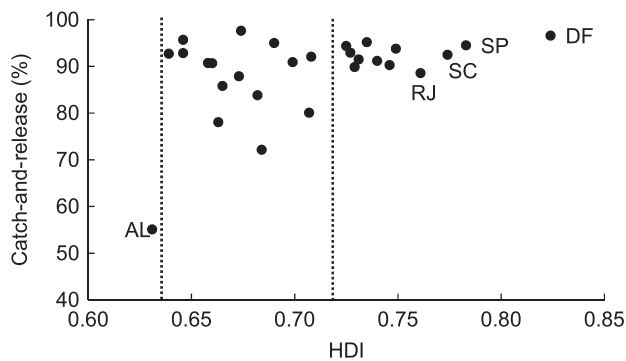
In countries such as the USA, catches originating from recreational fisheries keep increasing (Ihde *et al.* 2011). However, Arlinghaus (2014) argued that societal-level values shift when urbanisation increases and values such as the conservation of wildlife are emphasised. Thus, the effect of the Human Development Index (HDI) on the percentage of recreational anglers stating that they always or only sometimes release fishes was tested for each Brazilian state using the licences issued in 2013. No general association between these two variables was found (Fig. 6). However, the lowest HDI was observed for the state of Alagoas, in the north-eastern region, where only 55.1% of recreational fishers release fish at least occasionally. On the other hand, the highest HDIs were found for the Federal District, São Paulo, Santa Catarina and Rio de Janeiro, all of which have a high proportion of fish releasers (>88.5%). HDI is not the only factor influencing catch-and-release behaviour, but there are also many others including historical and contemporary norms and the conservation status of species. However, HDI was the only one that could be easily analysed on a national scale with available data. It is important to follow changes in this relationship through time and access the effect of other factors locally.

#### Governance of recreational fisheries

According to the Brazilian Constitution, natural resources from the ocean, rivers and lakes belong to the State. Federal and state laws regulate fisheries in these areas. The latter occurs only in waters under the domain



**Figure 5.** Results of the correspondence analysis applied to 263 222 licences issued in all of the Brazilian states in 2013. Mgr = mangrove, ocn = oceanic fishery, bch = beach (coastal fishery), rvr = river, reg = region (N = north, NE = north-east, SE = south-east, S = south, CW = centre-west), cost (1 = very low to 4 = very high), nbait = natural bait, abait = artificial bait, f&p = fish-and-pay, c&r = catch-and-release (1 = always, 2 = sometimes, 3 = never), ows = fish in their own state, boat = boat-based fisher, guide = make use of fishing guides, sex = masculine (M) or feminine (F), and Y = Yes, N = No.



**Figure 6.** Relationship between the percentage of recreational fishers always or sometimes releasing fish, and the Human Development Index (HDI) for each Brazilian state (including the Federal District – DF). AL: Alagoas, RJ: Rio de Janeiro, SC: Santa Catarina, and SP: São Paulo.

of its states, and state legislation should be stricter than federal. On the national level, recreational and commercial fisheries have always been managed by the same institution. Thus, when the first recreational fisheries regulation was introduced in 1934, fisheries management was under the department of the Ministry of Agriculture (MA). Later, the more autonomous SUDEPE (Superintendence for Fisheries Development) was responsible for fisheries management, but still under the MA. In 1989, the Brazilian Institute for the Environment and Renewable Resources (IBAMA) was created and became responsible for managing Brazilian fisheries. In 2009, the Ministry of Fisheries and Aquaculture (MPA) was

founded and shared that responsibility with the Ministry of the Environment (MMA). In October 2015, the MPA was extinguished and fisheries management is back again under the MA.

The first Brazilian legal instrument concerning recreational fisheries was created in 1934, which established a mandatory licence for recreational fishers and prohibited selling their catches. In the 1960s, Law N.5197 (1967), Decree N.221 (1967, known as Fishing Law), and Decree N.65005 (1969) were established during a period characterised by rapid development in both commercial (SUDEPE/PDP 1976) and recreational fisheries. Decree N.221 established a list of the permitted fishing gears (excluding any kind of seine) and a bag limit of 50 kg plus one fish for marine and fresh waters. In 1989, this limit was reduced to 30 kg plus one fish. In 2003, the bag limit was decreased again to 10 kg when fishing in fresh water and 15 kg in marine water, plus one fish (any species), which is currently the adopted regulation. In 1988, Federal Law N.7679 introduced the minimum size and closed seasons and areas as regulatory measures.

In relation to fresh water, all of the measures defined above were intended to be basin-based (although not mandatory). By 2009, seven out of the twelve major Brazilian basins had their own stricter set of rules. Overall, the generic regulation applies to the remaining states. In 2009, Federal Law N.11959, known as the New Fishing Law, established that all fishery and aquaculture regulations were supposed to be defined using a co-man-

agement approach (between MPA and MMA). These regulations could include, among other measures: access regimes, total allowable catch, sustainable fishing effort, closed seasons and areas, catch size, allowed fishing gears and methods, and protection of individuals during their reproduction process or recovery.

Two national meetings, the First National Meeting on Recreational Fisheries (MPA 2010) and the National Seminar on Prospecting Demand of Supply Chain in Fisheries, were organised by the Brazilian government in recognition of the need to increase societal participation in the management of recreational fisheries (Prythor *et al.* 2012). The first aimed to identify demands and priorities established by democratically elected representatives of the recreational fisheries sector for all Brazilian states, and the second one concentrated on demands of research and development identified by scientists and managers. However, recreational fishers are not organised into strong, well-represented entities, and are often not properly represented before management decisions are made. Contrary to the legal framework establishing co-management in Brazil in 2009, the government/society council that should address recreational fisheries management has never been put into practice. Finally, the participation of experts in fisheries and fish populations in discussions regarding recreational fisheries is very restricted, more so than for commercial fisheries. Thus, decisions are made based on industry operators, associations without scientific support, and politicians, which has contributed to the existence of a management system deprived of a scientific basis in many cases.

### Challenges and future direction

The analysis of Brazilian recreational fisheries resulted in the compilation of information on several initiatives spread throughout the entire country and showed some important insights on the future direction of recreational fisheries.

- While the two recent national meetings indicated that the government is increasingly recognising the importance of recreational fisheries, the relevance of recreational fisheries research should also be understood for the establishment of a sound management plan in cognisance with other fishing sectors (artisanal, industrial and subsistence) and stakeholders. This includes the economic assessment of recreational fisheries because currently, there are only a few local studies available.
- In many regions, commercial and recreational fishers share common fishing grounds and target species. Thus, actions to reduce conflicts and maintain the health of fish stocks are required, including zoning, effective supervi-

sion, training of fishing guides and fishers, and expansion of the fisheries monitoring system;

- Recreational fishers should be informed or reminded of 'good fishing practices' through education programmes, and these would include impacts of stocking, legal minimum and maximum size, and the danger of the introduction and translocation of species. The translocation of *Cichla cf monoculus*, *Astronotus ocellatus* (Agassiz) and *Pygocentrus nattereri* Kner into the River Doce State Park led to decreased fish diversity with the disappearance of some species and reduction of the mean weight of others (Latini & Petrere 2004 and references therein). IBAMA regulation N.145-N (October 29, 1998) on introduction and translocation should be revised to include recreational species.

- Recreational fisheries cannot be referred to as a homogeneous group with similar behaviour and needs; thus, subgroups should be defined along with the need to conduct research for those specific subgroups accessed, for example freshwater vs marine fishers, competition participants vs non-participants and spearfishers. The latter have been marginalised by some conservationist groups contrary to the practice of spearfishing.

- If catch-and-release is to be promoted, studies on the lethal and sublethal effects of releasing the species caught in Brazilian waters are necessary through partnerships.

- Remodelling the questionnaire provided together with the fishing licence is needed where all fields should be required and validations introduced to avoid the high number of errors found in this study;

- The federal government is expected to move towards a system of collection of catch statistics that includes those originating from recreational fisheries, following an international trend (see recommendation in FAO 2012), which is a major challenge considering that the system for compiling commercial catches has collapsed since 2008. If a new or remodelled system is to be created, recreational fisheries should be embedded from the beginning, including partnerships among fishing clubs/associations, associations of commercial fishers, MPA, IBAMA, *Instituto de Pesca* and hydroelectric companies with guaranteed funds;

- Bait-fishing has emerged as a new subsector in commercial fisheries to meet the demand of recreational fishers in some regions. However, there is a need for the regulation of this activity, including a system of collection of the catch statistics.

It should be stressed that this is the first time that Brazilian scientists have worked together to analyse Brazilian marine and freshwater recreational fisheries. This undertaking was only possible due to the 7th World Recreational Fishing Conference hosted in Brazil in 2014 (the

first time in South America), which permitted most of the Brazilian recreational fishing-related scientific community to unite together with an international group of specialists. However, the participation of emerging economies was still timid. Organising all of the diverse information available was not an easy task, and scientists should move towards regional initiatives to fill missing information gaps using similar methodologies and later move towards initiatives that also involve other countries in South America.

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### Supporting Information

Additional Supporting Information may be found in the online version of this article:

**Annex S1** Selected translated questions from the recreational fishing license included in the analysis of the fishers' profile and their respective answer options.

**Table S1** Descriptive parameters of the Brazilian recreational fisheries.