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Biological and socio-economic aspects of recreational fisheries and their implications for the management of coastal urban areas of south-eastern Brazil

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Abstract A total of 442 anglers in a coastal region of SE Brazil were interviewed to obtain information about recreational fishing. The anglers were mature individuals (mean age ≈43 years) with a high level of education. However, many did not have a fishing licence. Target fishes belonged to 47 species. Mean catch (Catch per unit effort - CPUE) was 4.2 fish^{-1} day^{-1} or 488 g^{-1} angler^{-1} day^{-1}. Total estimated catch in the study period was equivalent to 2% of commercial landings, indicating that recreational fishing has little impact on fish stocks. The anglers complained that fishing conditions had worsened because of environmental degradation. Catch-and-release was classified as a 'good' attitude despite reports of practices that caused suffering to fish. However, when asked about prohibition of catch-and-release, which is enforced in some countries, the anglers said they would not accept such a prohibition if proposed by Brazilian fishing authorities. As a general rule, issues related to animal welfare and animal rights are not discussed widely by society or by fishing authorities in Brazil. Suggestions for integrated management of coastal resources and for monitoring recreational fishing are presented.

KEYWORDS: anglers, biodiversity conservation, fisheries management, recreational fisheries, Santos estuary.

Introduction

Different fishing modalities (commercial, recreational and subsistence) cause different pressures on fish stocks (Pitcher 1999; Netto & Mateus 2009). While commercial fishing has always been considered the main cause for declines in stocks, increase in recreational fishing suggests that this modality could also contribute to reduction of some target species in particular locations (Coleman *et al.* 2004; Cooke & Cowx 2006; FAO 2012). Traditionally, recreational fishing is not monitored with the same rigour as commercial fishing (Lloret *et al.* 2008).

Recreational fishing is a complex subject as it includes catch-and-release, catch-and-keep, hook and line, netting

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and spearfishing and is characterised by different management, demographic and environmental education traits. It may also involve tournaments, in which people win prizes (Wilde *et al.* 1998). Strictly, recreational fishing is carried out for sport and leisure without any commercial purpose and with a secondary objective of capturing fish for personal consumption (FAO 1997). It can generally be characterised by high effort and low catchability, while commercial fishing is the opposite (Cooke & Cowx 2006). However, the impact of recreational fishing on fish stocks can be measurable and comparable to that of commercial fishing (Cooke & Cowx 2004, 2006; Figueira & Coleman 2010; Freire 2010). For example, Coleman *et al.* (2004) found that fish stocks have declined in several coastal regions of the United States and that recreational fishing contributed to this decline. In Norway, Moksness *et al.* (2011) found that although sport fishing has become an important part of the tourism industry and has local economic benefits, measures are needed to limit its adverse effects on the local ecosystem. Cooke and Cowx (2004) estimated that sport fishing around the world represented 12% of global fish yield. Catella (2003), reviewing the history of fishing in the Pantanal (Brazil), found that recreational fishing accounted for 76% of the number of fish caught or 75% of the yield.

Data on Brazilian recreational and commercial fisheries are scarce for many species, particularly small-scale coastal marine fisheries. Indeed, with a few exceptions, most small-scale freshwater fisheries around the world are illegal, unreported and unregulated (IUU) (http://www.nmfs.noaa.gov/ia/iuu/iuu_overview.html, accessed on 6-18-2015).

Recreational fishing in Brazil is widespread in freshwater environments, such as rivers and reservoirs in the Amazon and Pantanal biomes. Coastal marine environments are also exploited, but again little is known about catch and effort. In general, there is a lack of biological, social and economic information (Freire 2005a,b), making suitable planning and management difficult (Freire 2005a,b, 2010; Pereira *et al.* 2008; Brasilia 2010; Cowx *et al.* 2010).

Urban fisheries in Brazil are a source of extra income and protein for the poor yet are rarely studied (Godinho *et al.* 1992; Minte-Vera & Petrere Jr, 2000; Petrere Jr *et al.* 2006). They can enhance local economies, generating benefits (and causing problems) and increasing environmental awareness even for non-anglers (Schramm & Edwards 1994).

This article examines recreational fishery data (collected in personal interviews) for the Baixada Santista coast (SE Brazil). The analysis takes into account anglers' socio-economic status and technical information about the fishing itself. Baixada Santista, being one of the most populated subregions in SE Brazil, is not only highly industrialised and home to the most active port in Latin America, but also an important beach resort and commercial centre that attracts visitors all year round.

Materials and methods

Baixada Santista is a macroregion covering an area of 2373 km^2 with a permanent population of 1.7 million people that can double in the summer. The Santos-São Vicente estuarine system in the Baixada Santista contains the largest port and petrochemical industrial complex in South America. These cause severe environmental degradation, especially in what is the largest concentration of mangroves in the State of São Paulo (CETESB 2004; Pinheiro *et al.* 2008; Sampaio & Ferreira 2008).

To study recreational fishing in this area, data were collected in seven locations in four municipalities during interviews with sport fishers who fished along the shoreline but not in boats (Fig. 1). The seven locations were chosen because they have the most fishers in the region, they can be easily reached and recreational fishing in these locations has not been described to date. Spots 1, 2 and 3 are located on the beach itself; 4 is a boat ramp in an estuary habitat; and 5, 6 and 7 are fishing decks among coastal rocks with facilities such as public bathrooms, an access ramp for wheelchairs, benches and night-time illumination. All the spots potentially have different fish catching opportunities as they constitute different habitats.

Anglers were interviewed between March and October 2012 at random times during the day. Using a random numbers table, the day of the week or weekend and one of the following three periods of the day was chosen: morning (07:00–12:00), afternoon (15:00–20:00) and night (22:00–03:00). To characterise the anglers, their age, sex, education, profession, residence, distance travelled and lodging type were collected. Information about fishing activity, including whether the anglers had a fishing licence, how many years they had been fishing, the average duration of a fishing trip, the average number of fish caught on a trip, average number of partners they went with on a fishing trip, frequency of their fishing trips, reasons for choosing the particular location; target species and quality of the fishing spot compared with previous years were collected. With the fishers' permission, the fish they caught were counted and weighed (g) but not measured because of lack of convenient facilities and also because the fishers suspected the interviewers might be government inspectors trying to find them for catching fish below the minimum legal size. Mandatory

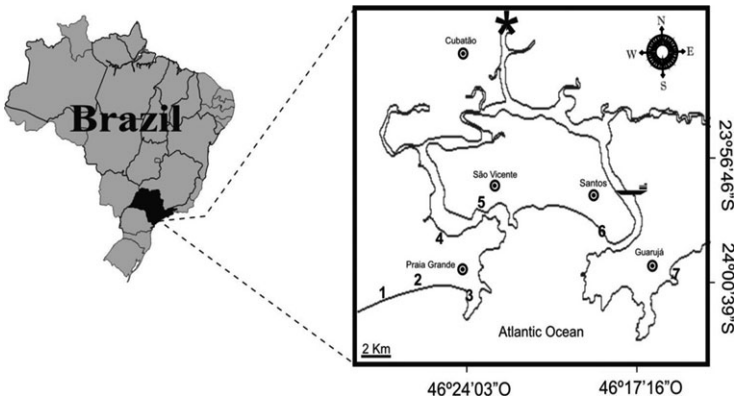

Figure 1. Map of the area showing where the fishers were interviewed, the port of Santos (shown by a ship), and industries near one of the inlets to the estuary (shown by an asterisk). Locations nos. 1, 2, 3 and 4 are the fishing spots in the municipality of Praia Grande; no. 5 is in São Vicente; no. 6 in Santos; and no. 7 in Guarujá.

ethical guidelines for research involving humans were complied with, and the study was approved by, the University of Santa Cecília (UNISANTA) Research Committee on Ethics (CAAE ref. no. 07528712.8. 0000.5513).

Interviews were not validated as it was not possible to have a control for this purpose, and several fishers who provided data failed to return as they were visitors from other cities.

Fishers were counted on random days and at random times to estimate the mean number per day at each location. Catch and effort were calculated following the procedures described by Pollock *et al.* (1994) and Lockwood *et al.* (1999). Catch was expressed in grams, and fishing effort ($\hat{E}_p$) as the mean number of anglers by date and location (expressed as anglers/day), according to:

$$\hat{E}_p = \alpha_p f_p \qquad \text{(eq1)}$$

where α_p is the average instantaneous count of fishers and f_p is the number of days for the period p.

The catch-per-unit-effort for period p and a given location, R_p, in terms of catch-per-fisher-day was calculated using the mean ratio estimator (Pollock *et al.* 1994; Jones *et al.* 1995; Hoenig *et al.* 1997; Lockwood *et al.* 1999) according to:

$$\hat{R}_p = [\sum_{i=1}^{Kp} (C_{pi} d_{pi}^{-1})] K_p^{-1} \qquad \text{(eq2)}$$

where C_{pi} is the catch in weight (g) of fish caught by the i^{th} fisher, d_{pi} is the fraction of a full day's fishing spent by the i^{th} fisher within period p, and K_p is the total number of anglers sampled in the period p.

Total catch was estimated for each location and period p according to:

$$\hat{C} = \hat{E}_p \hat{R}_p \qquad \text{(eq3)}$$

(eq3) where E_p and R_p are defined as above.

Fish weight (g) was used as the catch unit because it is the best basis for comparing different catches of different fish species of varying size.

Results

A total of 442 anglers were interviewed: 150 in Santos, 167 in São Vicente, 55 in Guarujá and 70 in Praia Grande. Mean age was 42.9 (SD ±16.1) years; the youngest fisher was 7 years old and the oldest 82. In Santos, mean age was 41.5 (±18.1) years, in São Vicente 43.1 (±15.5) years, in Guarujá 47.5 (±16) years and in Praia Grande 41.6 (±11.9) years. Taking these four municipalities together, 94% of respondents were men. In Guarujá and São Vicente, 100% and 95% of respondents, respectively, were men, while in Santos and Praia Grande, women represented about 17% of respondents. Respondents' formal education varied between locations. In Santos and São Vicente, more than 50% of interviewees had completed first degrees at college, while in Guarujá and Praia Grande, most respondents had only completed high school.

Interviewees' jobs varied widely, and 63 different occupations were recorded. Retirees (16.6%) and students (6.4%) were the most common, followed by lawyers (5.0%), deliverymen (5.0%), businessmen (4.7%), porters (4.5%), teachers (4.5%), engineers (4.3%), technicians (3.3%), salespeople (3.0%), drivers (2.4%), bank workers (1.9%), doctors (1.4%) and dock workers

(1.2%). The remaining 35.8% belonged to other less common professions.

Seventy-two percent of respondents lived near the fishing spot where they were interviewed. Fifty-six percent used an automobile to reach the fishing spot, 18% a bicycle and 15% a bus. Another 15% walked and 5% used a motorcycle. Mean travelling distance was 33 (±53) km, with a minimum of 0.5 km and maximum of 430 km. Safety, comfort and facilities (toilets and access ramps) were the reasons given by 47% of fishers for their choice of location. Proximity and ease of access were cited by 21% of respondents as the reasons for their choice. Being with other anglers was given as a reason by 15% of the total. Other reasons mentioned (27%) were the scenic beauty and the quality of the fishing, that is the locations were considered productive fishing spots.

The anglers were permanent local residents or had a second summer residence in the region. In Santos, 49% of respondents lived in the city, 20% came from the city of São Paulo and 19% from the nearby city of São Vicente, while the remaining 12% come from the municipalities of Praia Grande, Guarujá, São Bernardo do Campo and more distant regions (above 200 km). In São Vicente, the situation was different, as only 29% of fishers live in this municipality and 24% and 20% came from Santos and São Paulo, respectively. The remaining 27% also come from neighbouring municipalities (Praia Grande, Guarujá and Cubatão) or other regions of Brazil (Bahia and Goiás). São Vicente was the location where the anglers came from the greatest number of different places. In Guarujá, 65% of the anglers lived close to the fishing spot; in Praia Grande, this proportion was 53%.

Sixty-nine percent of respondents did not have a fishing licence, indicating that fishing is conducted illegally by many anglers. Respondents had been fishing for about 14.5 (±12.2, $n = 442$) years, and some had over 70 years' experience fishing in the region. Many anglers preferred fishing with companions (61.4%). Over a third of respondents (38%) fished daily, especially in Santos (52%) and São Vicente (46%). Weekly fishing (1 or 2 days per week) was preferred by another third of respondents, especially fishers from Guarujá (56% of fishers from this municipality preferred weekly fishing), while 7% of all respondents said they went on fortnightly fishing trips. Twenty percent of the Praia Grande fishers preferred fortnightly fishing and 40% monthly fishing. Generally, the anglers considered the fishing spots to be of average or good quality. However, most

Table 1. Abundance in numbers and weight of fish caught by anglers

	Number of fishes					Weight (g)				
Species	Sts	SV	Gu	PG	Total	Sts	SV	Gu	PG	Total
Bagre (catfish)	1	0	1	5	7	200	0	572	1730	2502
Baiacu (Puffer fish)	3	4	0	3	10	1400	2300	0	1173	4873
Bandeira (Flagtail catfish)	0	0	1	0	1	0	0	1026	0	1026
Caratinga (Brazilian mojarra)	0	0	0	3	3	0	0	0	1017	1017
Corvina (Whitemouth croaker)	5	9	0	1	15	2300	3250	0	353	5903
Espada (Swordfish)	28	33	2	0	63	16 500	17 500	740	0	34 740
Pampo (Pompano)	5	7	0	0	12	4100	4200	0	0	8300
Perna-de-moça (Southern king croaker)	3	1	0	4	8	1200	500	0	1348	3048
Pescada (Weakfish)	1	2	4	0	7	400	800	910	0	2110
Pescada-amarela (Southern king weakfish)	3	3	0	0	6	1500	1500	0	0	3000
Pescada-branca (Acoupa weakfish)	2	3	0	0	5	950	1350	0	0	2300
Robalo (Snook)	12	13	1	0	26	21800	15100	298	0	37 198
Sargo (Black margate)	0	0	1	0	1	0	0	166	0	166
Total	63	75	10	16	164	50 350	46 500	3712	5621	106 183

Sts, Santos; SV, São Vicente; Gu, Guarujá; PG, Praia Grande.

complained that the quality of fishing at the spots had declined in recent years.

Fishing trips lasted on average 5.1 (±2.4, n = 442) hours, with a minimum of 2 and maximum of 18 h. The average number of fish caught was 4.2 (±3.2, n = 442) per fishing day. Some fishers released all the fish they caught, while others reported that on occasions they took home fish and one fisher reported having taken home over 30 fish from one trip. A list of the common names of 25 fish and two invertebrates caught by the fishers based on interviews and direct inspection of the fish caught is provided in Table S1.

A total of 164 fishes from 14 species were weighed (Table 1), and this information was used to calculate the weight of the catch. Santos had the highest catch by weight (50 350 g), with a mean CPUE of 851 (±962, n = 63) g fisher^{-1} day^{-1}, while the total catch in Guarujá was the lowest (3712 g), with a mean CPUE of 49 (±51, n = 10) g fisher^{-1} day^{-1}. The overall mean CPUE for the four locations was 488 (±469, n = 164) g fisher^{-1} day^{-1} (Table 1). Differences were observed in the composition of species caught in these locations, and there were significant differences in species catch weights between one location and another (P = 0.026). The mean daily CPUE for the 12 most important species groups (common names) caught by the anglers varied between each of the four municipalities (Fig. 2). Snook (*Centropomus undecimalis* and *C. paralellus*), swordfish (*Trichiurus epturus*) and pompano (*Trachinotus carolinus*) were the species with the largest catches, especially in Santos and São Vicente. In Guarujá, catfish, weakfish and flagtail catfish were also caught, while in Praia Grande puffer fish, catfish, southern king croaker, Brazilian mojarra and white croaker were the species that contributed most to catch by weight.

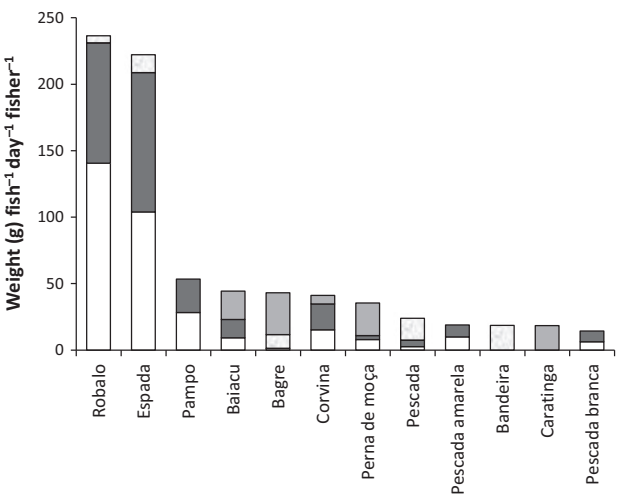

Figure 2. Mean CPUE by species group by location.

Anglers were counted on randomly selected weekdays. The mean fisher effort by day of the week varied between locations (Table 2). Values at the weekends were higher only in Santos and Guarujá. Fridays were the busiest day in São Vicente and Praia Grande, and Wednesday nights in Guarujá.

Estimated total catch weight during the study period was 2299 (±1290, n = 164) kg, of which 1314 (±820, n = 63) kg was captured in Santos, 673 (±354, n = 75) kg in São Vicente, 58 (±45, n = 10) kg in Guarujá and 253 (±69, n = 16) kg in Praia Grande.

Discussion

The anglers interviewed were mostly men and had a mean age of 42.9 (±16.1, n = 442) years, reflecting the situation in other inshore fishing areas (Basaglia & Vieira 2005; SantAnna 2011; Barcellini *et al.* 2013), Brazilian rivers (Moraes & Seidl 2000; Peixer & Petrere-Jr 2009a,b) and other parts of the world (Ditton *et al.* 1978; Veiga *et al.* 2010). The anglers' education level was high and reflected their economic status, which allowed them to maintain a second residence and pay for travel expenses and the specialised and comparatively expensive fishing equipment. Similar results were reported for anglers in the Pantanal (Moraes & Seidl 2000), on the coast of Rio Grande do Sul (Basaglia & Vieira 2005; SantAnna 2011) and on the urbanised New Jersey coast (Burger *et al.* 1999). The large number of retirees and students indicates that many of these anglers have a large amount of free time, explaining the high daily and weekly frequencies recorded in the interviews. Anglers in the study also live close to the fishing spots and so have to travel shorter distances to reach them. This is similar to the situation reported in Portugal (Veiga *et al.* 2010) and Norway (Moksness *et al.* 2011).

The mean number of anglers in the four fishing locations was 28.6 (±17.4, n = 442) fishers day^{-1}, corresponding to an estimated 4404 (±2680, n = 442) anglers in the 154-day study period. The preferred period for fishing was from April to November as, according to the interviewees, in the summer months (January to March), the water is hot and unsuitable for fish that move to deeper offshore waters. From the month of April onwards, the water becomes cooler and several species return to the estuarine areas. Also according to the fishers, water conditions remain favourable until November and December, when the water heats up and drives fish away.

Fishing time [5.1 (±2.4, n = 442) h] was longer than the corresponding figure for coastal anglers in Majorca

Table 2. Mean ± standard deviation of fisher effort by day of week in each fishing location

Day	Santos	S. Vicente	Guarujá	P. Grande	Total
Monday	8.7 ± 2.3	5.3 ± 1.5	8.0 ± 2.9	1.5 ± 0.5	23.5 ± 7.2
Tuesday	7.3 ± 4.5	4.5 ± 1.9	4.0 ± 1.1	2.2 ± 1.2	18.0 ± 8.6
Wednesday	4.6 ± 1.8	4.3 ± 1.0	12.0 ± 3.4	1.7 ± 0.7	22.5 ± 6.9
Thursday	8.5 ± 3.1	3.8 ± 1.3	2.0 ± 1.1	3.0 ± 0.7	17.3 ± 6.3
Friday	5.5 ± 2.2	12.5 ± 7.1	2.0 ± 1.1	9.0 ± 1.1	29.0 ± 11.6
Saturday	17.3 ± 2.5	8.8 ± 5.7	8.0 ± 2.3	5.7 ± 4.5	39.8 ± 15.1
Sunday	18.3 ± 2.5	9.3 ± 7.1	18.0 ± 6.0	4.3 ± 2.1	50.0 ± 17.9
Average	10.0 ± 5.5	6.9 ± 3.3	7.7 ± 5.8	3.9 ± 2.7	28.6 ± 17.4

(3:42 ± 0:06 h) (Morales-Nin *et al.* 2005) but similar to that reported by Peixer and Petrere-Jr (2009a,b) in Mogi Guaçú (São Paulo-Brazil) and Veiga *et al.* (2010) on the Portuguese coast. Maximum and minimum times were 18 and 2 h, respectively, although most anglers (whether daily or weekly) tended to remain for shorter periods, while those travelling longer distances spent longer, as Hunt *et al.* (2011) found in the lakes of Ontario (Canada). Rangel and Erzini (2007) found that the late afternoon/early evening period after working hours on weekdays was preferred by fishers on the northern coast of Portugal, emphasising the recreational aspect of this activity. Unfortunately, the only comparisons possible in this study were numerical rather than statistical, as most publications cited provide neither the standard deviation of their estimated means nor the sample size. However, these comparisons at least show the order of magnitude of their means, although some comparisons are not clear-cut, as tropical recreational fisheries, as previously mentioned, are poorly studied and the fish species in these fisheries are ecologically very different from those found in temperate zones.

It is also noted that environmental heterogeneity leads to differences in species composition in fishing spots, making even numerical comparisons quite difficult. For example, while swordfish, whitemouth croaker, snook and southern king croaker are common species in south-west Atlantic estuarine and coastal habitats (Froese & Pauly 2014) and were reported in all the localities studied, anglers' fishing in the rocky, sandy habitat of Guarujá (Tsuruda *et al.* 2013) only reported grouper, barbu and black margate species that are found in shallow reefs (Froese & Pauly 2014). Conversely, Brazilian mojarra, banded croaker and mojarra, which are typical of shallow, soft habitats, were reported exclusively by anglers from Praia Grande, and catfish and southern king croaker were also present in surf beaches. In Praia Grande, the fisheries were in estuarine sites and the surf zone along the beach, where the bottom is sandy and muddy without any rocks or other types of substrate. In Santos and São Vicente, the fishing decks were located at the entrances to the estuaries, where the water was brackish and the bottom was soft; snook, swordfish and pompano were the main species caught. Paiva Filho and Toscano (1987) found similar species differences between a beach in Guarujá and the estuary channel in São Vicente related to the physical characteristics of the substrates and the physical and chemical conditions of the water.

The average catch was 4.2 (±3.2, $n = 164$) fish fisher^{-1} day^{-1}, larger than that of Cox *et al.* (2003) for rainbow trout fishing in the lakes of British Columbia (1.2 fish fisher^{-1} day^{-1}), but lower than 19.78 (±1.06, $n = 1271$) fish fisher^{-1} day^{-1} reported by Morales-Nin *et al.* (2005) for coastal anglers on the island of Majorca. Using the mean fishing time in Eqn (2) gave an average of 0.82 (±0.62, $n = 164$) f fish fisher^{-1} h^{-1}, which is greater than Beckley *et al.* (2008) (0.064 fish fisher^{-1} h^{-1}), Rangel and Erzini (2007) on the northern coast of Portugal (0.42 fish fisher^{-1} h^{-1}), Gartside *et al.* (1999) in Australia (0.47 fish fisher^{-1} h^{-1}) and Pradervand *et al.* (2007) on the coast of South Africa (0.25 fish fisher^{-1} h^{-1}). Veiga *et al.* (2010) reported higher values (1.1 fish fisher^{-1} h^{-1}) for anglers on the southern coast of Portugal, and Llompart *et al.* (2012) found that anglers in the San Blas Bay (Argentina) had yields of 1.28 fish fisher^{-1} h^{-1}, which they considered to be the highest in the southern hemisphere. Mean catch weight for the anglers in the Baixada Santista surveyed was low (487.8 ± 469.2 g fisher^{-1} day^{-1}) compared with the values of between 1 and 3 kg of fish per fishing trip recorded by Morales-Nin *et al.* (2005) for anglers on the island of Majorca (Spain). Wedekind *et al.* (2001) found that anglers from the state of Saxony-Anhalt (Germany) captured 0.71 kg day^{-1}; Seidl and Moraes (1997) recorded the average catch in the Pantanal in Mato Grosso (Brazil) to be 4 kg fisher^{-1} day^{-1}; Carvalho and Medeiros (2005) found a mean catch of 3.2 kg fisher^{-1} day^{-1} on the Araguaia River; and Peixer and Petrere-Jr (2009a,b) recorded an average of 19.9 kg fisher^{-1} day^{-1} (3.31 kg fisher^{-1} h^{-1}) in Cachoeira das Emas on the Mogi Guaçú river (Brazil).

Using mean fishing time in Eqn (3), the CPUE was 95.6 ± 92 g fisher^{-1} h^{-1}, greater than that of calculated by Rangel and Erzini (2007) for the northern coast of Portugal (78 g fisher^{-1} h^{-1}). Veiga *et al.* (2010) found even higher values (210 g fisher^{-1} h^{-1}) for anglers fishing on the southern coast of Portugal.

Most of the fishers in this study consider catch-and-release, a 'good' system that allows fishery resources to be conserved. However, some were concerned about this issue and mentioned improper practices that caused suffering and pain to the fish caught, as mentioned by Arlinghaus *et al.* (2007a,b). Even so, these fishers would not accept prohibition of catch-and-release (i.e. kill and grill) for ethical reasons, as already occurs in some European countries (Arlinghaus *et al.* 2012; Petrere 2014). This would suggest that in Brazil, where fishing is considered the second national sport after soccer, issues related to animal welfare and animal rights are not discussed widely by society or the fishing authorities. Although studies of the physiological consequences of catch-and-release on the diverse Brazilian fish fauna are scarce, this type of fishing is promoted by IBAMA/MPA (the Brazilian Institute for the Environment and Renewable Natural Resources/Ministry for Fisheries and Aquaculture) without due regard for the consequences, to attract rich foreign recreational fishers from abroad and the hard currency they bring.

Recreational fishing provides considerable satisfaction for fishers despite the low weight and small size of the fish caught, which are then released by most anglers. In the Baixada Santista, anglers proved to be knowledgeable and very sociable; indeed, fishing can be regarded as a leisure activity in the company of relatives and friends for the majority of respondents, many of whom do not really care about catching fish. The opportunity to be in contact with nature and socialise with relatives and friends were cited as the main reasons for classifying the fishing in the locations studied as of good quality despite the reported worsening fishing conditions. This has also been reported in other areas of Brazil: Barra do Una, Jureia-Itatins Ecological Station (Ramires & Barrella 2001), Cachoeira de Emas on the Mogi-Guaçú River (Peixer & Petrere-Jr 2009a,b) and Ilha Grande National Park (Zacarkim *et al.* 2005). Conversely, the quantity and species of fish caught are the main reasons why anglers go to the Pantanal (Moraes & Seidl 2000), the Araguaia river (Carvalho & Medeiros 2005) and Praia do Cassino (Basaglia & Vieira 2005). On the coast of Portugal, Veiga *et al.* (2010) found that 73% of anglers fished alone, as did fishers at Guarujá. Arlinghaus and Mehner (2004) found that urban anglers in Berlin tended to catch fish to win competitions more than their rural counterparts did. However, contact with nature, leisure and socialising with other people were also the main motivations referred to by both groups of anglers. Despite this, some anglers derive satisfaction purely from catching fish (Arlinghaus and Mehner (2004), as observed by Arlinghaus (2006). Johnston *et al.* (2010) concluded that angler satisfaction was explained by the presence of large fish and the individual's proximity to the fishing location. Fedler and Ditton (1986), on the other hand, reported that catch was considered to be of low-to-moderate importance by Texas coastal fishers (USA). In the present study, the loss of quality in fishing locations may explain the low level of angler satisfaction, which was attributed by the anglers to extensive environmental degradation and the proximity of pollution sources (a port and industrial facilities) in the Santos and São Vicente estuary (Vargas-Boldrini *et al.* 1991; Hortellani *et al.* 2008). As a recent example, in 2013, a great fire in warehouses in the port of Santos liquefied 180 thousand tonnes of cane sugar into syrup, which spilled into the estuary causing the deaths of thousands of tons of fish (http://g1.globo.com/sp/santos-regiao/noticia/2013/10/empresa-inicia-retirada-de-milhares-de-peixes-mortos-do-porto-de-santos.html). Anglers complained that after this accident, the amount of fish caught in Santos fell drastically.

It is worth considering what influence recreational fisheries could have on stocks compared with competing commercial fisheries. Land-based recreational fishing, which is practiced on beaches, shores and decks, results in only small quantities of fish being caught and so has little impact on regional fishery stocks. This is illustrated by the total estimated catch weight in the study period (154 days) being only 2299 kg (±1290, n = 164), only 2.1% of the 110 t of fish landed by the Santos fishing fleet in the same period, albeit from an extensive marine area. This percentage increases to 9.1% if the more comparable surface long-line catch of the Santos fleet (25 137 kg: http://www.pesca.sp.gov.br/estatistica) is included. These percentages may be underestimated because most of the hottest period of the year (October to March), when CPUE and effort is higher, was excluded from this study (Paiva Filho & Toscano 1987; FAO 2002a,b; Barreiros *et al.* 2004; Godefroid *et al.* 2004; Freire 2005a, 2010; Llompart *et al.* 2012, 2013). Font and Lloret (2011) also found that recreational fishery yield was far below that of commercial fisheries in the NW Mediterranean. On the other hand, Schroeder and Love (2002) compared the results of catches in three fishing areas off the coast of California (USA) where all forms of fishing (commercial and recreational) were permitted, only recreational fishing was permitted and all fishing was prohibited, respectively. Comparing the density and size of fish catches, they found that the area

where recreational fishing was allowed showed the worst results, with small fishes and low densities. The authors rejected the hypothesis that recreational fishing is an activity that has little or no impact. Agreeing with this, McPhee *et al.* (2002) and Lewin *et al.* (2006) presented a list of impacts of recreational fishing and considered it to be ecologically unsustainable. However, Cowx *et al.* (2010) stated that recreational fishing can be reconciled with modern views of conservation. To achieve this requires (1) improved legislation, (2) continuous communication with fishers, (3) development of integrated management policies on smaller scales based on aquatic biodiversity conservation and (4) reduction of the threat imposed by the recreational fishing sector. According to Radomski *et al.* (2001), fishers are heterogeneous in their interests and respond in complex ways to management actions. Understanding this heterogeneity and their attitudes could improve management practices. Although they consider themselves 'defenders of nature', the anglers in the present study do not know the minimum sizes for the species they catch. Furthermore, many of them do not have a fishing licence, adversely affecting stock monitoring and fisheries management. Control of recreational fishing is virtually nonexistent, and many fishers resist any kind of surveys of their catch. During the interviews, the fishers expressed concerned about how the information collected would be used and whether the interviewers were members of an environmental inspection agency. In the light of this, it is important to run effective educational campaigns promoting human behaviour consistent with sustainable use of aquatic ecosystems as argued by Lewin *et al.* (2006).

It should be added that fishing in the study area is carried out in urban and suburban environments, where many human activities may mask its impacts. Unlike in the areas studied by O'Toole *et al.* (2009) and Pickering and Hill (2007), who recorded the impacts of recreational fishing in Canada and Australia, in the present study, the impact of recreational fisheries has been overshadowed by major environmental problems caused by urbanisation. In the study area, the changes resulting from the presence of buildings, roadways and embankments, as well as garbage and sewage disposal were similar to those described by Cendrero (1989), Weslawisk *et al.* (2000) and Defeo *et al.* (2009). The presence of groups of anglers at fishing spots in the urban areas in the present study tended to make them exercise a certain self-regulation. In contrast to what happens in protected estuaries in wild regions (Barcellini *et al.* 2013), the lack of regulatory oversight has not contributed to an increased incidence of inappropriate, illegal fishing practices that reduce fish numbers and affect the life cycles of many species.

Urban fisheries offer advantages for the elderly and disabled in terms of accessibility and social benefits. Hickley (1998) therefore argued that in addition to improving the physical habitat for fish, urban fishing rehabilitation measures should seek to improve access to fisheries and make them environmentally friendly. To do this, suitable fishing sites must be chosen, with decks, driveways, parking, restrooms, public transport links and specialised facilities for the disabled. In this way, urban fishing can be practiced by those unable to travel or with limited access (young, disabled and elderly), as well as highly committed anglers and people for whom fishing is of great importance to their lifestyle. All these measures should form part of a larger plan for integrated coastal zone management. However, integration between the institutions responsible for management of the coastal zone in Brazil is threatened by serious problems, as mentioned by Diegues (2001). Any solution to these problems should be based on the concepts of Responsible Recreational Fishing (FAO, 2012) and the Recommendation of the European Parliament and the Council of the European Union for the Implementation of Integrated Coastal Zone Management in Europe [EUICZM Recommendation (413/2002/EC)], which advocate the need to establish effective legislation combined with appropriate environmentally sustainable, economically equitable, socially responsible and culturally sensitive management practices in coastal areas. High-quality management ensures a financial return, higher levels of environmental conservation and higher multiplicative effects on the socio-economic structure of beach municipalities (Micallef & Williams 2002; Ariza 2010; Ariza *et al.* 2010). In practice, there are insufficient financial and human resources to ensure integrated recreational fisheries and coastal-zone management in the study area. Nevertheless, there is a dynamic response to the demand for services, and new service providers offering food, equipment, bait and other services to tourist fishers are emerging in a process similar to that reported by Ramires and Barrella (2003) in an artisanal coastal fishing community south of São Paulo (Brazil). However, the challenge of developing the infrastructure necessary to turn the seven fishing spots studied here into popular tourist destinations will not be one that everyone relishes, and potential incompatibilities between fishing (recreational and commercial) and other economic activities (ports, industry and urban development) will require new regulations and tighter controls to protect stocks and habitats. Running campaigns to raise people's awareness of sustainable fishing tourism and providing fishers with information about this should also result in net benefits to local communities and avoid new conflicts (FAO, 2012).

Although the CPUE data collected here are of limited use because of the different types of fish caught and the great variability of the data, if collected over many years, they could prove useful. In the short term, they would be very useful if the yields of the most frequently caught species or at least species groups could be compared. In any case, as previously mentioned, it is unlikely that the impact of recreational fishing on total mortality and fishing mortality of the stocks would even be detectable. In other words, there does not appear to be incompatibility between the different types of fisheries, which should be seen as positive from the perspective of management costs. In terms of investments in more information, it is suggested (1) repeating the creel survey once every 5 years to provide long-term monitoring; (2) ensuring that fishers have easy access to the simplified results of the survey; and (3) conducting a more detailed appraisal of stocks exploited by commercial and recreational fishing at a species or at least species-group level. It is very easy to demand more regulation, but unreasonable when there are only 'possible incompatibilities', as the cost of effective regulation of fishers can easily exceed the benefits of the fishing resource and divert funds from more pressing issues.

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Supporting Information

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

Table S1. Common and scientific names of fish species or species groups cited by anglers in the municipalities of Santos, São Vicente, Guarujá, and Praia Grande.