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Assessment of a major shore-based marine recreational fishery in the southwest Atlantic, Argentina

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This work provides, based on data from roving creel surveys, the first quantitative analysis for a main recreational fishery of the southwestern Atlantic coast. Anglers interviewed were willing to accept minimum size limits but mostly did not approve the maximum daily catch, despite the fact that they considered that the fishery quality was decreasing. Angler profile differed among months but the avidity effect was negligible. Fishing effort was highest during January, with the greatest total catch per unit effort (CPUE) in November and the highest total catch in December. Twelve species were caught, with *Cynoscion guatucupa* and *Micropogonias furnieri* accounting for 80% of the harvest. The average lengths for both species were larger than their size at first maturity. Mean ($\pm$SD) CPUE values (1.28 ± 0.59 fish/angler/h) and total harvest were high compared with those of other recreational fisheries in the Southern Hemisphere. Some specific fishing-management guidelines are proposed to promote good angling practices and sustainable long-term use of the resource.

Keywords: angler preferences; catch per unit effort; fisheries management; fishing quality; recreational fisheries

Introduction

Recreational fishing is widely practised over the entire planet, with as many as 727 million anglers participating in this activity annually (Pitcher & Hollingworth 2002; Cooke & Cowx 2004). In addition, related fishing effort in both freshwater and coastal-marine environments has also strongly increased (Post et al. 2002; Allan et al. 2005; Cooke & Schramm 2007). The resulting increase in recreational-fishing captures, currently at 47.1 billion fish annually, has therefore significant sustainability implications (Cowx 1995; Cooke & Cowx 2004) and is sometimes even higher than the harvests from commercial fishing (McPhee et al. 2002; Schroeder & Love 2002; Arlinghaus et al. 2005). The recent decline of global fish stocks has nevertheless been attributed to an increase in commercial fishing pressure, as well as the contamination of marine coastal environments (Jackson et al. 2001; Pauly et al. 2002; FAO 2003; Hilborn et al. 2003; Lotze et al. 2006), with little attention being paid to the role of recreational fishing (Coleman et al. 2004; Cooke & Cowx 2004; Arlinghaus et al. 2005; Lewin et al. 2006). The impact of recreational fishing also becomes relevant when that activity affects coastal areas critical for fish breeding, feeding and migration (Jackson et al. 2001; Cooke & Cowx 2004). Moreover, the impact may be enhanced if juvenile or top predator-target species are affected, where their removal would produce changes at the community level

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(Policansky 1993; Coleman et al. 2004). For this reason, an understanding of the dynamics of recreational fishing is critical for developing new management guidelines (EIFAC 2008; Arlinghaus et al. 2010) that will incorporate the impact of this activity on coastal ecosystem-management strategies (McCluskey & Lewinson 2008).

The most popular countries for tourism related to recreational fishing are the USA, Canada, Scotland, Norway, Russia, New Zealand and Argentina (SENARPESCA 2008). Most of the studies dealing with estuarine and marine recreational fishing have been carried out in the Northern Hemisphere, whereas considerably less information has been gathered in the Southern Hemisphere except for Australia (e.g. Lyle et al. 2005; Smallwood et al. 2006; Beckley 2009; Jones 2009), New Zealand (e.g. Holdsworth et al. 2003; Kopf et al. 2005) and South Africa (e.g. Mann 2000; Brouwer & Buxton 2002; Pradervand 2004; Everett & Fennessy 2007). Consequently, little information is available for the Atlantic and Pacific coasts of South America, with the limited data available being only on the subtropical and tropical areas of Brazil (e.g. Medeiros et al. 2007; Pereira et al. 2008). Furthermore, the cold temperate areas of the South American coast constitute highly frequented but poorly documented coastal recreational fisheries, important to the local economies.

The aim of this study was therefore to assess for the first time the major coastal recreational fishing located in the southwestern Atlantic Ocean (north Patagonia). As a case study, we selected the San Blas Bay fishery, for which we attempted to: (1) characterise the angler profile; (2) estimate the fishing effort; (3) analyse catches in terms of species composition, length structure and total harvest; and (4) propose some general management guidelines to provide direction for better practice of coastal recreational fishing within the study region.

Materials and methods

Study area

San Blas Village (Fig. 1) is located in the Bay of the same name, on the east coast of Jabalí island, along the southern coastline of the Buenos Aires Province (40°33′S and 62°14′W), Argentina. This area is included in a protected nature area of multiple uses, the Anegada Bay, encompassing several types of coastal environment, e.g. marshes, tidal plains and sandy beaches (Penchaszadeh et al. 2003). The Bay comprises small islands and banks connected by a diffuse net of channels with depths ranging from 10 to 24 m in the main channel (Lucifora 2003). The tidal regime in San Blas Bay is predominantly mixed semidiurnal with a maximum amplitude of 2.56 m and minimum of 1.73 m (SHN 2009). The water temperature ranges from 6 °C in winter to 19.2 °C in summer, while the salinity varies between 32.5 and 35.0 PSU (Borges 1997, 2006). The climate is dry (300 mm/year of precipitation), and the prevailing winds are from the northwest.

The recreational fishing in the San Blas Bay area take places during the 6 hottest months of the year and almost no fishing activity is observed during autumn and winter. The shore-based fishing is carried out at two main fishing sites, one along 4 km of the village's coastline, on a steeply sloping pebble-and-gravel beach (BG). The second site is a 4.4-km-long sand beach (BS) located to the south of the village, with a gentle slope.

Sampling framework

Taking into account the seasonality of the fisheries and the coastal sites used, we developed a two-stage stratified sampling design spanning the period from November 2008 to April 2009. The two variables were substrate (BG and BS) and fishing effort over the week [i.e. weekdays (WD) and weekend days (WED)] (Malvestuto & Knight 1991). The monthly sampling effort was fitted from the percentage of monthly tourist participation in such fishing

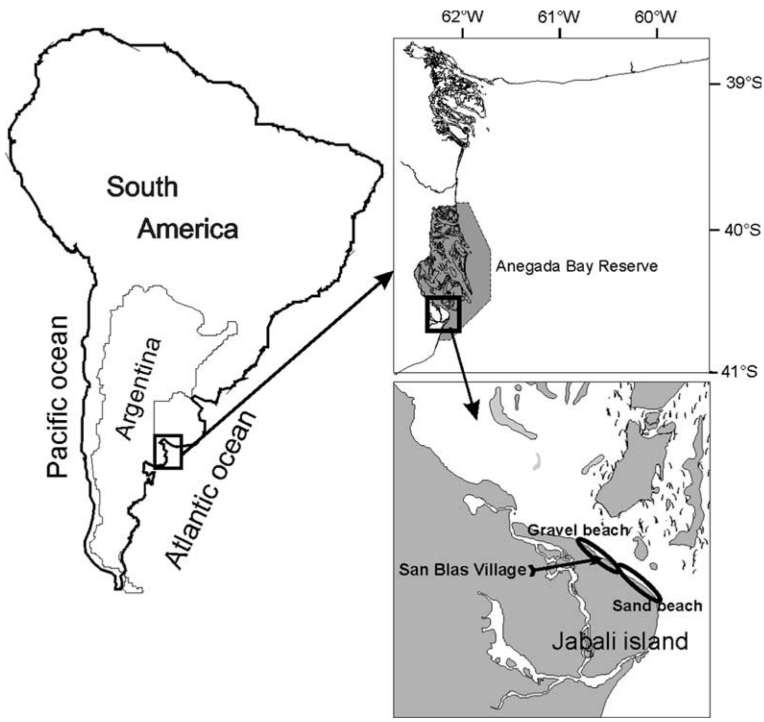

Figure 1 Geographic location of study area and sampling sites.

activities during the last 10 years obtained from the records of the local tourism office. This design, summarised in Table 1, was developed in order to minimise estimation bias (Best & Boles 1956; Cochran 1977; Malvestuto 1983, 1994).

Using roving-creel surveys (Robson 1991; Malvestuto 1994; Pollock et al. 1994; Sullivan et al. 2006), we obtained information about anglers and their fishing. This technique consists of onsite interviews, based on a questionnaire, to gather information on a given fishing day and subsequent extrapolation first to the entire day and then to an individual's overall fishing activity. A semi-structured questionnaire (Sudman & Bradburn 1982; Robson 1993),

Table 1 Distribution of monthly sampling effort during the 2008–9 fishing season for the recreational fishery of San Blas Bay.

Month	Tourist %	DW	DM	Coverage %	WW	WD	Coverage %	WWD	WDM	Coverage %
November	11.8	9	30	30	6	20	30	3	10	30
December	19.9	13	31	42	10	23	43	3	8	37
January	31.6	15	31	48	10	22	45	5	9	56
February	18.9	11	28	39	8	20	40	3	8	37
Mach	10.1	9	31	29	6	22	27	3	9	33
April	7.7	6	30	20	3	22	14	3	8	37

DW, days worked; DM, days per month; WW, weekdays worked, WD, weekdays per month; WDW, weekend days worked; WDM, weekend days month.

designed to elicit information about angler preferences, demands and motivations, was used and anglers were chosen randomly during the day. In this way, the fishing surveys yielded information on: (1) the age distribution of the angler population interviewed; (2) angler opinions on the importance of the San Blas fishery at a nation-wide level; (3) angler expenditure on fishing tackle; (4) preferred species; (5) the ideal daily catch; (6) the minimum length of retained fish; (7) anglers' evaluation of their fishing experience on present day; and (8) angler perception of the present fishing quality relative to that of previous years or decades. The data were transformed to frequency percentages and were plotted to show trends. After each interview, species composition and the number and length of fish caught were recorded, and the total weight was calculated from length–weight relationships for each species estimated for the study area (Llompart unpublished data).

In order to estimate the fishing effort, we conducted two daily instantaneous counts of the anglers at each site (BG and BS) (Hoening et al. 1993). The fishing period (12 h) was split into morning (08:00 to 14:00 h) and afternoon (14:00 to 20:00 h) blocks, and two anglers counts (Phippen & Bergensen 1991) were made in each block to encompass all tide possibilities. Both counts were conducted from a four-wheel vehicle on the beaches and it took 20 min to transverse the overall fishery. Night fishing was not sampled for personal safety reasons.

Basic catch and effort statistics were calculated following the procedure of Pollock et al. (1994). Thus, the daily effort (e_{i}) was calculated, as were all estimations, independently for each stratum of the survey and for WD and WED in each month as follows:

$$e_i = \bar{I}_i \times H_i$$

where $\bar{I}_i$ is the average number of anglers and H_i is the length of the fishing period.

The effort on WD (E_{wd}) and WED (E_{wed}) was calculated as:

$$E_{wd} = \bar{e}_{iwd} \times N_{wd} \text{ and } E_{wed} = \bar{e}_{iwed} \times N_{wed}$$

where, $\bar{e}_{i\mathrm{wd}}$ and $\bar{e}_{i\mathrm{wed}}$ are the average of the daily effort on WD and WED, respectively; N_{wd} and N_{wed} are the number of WD and WED in each month.

The monthly effort (E_{M}) was calculated as:

$$E_{\mathrm{M}} = E_{\mathrm{wd}} + E_{\mathrm{wed.}}$$

In turn, the catch on WD (C_{wd}) and on WED (C_{wed}) was calculated as:

$$C_{\mathrm{wd}} = E_{\mathrm{wd}} \times \mathrm{CPUE_{wd}} \text{ and } C_{\mathrm{wed}} = E_{\mathrm{wed}} \times \mathrm{CPUE_{wed}}$$

where $\mathrm{CPUE_{wd}}$ and $\mathrm{CPUE_{wed}}$ is the catch per unit effort (fish number/h) on WD and WED, respectively, and was estimated as:

$$\mathrm{CPUE} = \sum_{i=1}^{n} \frac{C_i}{n}$$

where C_i is the daily catch rate for the ith day (fish number/h), n is the number of interviewed anglers.

The total monthly catch (C_{TM}) was calculated as:

$$C_{\mathrm{TM}} = C_{\mathrm{wd}} + C_{\mathrm{wed}}$$

For each month the standard errors (SE) were calculated on E_{M} or C_{TM} as follows:

$$\mathrm{SE}\ \bar{Y} = \sqrt[2]{N_i^2 \left[\frac{1}{n_{\mathrm{d}} - 1} \sum_{\mathrm{d}=1}^{n_{\mathrm{d}}} (x_{\mathrm{i}} - \bar{x})^2 \right]}$$

where $\bar{Y} = E_{\mathrm{M}}$ or C_{TM}, $N_i = N_{\mathrm{wd}} + N_{\mathrm{wed}}$, n_{d} is the number of weekdays worked or weekend days worked per month, $x = e_i$ or c_i (daily catch) and $\bar{x} = \bar{e}$ or $\bar{c}$ (average daily catch).

'Avidity bias' and 'length-of-stay bias' are intrinsic to the roving-creel method, because the probability of intercepting an angler fishing is proportional to his or her fishing avidity and to the length of the fishing trip, respectively

(Sullivan et al. 2006). Since avid anglers have a higher likelihood of being sampled and because of the positive relationship between avidity and expenditure, we applied weighted expenditure means to correct for avidity bias using the procedure proposed by Thomson (1991):

$$\mathrm{EFT}_c = \left[\frac{\left(\sum^n Z_i/T_i\right)}{\sum\left(1/T_i\right)}\right]$$

where $\mathrm{EFT_c}$ is the expenditure on fishing tackle corrected, Z_i the value of fishing tackle by angler i, $\mathrm{T_i}$ the number of trips taken annually by angler i, and

$$\mathrm{Var\ EFT}_c = \left[\frac{\left(\sum^n Z_i/T_i\right)}{\sum(1/T_i)}\right] \times \frac{1}{n}\left[\frac{\left(\frac{\bar{T}^2}{n-1}\times\left[\sum^n\left(\frac{Z_i}{T_i}\right)^2-\frac{1}{n}\left(\sum^n\frac{Z_i}{T_i}\right)^2\left(\sum^n\frac{Z_i}{T_i}\right)\right]\right)}{\left(\frac{\left(\sum^n Z_i/T_i\right)}{\sum(1/T_i)}\right)^2} + \frac{\left(\frac{\bar{T}^2}{n-1}\times\left[\sum^n\left(\frac{1}{T_i}\right)^2-\frac{1}{n}\left(\sum^n\frac{1}{T_i}\right)^2\right]\right)}{1} - \frac{\left(\frac{\bar{T}^2}{n-1}\times\left[\sum^n\left(\frac{Z_i}{T_i}\times\frac{1}{T_i}\right)-\frac{1}{n}\sum^n\frac{Z_i}{T_i}\sum^n\frac{1}{T_i}\right]\right)}{\frac{\left(\sum^n Z_i/T_i\right)}{\sum(1/T_i)}}\right]$$

where Var is the variance, $\bar{T}$ the average number of trips in each month

$$SD\ EFT_c = \sqrt{Var\ EFT_c}$$

The one-way analysis of variance (ANOVA) was used to check differences in the daily fishing effort between WD and WED and between substrates (i.e. BG and BS). In addition, ANOVA was used to test for significant differences in the daily number of fish caught between the BG and the BS. If necessary, the data were log-transformed in order to achieve normality where Levene's test was applied to assess the homogeneity of variance.

Results

Social characteristics and angler fishing preferences

In this study, the 507 interviews conducted showed that angler age distribution has a wide range (between 17 and 77 years old), with high predominance of males (98%). Anglers come from 13 different provinces of the country, travelling an average of 500 km to fish at San Blas Bay, but 50% of these anglers travelled up to 900 km or more. Of the interviewed anglers, 75% considered San Blas Bay to be the best marine fishery of the Argentinean Atlantic coast. The $\mathrm{EFT_c}$ (including rod, reel and line) differed among months and were highest in November (±SE), at US$170±22, followed by December at US$152±11; the subsequent values, in decreasing order, were for January at US$86±7, February at US$119±11, March at US$135±10 and lastly, April at US$32±9. Such values varied between 2% to 8% with respect to non-corrected values.

The whitemouth croaker, *Micropogonias furnieri*, was selected by anglers (42%) as their preferred target species, because of its size and therefore its status as a species of high sport value. The second-most preferred species (16%) was the striped weakfish *Cynoscion guatucupa*. Apart from these two sizeable preference groups, the most notable one was the 19% group, comprising anglers who had expressed no preference at all.

Of the anglers, 39% considered 30–40 cm as the minimum preferred capture size, while 13% recognised the need to regulate the minimum catch size according to species, with only a 10% wanting to retain all the caught fish regardless of their size (Fig. 2). Furthermore, 85% of the anglers kept for consumption the fish that exceeded the preferred minimum catch size. In addition, 41% of the respondents wished to catch as many fish as possible during a day of fishing; while 21% stated that the ideal capture should be between 20 and 30 fish, and 14% believed that a daily catch should be roughly

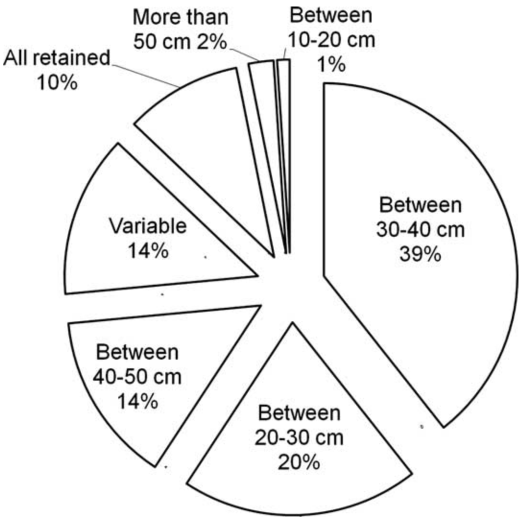

Figure 2 Percentages of minimum total length preferred by anglers based on retained fish during the 2008–9 season in the recreational marine fishery of San Blas Bay.

between 30 and 50, with only a 17% preferring merely 20 fish or fewer.

Overall, reflecting on the 6 months of the fishing season, 60% of anglers declared their fishing experience had been 'acceptable' (very good + good + more or less) with respect to the number and sizes of the fish caught, but at the beginning of the season, the fishing experience was felt to be more positive (Fig. 3). Moreover,

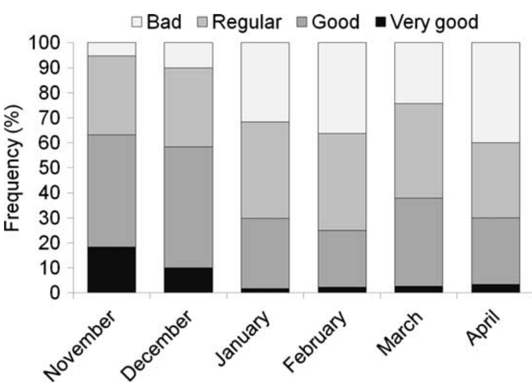

Figure 3 Perception of daily fishing experience in the shore-based marine recreational fishery of San Blas Bay during the 2008–9 season. Acceptable = very good + good + regular.

anglers with more than 5 years of local fishing experience reported a notable decrease in the number of catches during recent years, with 64% of them stating that in the past, they had been able to catch more fish per unit time; by comparison, only 2% of the anglers surveyed found the opposite trend. Of those more experienced anglers, 39% insisted that a drop-off in the mean catch length had occurred, while 38% stated that no such change had taken place.

Estimates of effort and catch

Fishing effort passed through a maximum during January, the month of peak of summer tourist activity in San Blas. Daily fishing effort was significantly greater on the WED than on the WD in November, December, March and April ($F = 6.94$, $F = 113.21$, $F = 5.19$, $F = 86.32$, respectively; $P < 0.05$); but no differences were found in either January or February ($F = 1.85$, $F = 2.16$, respectively; $P > 0.05$). Between December and March, the overall fishing hours of the WD were greater than those of the WED, whereas the opposite pattern was evident in November and April. The fishing effort was slightly higher on the BS than on the BG, although there were no significant differences ($F = 3.23$; $P > 0.05$; Fig. 4).

Peak CPUE values were recorded in both November and December for both substrates (BS and BG) where the angler catch was more than 2 fish/h. The CPUE was slightly higher on the BS than on the BG in March and April, while the opposite pattern was noted in January and February (Table 2).

During the 6 months of the survey, the total fish caught in San Blas Bay was estimated to be as many as 196 metric tons, those fish consisting of 12 species. Two sciaenids (*C. guatucupa* and *M. furnieri*) accounted for 80% in weight of that total catch and represented more than 70% of the fish biomass harvested monthly, except in February when this figure reached 50%. Furthermore, these two species were 53% of the total fish removed in only November and

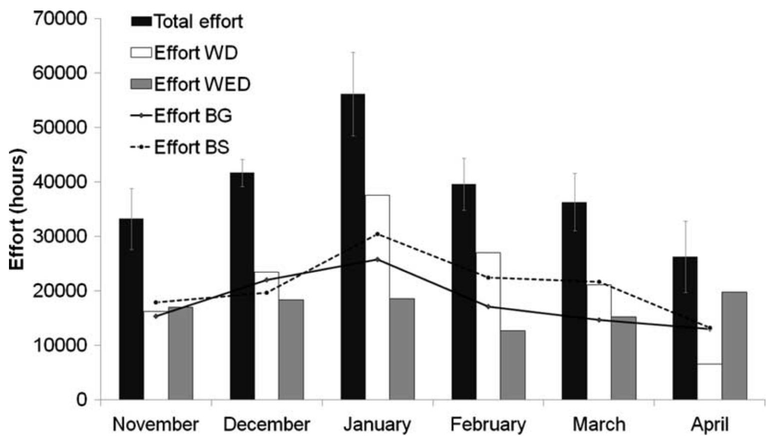

Figure 4 Monthly distribution of the mean total fishing effort (fishing hours) ± standard error for week days (WD) and weekend days (WED). BG, gravel beach (solid line); BS, sand beach (dashed line).

December. The most harvested species was the striped weakfish, whose removal surpassed 116 metric tons during the season, followed by the whitemouth croaker at 31.6 metric tons (Table 3).

The maximum catch in number of fish occurred during December followed by November, while during the remaining months, the catches showed no differences. The number of fish caught on the BG was similar to that of the BS during the entire fishing season; even in March, when no significant difference was found between the areas ($F = 2.9$; $P < 0.05$; Fig. 5).

The total length of the weakfish ranged from 296 to 580 mm and that of the whitemouth croaker from 420 to 696 mm. The average lengths for both species were 435 and 561 mm, respectively, with both these lengths being greater than the respective sizes of those species at first maturity (Cosseau & Perrota 2000). In contrast, the average total length recorded among the captures of the smooth-hound, *Mustelus schmitti*, was shorter than the size at the first maturity of this species, as estimated by Colautti et al. (2010) for this area (Table 4).

Discussion

This study analyses and discusses the first quantitative results obtained from an important recreational fishery that can be considered representative of others similarly distributed along the cold temperate southwestern Atlantic coast. In San Blas Bay, the current management regulations correspond to those applied

Table 2 Capture per unit effort (CPUE) in fish/angler/h in San Blas Bay marine recreational fishery during the 2008–9 season.

Year	2008		2009			
Month	November	December	January	February	March	April
BG	2.20	2.03	0.81	0.80	0.80	0.95
BS	2.05	1.97	0.63	0.76	1.12	1.26
Mean	2.13	2.00	0.72	0.78	0.96	1.11
SD	1.53	1.48	0.46	0.24	0.43	0.88

BG, gravel beach; BS, sand beach.

Table 3 Monthly total catch (kg) of the most prevalent target species of the shore-based recreational fishery at San Blas Bay during the 2008–9 season.

	2008		2009			
Species	November	December	January	February	March	April
Striped weakfish (*Cynoscion guatucupa*)	33,686	36,236	13,388	4498	17,833	10,686
Whitemouth croaker (*Micropogonias furnieri*)	6093	13,465	7427	6238	3709	1235
Smoothhound (*Mustelus schmitti*)	4121	2251	1564	3212	1158	867
Rays (*Sympterygia bonapartii* + *Sympterygia acuta*)	633	1950	1390	3891	1928	770
Others	457	2694	4698	3676	446	2820

for the entire coastal area of the Buenos Aires Province (disposition No. 217, Ministerio de Asuntos Agrarios de la Provincia de Buenos Aires 2007) not considering different ecosystems, fish population parameters and specific angler attitudes. Even though no specific management guidelines have been developed for the San Blas area *per se*, the anglers interviewed did show a willingness to accept the regulation of minimum catch size as a form of management. The enforcement of a maximum daily catch, however, was not considered acceptable since more than 50% of the anglers wanted to retain more fish than the legal maximum allowed. This attitude could be attributed to several causes, such as the angler's preference to keep fish to eat, an ignorance of fishing rules, or a frank resistance in complying with regulation guidelines. Moreover, since most of the anglers must travel long distances in order to fish in San Blas Bay, the high travel costs could be influencing their desire to catch an unlimited number of fish. Such a scenario would certainly suggest that, in order to overcome the lack of willingness to meet recreational fishing regulations, it will be necessary to raise awareness concerning the rational use of resources and the proper control of this activity for the long term.

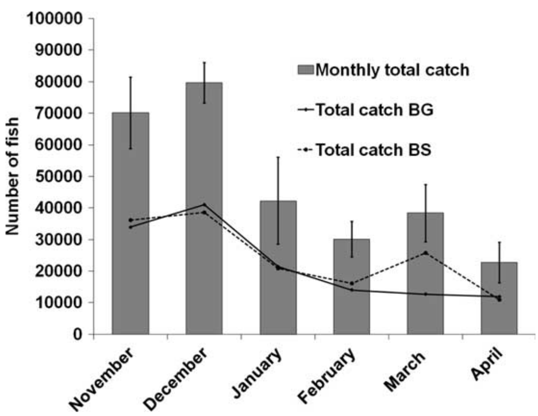

Figure 5 Number of fish caught ± standard error during the 2008–9 season in San Blas Bay. BG, gravel beach (solid line); BS, sand beach (dashed line); grey bars, total monthly fish caught.

Based on the average angler's point of view, as determined by this survey, the San Blas fishery was esteemed as the best marine recreational site in the country. Angler perception of the daily fishing experience showed changes throughout the seasons, with November and December being considered the best months. Accordingly, during those months the maximum CPUE values were recorded, and 50% of the total catch in weight was removed. This pattern can be accounted for by the concentration of sciaenids within protected natural areas close to the coast (Lopez Cazorla 1987, 1996) and to the arrival of smoothhound adults into the Bay (Colautti et al. 2010), since these movements imply an increased number of target fish. Therefore, during the first 2 months of the season, the most relevant incentive for the angler to come to the San Blas Bay fishery would be the possibility of a larger catch. The profile of this so-called 'extractive angler' of these 2 months characterises most of the sport fishermen from the Buenos Aires Province

Table 4 Mean length ± standard deviation (SD), maximum (Max) and minimum (Min) of fish caught at the shore-based recreational fishery at San Blas Bay during the 2008–9 season.

	Catch					L_{50}	
Species	Mean	SD	Max	Min	MSR	Female	Male
Whitemouth croaker (*Micropogonias furnieri*)	561	68	696	420	350	360[a]	340[a]
Striped weakfish (*Cynoscion guatucupa*)	435	35	580	300	300	320[a]	320[a]
Smoothhound (*Mustelus schmitti*)	507	91	683	180	600	620[b]	600[b]

MSR, minimum size regulation, L50, size at first maturity. [a]Following Cousseau & Perrota (2000); [b]following Colautti et al. (2010).

(Vigliano & Grosman 1996) and especially pertains to the experienced anglers with moderate-to-extensive fishing expertise, as can be identified by the high cost and quality of their fishing tackle. Higher CPUE values observed in November and December are probably accounted by for the combination of greater resource availability and secondarily by the higher angler expertise. In contrast, January and February are the 2 months of the summer holidays, and tourists' motivations to travel to San Blas are more diverse and include reasons other than the enjoyment of fishing. This profile of the so-called 'recreational angler' (Vigliano et al. 1994; Vigliano & Grosman 1996) includes much less expertise in sport fishing, as reflected in the less expensive fishing tackle. These sport fishermen would thus have an opposite effect on the CPUE values from that of the extractive anglers. Despite the existence of different anglers profiles, we did not detect a significant proportions of avid anglers. This could be explained by the fact that San Blas is far from the main cities, and high travel costs would preclude multiple visits by anglers during fishing season. These considerations point to the need for additional efforts to be made to determine the ways in which angler profiles affect catch rate and other indicators of fishing quality. The concept of specialisation in fishing has already been documented by other authors around the world (Bryan 1977; Fedler 1984; Graefe & Ditton 1986; Loomis & Ditton 1987; Han 1991) and is useful for understanding the differences in angler motivation and how anglers may respond to specific changes in management policies (Fedler & Ditton 1994). As was observed in other recreational fisheries (Morales-Nin et al. 2005; Smallwood et al. 2006), the anglers in San Blas Bay had a significantly higher attendance on WED compared with WD except during the months of the summer holidays.

Although 37 fish species have been recorded for San Blas Bay (Llompart et al. 2010), the shore-based recreational anglers catch 12 of them. However, the fishing activity is focused mostly on two of the sciaenids, the weakfish and whitemouth croaker, the latter being the favourite target species of the anglers. The weakfish represented more than 50% of the captures by weight, whereas the total capture of the whitemouth croaker amounted to only 25% of that value by weight. Unlike the two sciaenid species, which were mostly captured above their length at first maturity, the mean capture length of the smoothhound was below that minimum size. This difference can be attributed to the use of the San Blas Bay as a breeding area by this shark, such that the juveniles remain in the Bay until they reach the adult stage, when they finally migrate into the open sea (Colautti et al. 2010). Consequently, to avoid juvenile mortality, a mandatory catch-and-release policy for this species should be considered for the San Blas Bay as a both suitable and necessary management measure. This practice has been proposed for other recreational fisheries (Post et al. 2002; Schroeder & Love 2002; Cooke & Cowx 2004, 2006; Arlinghaus et al. 2007), even though the effectiveness and efficiency of such a practice still needs to be determined (Bartholomew & Bohnsack 2005; Coggins et al. 2007). Similar guidelines should be applied to the several rays that are captured as bycatch, owing as their low sport value and that they are not used for food.

On a regional scale, we have no documented information for comparisons of San Blas Bay to other recreational fisheries. The CPUE values (mean $\pm$ SD, 1.28 ± 0.59 fish/angler/h) and total annual harvest (196 ton/year) of San Blas Bay could be considered very high if compared with other shore-based recreational fisheries of the Southern Hemisphere, such as Richards Bay in South Africa, where the CPUE was as low as 0.328 fish/angler/h (including all the released fish, or 0.064 fish/angler/h for only the retained catch) and the total annual fish harvest was 8.371 ton (Beckley et al. 2008). In comparison, Pradervand et al. (2003) estimated the average CPUE for the shore fishery at two localities within the estuarine systems in KwaZulu-Natal, South Africa to be 0.071 fish/angler/h and the total harvest for Durban Harbour to be 7.898 ton; the figures for the Mgeni Estuary were 0.098 fish/angler/h and 1.443 ton, respectively. Furthermore, in that country, the catch rates given by Brouwer et al. (1997) for the KwaZulu-Natal marine shore fishery was 0.25 fish/angler/h, while Pradervand & Hiseman (2006) found in the Goukamma Marine Protected Area a CPUE of around 0.1 fish/angler/h.

Conflicts between commercial and recreational anglers in the Southern Hemisphere have been reported over the use of the same fishery resources (e.g. Begossi et al. 2001; Kearney 2001, 2002), and some attempts have been made to find peaceful solutions involving the coexploitation of fish stocks (Arlinghaus 2005; Cooke & Cowx 2006). For San Blas Bay, the estimated annual shore-based fish catch through recreational fishing was slightly greater than for commercial fishing (164 ton/year), but the target species strongly differed: namely, the commercial fishery focused exclusively on the smoothhound (Colautti et al. 2009, 2010), while the shore-based recreational fishing involved more than one species. Since the smoothhound is only 6% of the total recreational fishing catch and was not considered among the favourite target species for anglers, we conclude that these two activities have a low degree of resource overlap.

Although the present form of recreational fishing was considered acceptable by most of the anglers interviewed, the activity appears to have undergone a process of gradual deterioration, with a loss of fishing quality, in recent years, even though a reduction in the size of the harvested species has not been so apparent. The same situation could exist in other sport fisheries of the South American coast that have not yet been monitored. Our conclusion suggests that more research effort is necessary in order to begin to define research and management objectives for maintaining catch rates within acceptable levels that are compatible with the conservation needs for these areas. Thus, we suggest that this important recreational fishery area be managed under a co-management model. This model involves a wide range of stakeholders, including anglers and fishers, fishery scientists and fishing agencies, and has proven to be successful in solving problems of marine-resource exploitation in Australia (Wilson et al. 2003; Mazur 2010) and New Zealand (Taiepa et al. 1997; Yandle 2003), as well as in South Africa (Hutton & Pitcher 1998; Hauck & Sowman 2001; Napier et al. 2005) and South America (Da Silva 2004; Defeo & Castilla 2005).

The Code of Practice for Recreational Fisheries (CoP) (Arlinghaus et al. 2010) highlights the importance of gathering essential data that include the catch; the harvest; the catch structure (e.g. age and length structure, species and, if possible, the age and size at maturation); the recreational-fishing effort; and angler preferences, attitudes and behaviour. The CoP also stresses the need for monitoring of the social, economic, marketing and institutional conditions affecting recreational fishermen and fisheries. For this reason, although the present survey has gathered key general information for the first time for the San Blas area, the assessment of the recreational fisheries needs to be expanded and improved in other coastal areas of South America. As Beni (1998) stated, poorly planned sport-fishing management can lead to negative impacts on the regional societies and on the surrounding habitats. Indeed, we hope that this study will stimulate applied research in this area of fishery science, so as to move further toward a sustainable management of recreational fisheries throughout all developing South American countries with the ultimate objective of complying with the sustainable-practice principles of the CoP.

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