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Population biology and fishery characteristics of the smooth-hound *Mustelus schmitti* in Anegada Bay, Argentina

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A B S T R A C T

The smooth-hound *Mustelus schmitti* is a commercially important and common target shark inhabiting the southwestern Atlantic coastal system and is usually found in shallow waters. Using experimental and artisanal fishing records, we assessed seasonal biological and demographic characteristics related to fishing of the smooth-hound and its potential impact on this species. We found that after birth, juveniles remain in Anegada Bay until sexual maturity. The young adults mate in spring and then leave the bay in summer. The older adults come back to the bay in early spring to give birth, and mate and finally return to the open sea in late spring. This pattern suggests that the bay acts as a seasonal nursery and reproductive area. This species represents 95% of the fishery captures in this bay, although the fishery is highly seasonal. The average harvest during the years 2003–2008 was 164 tons, which represented only 2% of the total Argentinean smooth-hound landings. Fishing effort in the bay can be considered moderate due to the narrow time window and the use of selective gear that prevents the capture of juveniles. Future research should be directed at developing management plans at a broader regional scale to allow the recovery of *M. schmitti* stocks under heavy fishing pressure in other fishing areas.

1. Introduction

The smooth-hound *Mustelus schmitti* is a common shark inhabiting the southwestern Atlantic coastal system from Brazil to southern Patagonia (Menni, 1985; Chiaramonte and Pettovello, 2000) and is usually found in shallow waters (Cousseau and Perrotta, 2004; Oddone et al., 2007). *M. schmitti* is extensively exploited by commercial and artisanal fisheries along this coastline (Chiaramonte, 1998; Miranda and Vooren, 2003; Paesch and Domingo, 2003) and especially within latitudes from 36° to 41°S (Massa et al., 2004a), where the species represents the most highly targeted shark by artisanal gill net fishermen (Chiaramonte, 1998). *M. schmitti* is also captured during bottom trawling for other species through multifleet fishing and, as such, comprises up to 20% of that fishery's coastal harvest (Massa et al., 2004a,b; Fernández Aráoz et al., 2009). In recent years, the overall yield of this species within the southwestern Atlantic region has greatly decreased primarily because of an increase in fishing effort (Massa and Hozbor, 2003). The El Rincón area in the southwest Buenos Aires province is of particular significance because extensive coastal commercial fishing has developed there (Massa et al., 2004a) and because this region has also been identified as a main nursery site for this species (Cousseau, 1986; Cousseau et al., 1998).

Biological and demographic studies of *M. schmitti* have received considerable attention in recent years (*e.g.*, Chiaramonte and Pettovello, 2000; Oddone et al., 2005, 2007; Sidders et al., 2005). Most of these earlier studies, however, were based on samplings from moderate to deep waters during restricted sampling periods (Menni, 1985) and from net-trawling fishing vessels (Vooren, 1997; Miranda and Vooren, 2003; Pereyra et al., 2008). Such information may be skewed with respect to body size and may not consider seasonal demographic variation and size ranges, thus ignoring the possibility of differences in these parameters among the various shoreline zones. Because of the particular biological features of sharks, fishing could exert a large negative impact on these animals if their biological parameters and population structure were not properly considered as a basis for their sustainable management. More information based on the life-history patterns of this species is thus required to assess the influence of the fishery on

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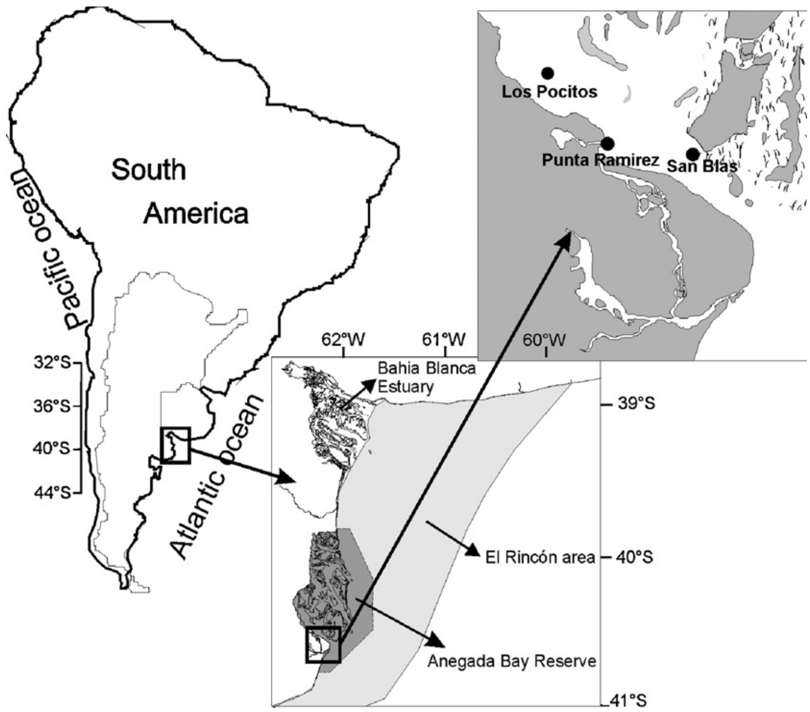

Fig. 1. Geographic location of the study area and the sampling sites.

fishing areas such, such as in Anegada Bay. Although artisanal fishing activity in this bay has a long history, unsound management guidelines were in place up until 2002, when a co-management framework was proposed to organize smooth-hound fishing. Since 2008, however, this fishery has been closed as a result of protective measures in this reserve area.

The present study investigates the seasonal biological and demographic characteristics of the *M. schmitti* populations in the shallow waters of Anegada Bay. Previous studies have focused only on deeper and more outlying regions and have not addressed the importance of coastal areas for this species or how these shark populations could be impacted by inshore fishing. Accordingly, we compared the fishery in this area with that throughout the El Rincón region in general to obtain a broader perspective on the conservation status of this species in the face of the current extent of fishing pressure. At the same time, we suggest future directions to achieve sustainable management of this resource in Anegada Bay and the El Rincón area.

2. Materials and methods

2.1. Study area

Anegada Bay (from 39.96°S to 40.60°S and from 62.10°W to 62.46°W) comprises a reserve designated in 2001 as a multiple-use zone and encompasses the southern part of the Buenos Aires province (Argentina), with its southernmost area considered as part of north Patagonia (Fig. 1).

The bay consists of three main coastal ecosystems characterized by marshes, tidal plains, and psammitic beaches and contains small islands and banks connected by a diffuse network of channels, with depths ranging from 10 to 24 m. The complete El Rincón coastal area has a low level of salinity (30–33 ups), partly as a result of the influence discharge from the Colorado and Negro river (Lucas et al., 2005). The water temperatures ranges from 5 °C in winter to 21.7 °C in summer, whereas the salinity ranges from 32.5 to 35.0 ups (Borges, 2006).

There are sandbars in the southern part of Anegada Bay that can become exposed during low tides. The coastal sediments are heterogeneous and are composed of sand, gravel, wave-cut platforms, and marshes. A distinctive characteristic of the area is the presence of a tidal-inlet system that connects Anegada Bay with the outer sea, the San Blas Channel. This channel is 2.5 km wide and 12 km long and has a maximum depth of 28 m. The current velocities there reach 2 m/s during flood tides and 1.8 m/s during ebb tides. The channel bottom is covered by unconsolidated sediments in its central regions and cohesive sediments toward its mouth (Cuadrado and Gómez, in press).

2.2. Sampling and data collection

2.2.1. Experimental fishing

The study area comprised the Southern part of Anegada Bay, where three main sites were chosen for the sampling of the fish community: (a) San Blas (40.5307°S, 62.2249°W), located in the north flank of the San Blas Channel, a high-current environment near the channel's opening to the outer sea where the sampling depth ranged from 3 to 4.5 m; (b) Punta Ramírez (40.5211°S, 62.3182°W), located at the mouth of a secondary tidal channel (3-m deep), a tributary of San Blas Channel, where the sampling depth ranged from 0.8 to 3 m; and (c) Los Pocitos (40.466°S, 62.366°W), located in the south flank of the San Blas Channel in a shallower (12 m depth) and lower-current environment situated within Anegada Bay, where the sampling depth ranged between 2.8 and 6.4 m.

Each area was seasonally sampled from October 2007 through February 2009 using seven bottom gill nets with a length of 25 m and a height of 2 m with different mesh sizes (distance between opposite knots: 64, 70, 80, 105, 135, 150, and 170 mm). Sampling was always carried out during a nocturnal tidal cycle. After each haul, all of the captured smooth-hounds were sexed, measured (total length: TL), and grouped into size classes differing by 10 mm. A subsample composed of ten randomly selected individuals within each length interval was measured (TL, in mm) and weighed (total weight, W, in g). The stage of maturity was determined macroscopically by means of a maturity key with five stages for females I1, I2, I3, I4, M1, M2 and four stages for males I1, I2, I3, M (Sidders et al., 2005). Accordingly, females were classified as mature from the time they exhibited ovaries containing yellow follicles, whereas males were considered mature if they had completely calcified claspers. Data on litters (the number and length of the embryos) were also collected, and the mean sizes for each sampling date were calculated.

2.2.2. Artisanal-fishing assessment

Captures from the commercial fishery in Anegada Bay were assessed for 2003–2007 using data from fishing licenses, logbooks, and landing samplings. Landings corresponding to other coastal areas from Argentina were obtained from official records and technical reports from the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP).

2.3. Data analysis

2.3.1. Experimental fishing

The frequency–length distributions from each sampling were corrected for gill net selectivity using the method proposed by Jensen (1973). We used cluster analysis (Euclidean distance, UPGMA) to group samples from each date and site based on percentage corrected-length structure. Analysis of similarity (ANOSIM) was also applied to the similarity matrix obtained to test for significant differences between groups (Clarke and Warwick, 2001).

To determine the dynamics of sexual maturation as a function of body length, a logistic model was fitted to binomial-maturity data (immature = 0, mature = 1): $Y = (1 + e^{-(a+bX)})^{-1}$, where Y is the proportion of mature individuals, and X is the TL class. The mean TL at maturity (TL_{50}) is given by $-a/b$ (Mollet et al., 2000). Specimens with lengths corresponding to 0.05% or less of the minimum adult size were referred to as juveniles, specimens between >0.05% and <0.95% as preadults or young adults, and specimens >0.95% as adults. The relative abundance of each group was estimated for each sampling date.

The capture per unit of effort in number (CPUEn) and in total weight (CPUEw) were estimated by standardizing each haul to 12 h of fishing time for the entire set of gill nets. Changes in the CPUE values were analyzed throughout the sampling period.

2.3.2. Artisanal-fishing assessment

Information on artisanal fishing was analyzed to obtain the species composition of the catch, the size of the harvest, the length structure, and the pertinent CPUE ($CPUE_f$) in kg/net/12 h.

The relative length structures from both experimental and artisanal fishing were compared by means of the Mann–Whitney test to determine the impact of the artisanal fishery on the *M. schmitti* population as a whole. The captures of *M. schmitti* in Anegada Bay per year were compared with the records from the general El Rincón area and from all of the Argentinean landings.

3. Results

3.1. Experimental fishing

A total of 2290 individuals of *M. schmitti*, 96% of which corresponded to the Los Pocitos and San Blas sampling sites, were captured during the study period, with only a few individuals being caught in the Punta Ramírez area. A cluster analysis of the size distributions indicated the existence of two main groups with differing characteristics that followed a seasonal pattern and were independent of the sampling site (Fig. 2). One of the groups consisted of samples from the spring and summer, whereas the other comprised samples from the autumn and winter, with the differences between these two groups being statistically significant (global $R = 0.95$, $P < 0.05$).

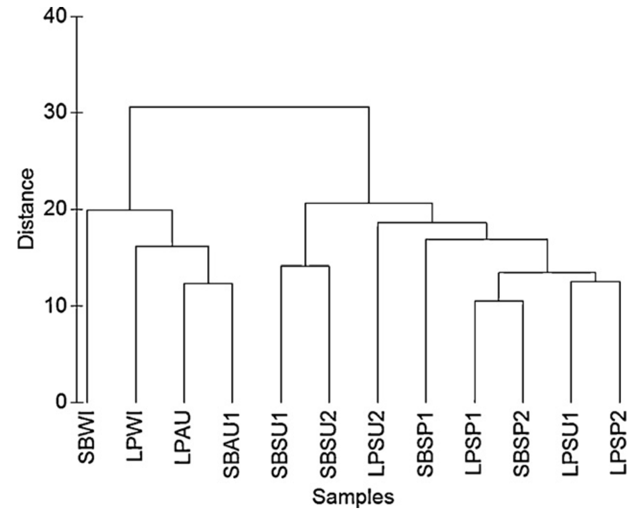

Fig. 2. Sample length structure cluster analysis through the use of Euclidean distances with UPGMA groupings. SB: San Blas; LP: Los Pocitos; SP: spring; SU: summer; AU: autumn; Wi: winter.

A wide range of lengths, encompassing minimum and maximum sizes, was observed in San Blas and Los Pocitos from spring and summer, whereas a narrow range, composed only of sharks up to 50 cm, was found from autumn and winter. In the spring and summer group, 59% of the similarity was accounted for by lengths longer than 47 cm, whereas in the autumn and winter group, 69% of the similarity occurred at lengths smaller than 40 cm. In contrast, most of the dissimilarity (68%) between groups was explained by the 35–40-cm and 50–55-cm length intervals (Fig. 3).

The overall average female/male ratio was 1.15. The sex ratio for various size classes varied from approximately 1:1 up to approximately 62 cm, after which length the proportion of females increased progressively (Fig. 3).

Pregnant females were detected only in spring and summer. However, the embryo sizes differed between these two seasons. The sizes of the embryos in the spring were close to that of the smaller juveniles recorded in the experimental sampling (24.4 ± 4.25 cm), whereas only small-sized embryos and eggs were detected in the females during the summer.

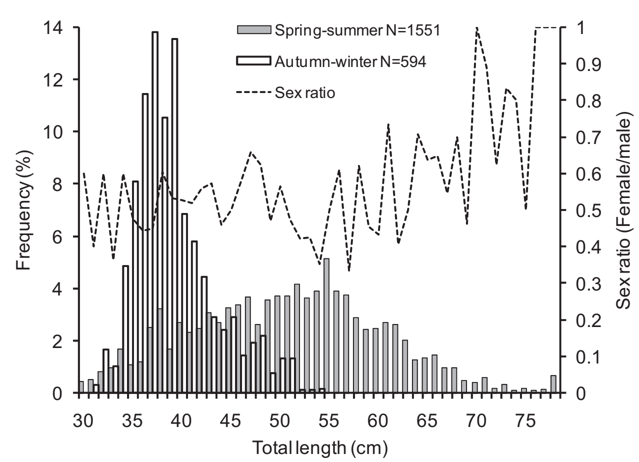

Fig. 3. Pooled proportional-length distribution of the spring–summer group and the autumn–winter group of *M. schmitti* in Anegada Bay, along with the sex ratio according to the length-class interval.

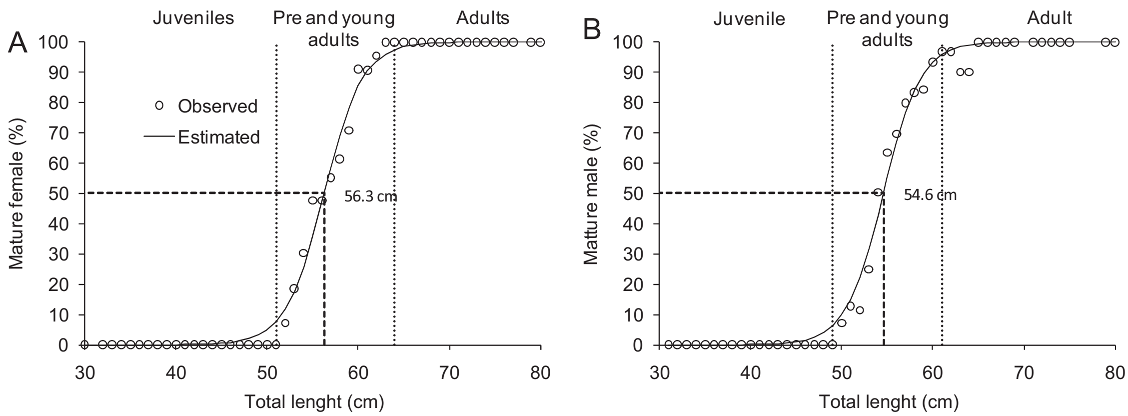

Fig. 4. Logistic model fitted for the relationship between the total length (cm) and the percentage of mature females (A) and males (B) of *M. schmitti* in Anegada Bay. The length intervals correspond to: juveniles, pre- and young adults, adults, and the TL_{50} for both sexes.

Table 1
Captures per unit effort at each sampling date and juvenile, pre- and young adult and adult relative abundance. CPUEw and CPUEn are in kilograms (kg) and fish number (*N*) captured in 12 h by the entire gill net set, respectively.

	Spring 1	Summer 1	Autumn	Winter	Spring 2	Summer 2
CPUEw (kg net 12 h^{-1})	113.93	56.66	34.50	10.34	91.53	35.24
CPUEn(N net 12 h^{-1})	186.75	135.86	148.82	52.96	185.08	87.26
Juvenile (%)	33.2	52.8	97.4	100.0	51.0	73.4
Pre- and young adult (%)	47.2	45.3	2.6	0.0	42.1	23.9
Adult (%)	19.6	1.9	0.0	0.0	7.0	2.7

The fitted-sexual-maturity model indicates that the TL_{50} for males and females was 54.6 cm and 56.3 cm, respectively, representing lengths that correspond to an approximate age of 2.4 years for both sexes, according to Massa et al. (2001). Males and females smaller than 49 and 51 cm, respectively, were identified as juveniles, whereas males between 50 and 61 cm and females between 52 and 64 cm were considered preadult or young-adult individuals. These two length ranges correspond to roughly 2–3.4-year-old sharks. The upper value of both ranges was considered as the smallest length for the adult stage (Fig. 4). These size groups exhibited significant variation in relative abundance among seasons.

The CPUE values from the experimental fishing revealed a large variation during the year, with higher values occurring in the two springs evaluated. Although most of the captured individuals in winter and autumn were juveniles, their CPUEn had no seasonal pattern. The highest percentages of preadults, young adults, and adults were noted in spring. Thereafter, the proportion of adults decreased markedly during the summer, whereas the relative abundance of preadult and young-adult individuals remained almost constant until autumn. From that time on, however, these last stages likewise became poorly represented in the catches (Table 1).

3.2. Artisanal fishing assessment

According to the logbooks surveyed, artisanal fishing season starts on October 15 and ends on December 15. The local fleet consisted of seven small vessels of lengths up to 10 m that operated in the San Blas area and eleven boats of lengths up to 8 m that fished only in the Los Pocitos region. Fishing was carried out with 5–10 bottom gill nets per boat that were 50 m long and had a 105–110-mm mesh size. In 2004 and 2008, fishing was banned as a result of stakeholder conflicts concerning the conservation and use of the natural resources in Anegada Bay.

The artisanal captures were strongly dominated by *M. schmitti* (96%), which had a size distribution that ranged from 52 to 75-cm TL, with a well-defined modal value at 65 cm. This length, in turn, can be attributed in part to the selectivity of the gill nets used. We also noted that only 1.8% of the fish captured corresponded to juveniles and that 36.8% corresponded to preadults or young adults. This distribution differed markedly from that of the experimental fishing ($P < 0.01$), which exhibited a pattern that, as expected, showed a greater range of fish lengths (Fig. 5). The largest individuals (with TLs as high as 90 cm) were recorded from commercial fishing, although these individuals were small in number; the smallest fish were collected during the experimental fishing. This latter approach to demographic sampling thus allowed us to acquire a more accurate picture of the population structure within the fishing areas surveyed.

During the fishing season, the mean annual CPUE in the San Blas area was much higher than that in Los Pocitos region (Table 2). Within the total Anegada Bay study zone, the captures ranged from 105 to 248 tons, representing from 3.5 to 7.5% of the values for the El Rincón area and from 1.6 to 4% of the total captures in Argentina, depending on the year (Table 3). The catches in Anegada Bay, how-

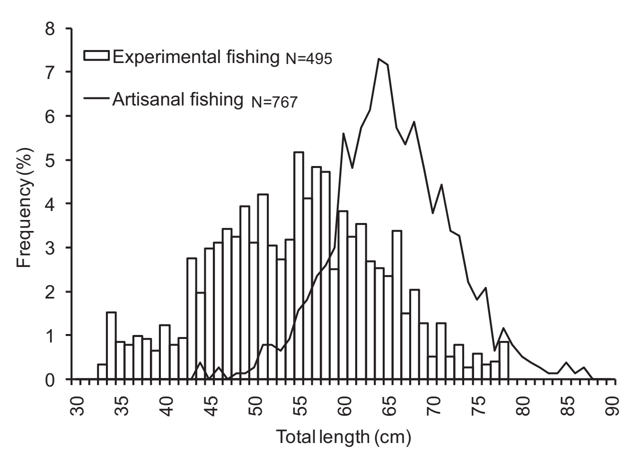

Fig. 5. Total length distribution of *M. schmitti* obtained from experimental (spring) and artisanal fishing.

Table 2
Capture per unit of effort between 2003 and 2008 for the Anegada Bay artisanal fishery at Los Pocitos (LP) and San Blas (SB). N/D: no data available, N/F: fishing banned.

Year	2003	2004	2005	2006	2007	2008	Mean
$CPUE_f$ LP (kg net 12 h^{-1})	N/D	N/F	100.21	87.89	129.05	N/F	105.72
$CPUE_f$ SB (kg net 12 h^{-1})	258.18	N/F	274.24	289.06	314.6	N/F	292.63

Table 3
Total catch from the Anegada Bay artisanal fishery, the El Rincón area, and Argentina between the years 2003 and 2008.

Year	2003	2004	2005	2006	2007	2008
Anegada Bay (tons)	105.3	N/F	248.2	160.9	142.4	N/F
El Rincón (tons)	3173.8	2877.4	3322.9	2926.3	3043.3	3528.8
Argentina (tons)	6451.8	5886.8	6254.7	7958	7524.7	8646.4

ever, tended to decrease after 2004, in contrast to the increase in the values nationwide after that year.

4. Discussion

4.1. Experimental fishing

This study analyzed, for the first time, important biological and fishing information about the smooth-hound population in the southernmost part of the El Rincón region and, in particular, Anegada Bay. A distinctive feature found in this study was that the length composition of the captures showed notable changes throughout the year that were associated with the reproductive cycle and with sexual maturation. Juveniles remained in this area during the entire year without exhibiting significant changes in their abundance, indicating that Anegada Bay could be considered as a nursery site. Experimental fishing allowed the detection of juveniles as small as 32 cm, a size close to the 24–28-cm embryo length recorded by Menni (1986) and Chiaramonte and Pettovello (2000). This tendency to remain in the bay could facilitate predator avoidance and provide access to appropriate food sources for juveniles until they reach maturity (Castro, 1993; Simpfendorfer and Milward, 1993).

In contrast, preadults and young adults were present in a high abundance during the spring and summer. The fact that most of these females carried embryos in their oviducts during the summer implies that they became pregnant immediately after reaching sexual maturity in the bay. These individuals could be considered to be first-time mating individuals that migrate into the open sea from the late summer and early autumn at three years of age, thereafter returning to give birth for the first time and mate for the second time during the fourth spring of their life. This observation suggests that the gestation period of this species lasts one year, as has been noted for *M. fasciatus* (Soto, 2001). Of notable interest is our finding that the length at which males and females of *M. schmitti* attain sexual maturity in Anegada Bay was estimated to be smaller than the value recorded by Menni et al. (1986) and Cousseau et al. (1998) within the Buenos Aires coastal areas and by Menni (1985) in north Patagonia (Table 4). As documented for other *Mustelus* species (Moulton et al., 1992; Conrath and Musik, 2002), *M. schmitti* females reach larger sizes at maturity than do males. Nevertheless, differences in the reproductive characteristics of different members within *Mustelus* populations are not uncommon (Lenanton et al., 1990; Yamaguchi et al., 2000; Pérez Giménez and Sosa-Nishizaki, 2008). We speculate that the larger TL_{50} observed in other studies could be explained by fishing gear selectivity because the trawling nets used in deeper waters tend to capture larger individuals, whereas juveniles remain in shallow waters until they reach sexual maturity and mate for the first time.

Pregnant females and fluent males (adults of four or more years of age) exhibited their maximum relative abundances during the spring, indicating that they enter the bay for reproductive purposes. We also noted that in the spring, the pregnant females from the adult group contained larger embryos than individuals sampled during the summer, indicating that these females entered the bay to give birth and mate once again. Nonetheless, unlike young adults, these females leave the bay in late spring and are, thus, scarce in summer and totally absent in autumn and winter. A similar reproductive and demographic pattern was recorded for *M. fasciatus*, which is a species that is sympatric with *M. schmitti* in Brazilian waters, where adults migrate into shallow areas for mating during the spring and summer, and neonates remain in shallow waters during the entire year (Vooren and Klippel, 2005).

A disappearance of *M. schmitti* from the coastal waters during winter has been associated with migratory movements to southern Brazil (Vooren, 1997), seasonality (Lopez Cazorla, 1987, 2004), reproductive patterns (Massa et al., 2004a), depths (Cousseau et al., 1998), and both individual sex and size (Pereyra et al., 2008). A similar behavior has been observed for other related species, such as *M. lenticulatus* (King, 1984; Francis, 1988), *M. mustelus* (Saidi et al., 2008), and *M. fasciatus* (Soto, 2001; Vooren and Klippel, 2005). Taking into account the geographical extensiveness of Anegada Bay, we conclude that this area, along with other coastal regions in Argentina, may represent a nursery and mating zone (Lopez Cazorla, 1987; Cousseau et al., 1998; Van der Molen and Caille, 2001). Nevertheless, more detailed studies are needed to confirm the value of Anegada Bay as a true nursery area. Such conclusions need to be based on more well-established criteria using data on neonate and juvenile densities, population sizes, bay residence times, and fidelity over the years (Heupel et al., 2007; Kinney and Simpendorfer, 2008).

4.2. Artisanal fishing

A distinctive feature of the artisanal fishery in Anegada Bay is that it occurs for only two months (from the middle of October to the middle of December), principally in response to inshore adult-migration patterns. During this period, pre- or young adults are present but in a smaller proportion. This fishery uses bottom gill nets exclusively, which, unlike trawling, minimizes the impact on benthic sediments and organisms. Thus, this fishing pressure is exerted only on a narrow segment of the population (mostly 60–70 cm) as a result of gill net selectivity. This size range exceeds the $TL_{50,}$ therefore avoiding juveniles and retaining fewer than 40% of individuals that are mating for the first time. In other words, more than half of the individuals recruited to the fishery have the chance to reproduce at least once. The use of specific gill net mesh sizes also minimizes bycatch, promoting a highly monospecific fishery.

These results contrast with other coastal fishing practices applied to *M. schmitti*, such as those employed in the Río de La Plata estuary and in the open waters of El Rincón, where multi-specific capture occurs throughout the entire year, especially in

Table 4
Comparison of first size at maturity corresponding to different areas.

Study site	Total length (cm)		
	Males	Females	Reference
Buenos Aires coastal area	60	62	Menni (1985)
Buenos Aires coastal area and Uruguay	54.9	60.5	Diaz de Astarloa et al. (1997)
Buenos Aires coastal area and Uruguay	57.6	59.9	Cousseau et al. (1998)
El Rincón	57.63	59.92	Cousseau et al. (1998)
Buenos Aires coastal area	–	56	Cortés (personal communication)
Buenos Aires area (open sea)	60	62	Menni (1985)
Río de la Plata estuarine front	59	72	Oddone et al. (2005)
Anegada Bay	54.6	56.3	This study

the spring and autumn, because trawl nets are used (Massa et al., 2004a; Oddone et al., 2005). Fishing records from the Buenos Aires coastal ecosystems show that the El Rincón area indicate the highest catches. This feature is consistent with the distribution of smooth-hound densities, which are highest in the southern part of the El Rincón zone (Massa et al., 2001) and where *M. schmitti* biomass decreased by 50% between 1994 and 2003 (Massa et al., 2001, 2004c). Additional evidence of resource deterioration was found by Massa and Hozbor (2003), who noted that the CPUE for *M. schmitti* associated with large vessels (>20 m in length) operating in deeper waters decreased and that the mean length of the smooth-hounds retained declined from 59 cm in 1994 to 55 cm in 1999. Because this latter value is smaller than the TL_{50}, conducting this fishery in deep waters can be considered unsustainable.

As stated above, however, this situation has not been observed in Anegada Bay, though the captures there represent an average of only 2% of the total Argentinean landings. Moreover, the fishing effort in the bay can be considered as only moderate because the selectivity of the gear used prevents the capture of juveniles along with an acceptable proportion of pre- and young adults. In contrast, in the El Rincón area outside of Anegada Bay and in the La Plata-estuary maritime front, *M. schmitti* is captured even before the onset of maturity, and the catch is composed of a high proportion of juveniles (Cousseau et al., 1998; Massa et al., 2001; Pereyra et al., 2008). The capture of high numbers of young adult or preadult sizes through high fishing effort, in combination with nonselective gear leads not only to overfishing on young sharks, but also favors a loss of genetic diversity by preferentially capturing those individuals exhibiting the highest growth rates.

Because fishing in Anegada Bay shows a strong seasonal pattern, unlike in the deeper El Rincón areas, where fishing takes place during the entire year, different sustainability-management guidelines should be applied in the bay. Upon consideration of the seasonal characteristics of the fishing there and given the sustainable nature and the regional importance of artisanal fishing in this bay, in addition to the minimal impact that the captures have on the overall status of this species nationwide, the conservation measures imposed in recent years would seem to be poorly justified.

The typical life history characteristics of sharks, *i.e.*, slow growth, low fecundity, and late maturity, make these species highly vulnerable to overfishing (Hoenig and Gruber, 1990; Frisk et al., 2005). Thus, future research on shark management should be directed at a better understanding of critical population issues, such as migratory patterns, density-dependent regulations, and stock-recruitment relationships, as well as with considerations of gear selectivity to predict population responses to variable fishing efforts (Walker, 1998). For *M. antarticus*, a species that can be considered highly productive, Walker (1998) proposed that up to 15% of its equilibrium biomass can be harvested sustainably. Although no similar analyses have been conducted for *M. schmitti*, Cortés (personal communication) has suggested that the minimum capture size in the Buenos Aires province shelf region should be longer than a TL of 75 cm for the fishery to be sustainable. This size likely corresponds to 5-year-old adults entering Anegada Bay to give birth for the second time and to mate for the third time. Individuals larger than that length, however, do not appear to be dominant in Anegada Bay, as shown by both artisanal records and experimental fishing. As noted by Walker (1994), gill net fishing might represent an artificial selection mechanism that could modify population structure and growth performance either positively or negatively depending on how species vulnerability is regulated in accordance with body length through gear selectivity. Because the litter size of *M. schmitti* appears to be linearly related to the pregnant female's length (Oddone et al., 2005), the largest individuals should be protected by implementation of regulations related to appropriate gear.

Taking into account the fact that *M. schmitti* populations exhibit complex reproductive behaviors associated with migratory patterns between shallow and deep coastal grounds, regulatory models should encompass the overall El Rincón area to allow a recovery of currently overfished zones and to protect the still-healthy segments of the smooth-hound stocks that support artisanal fishing in Anegada Bay and other regions like it.

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