

Ontogenetic habitat preferences of the narrownose smooth-hound shark, *Mustelus schmitti*, in two Southwestern Atlantic coastal areas

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Abstract The aim of this study was to determine the ontogenetic habitat preferences of the narrownose smooth-hound shark, *Mustelus schmitti*, in Río de la Plata and El Rincón coastal areas. There, canonical correspondence analyses of fishery research survey data showed that *M. schmitti* ontogenetic stages were differentially affected by depth, temperature and salinity. Neonates and juveniles were more abundant and remain in nearshore waters, suggesting the presence of nursery areas in which food availability and environmental conditions allow a faster growth. Adults *M. schmitti* presented different environmental

associations mainly associated with depth and temperature. During non-reproductive season they were associated with deeper coastal waters. With the arrival of the reproductive season, adults migrate from deep to nearshore waters and show sexual segregation associated with pre- or post-mating behaviors. Hence, the year-round presence of neonates and juveniles and the seasonal occurrence of adults in nearshore waters make this habitat essential to *M. schmitti* population dynamics since key ontogenetic stages will be vulnerable if a direct impact occurs there.

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Distribution pattern

Introduction

Coastal environments provide important habitat for sharks (McCandless et al., 2007; Knip et al., 2010). They are used in different ways by shark species, and characteristics and habitat type of a coastal environment may influence species distribution and movement (McCandless et al., 2007; Ubeda et al., 2009) and, therefore, the fishing impact on them. The different habitats in the coastal environment may be selected by sharks responding to abiotic factors such as temperature and salinity, as well as ecological factors such as prey availability, predation risk, and

presence of competitors (Sims, 2003; Simpfendorfer & Heupel, 2004; Speed et al., 2010). The shark strategy of coastal habitat use has been generalized in two main patterns (Knip et al., 2010). Those encompassing mainly large-sized sharks that use discrete nearshore nursery areas for short periods with adults occurring offshore except when they move inshore to give birth and mate (Springer, 1967), and those related to smaller sharks that occur in nearshore waters during their life span, move widely within nearshore areas and often appear less reliant on specific habitat (Knip et al., 2010). The increasing human activities in coastal environments and the worldwide decline in shark populations (Stevens et al., 2000; Baum et al., 2003; Myers et al., 2007; Ferretti et al., 2008) has led to increased effort on the identification of distribution patterns and habitats used by sharks along their life span (Heupel et al., 2007; McCandless et al., 2007; Knip et al., 2010). Understanding the ontogenetic habitat use patterns will help to determine the susceptibility of sharks to local and regional impacts such as habitat destruction, inter-annual climate anomalies, and fishery exploitation patterns.

Many shark species use the Southwestern Atlantic Coastal Ecosystem (SACE, 34°–42° S < 50 m depth) for feeding (*Mustelus schmitti*, *Squatina guggenheim*, *Galeorhinus galeus*, *Notorynchus cepedianus*), mating (*M. schmitti*, *S. guggenheim*, *G. galeus*, *Carcharias taurus*), and nursery grounds (*M. schmitti*, *S. guggenheim*, *G. galeus*, *Carcharhinus brachyurus*, *N. cepedianus*) (Cousseau, 1986; Menni, 1986; Menni et al., 1986; Lucifora et al., 2002, 2004, 2005a, b, 2006; Colonello et al., 2007; Vögler et al., 2008). These species have different biological characteristics, but most are targeted in a multi-specific fishery carried out by various float types (Carozza et al., 2001). Impact of the fishery is reflected in overall abundance and community structure, including changes in the number of dominant species (Jaureguizar, 2004) and the trophic level of commercial landings (Jaureguizar & Milessi, 2008). Due to these impacts and to continuous human pressure on the SACE it will be progressively more important to understand how sharks use coastal waters to implement management plans for ecosystem protection and conservation.

The narrownose smooth-hound shark *Mustelus schmitti* (Carcharhiniformes: Triakidae) is a small-sized shark (maximum total length = 105 cm;

Menni, 1985) that inhabits coastal waters in the Southwestern Atlantic from Rio de Janeiro (22°S, Brazil) to Puerto Deseado (47°45'S, Argentina) (Menni, 1985; Chiaramonte & Pettovello, 2000). Two main areas within SACE that have high concentration of *M. schmitti* are well defined, Río de la Plata and El Rincón (Cousseau et al., 1998), where *M. schmitti* fulfills their life requirements (Cousseau, 1986; Massa, 1998) and is the most abundant and most frequently landed shark (Massa et al., 2004). These areas encompass the highest abundance of *M. schmitti* within the Southwestern Atlantic (Miranda & Vooren, 2003; Massa et al., 2004). Although it is an abundant species, demographic analyses demonstrated that even moderate impacts on the *M. schmitti* population negatively affect the population growth rate (Cortés, 2007). In addition, based on the decline population trend during the past years and the continuous fishing intensity, the IUCN Red List of Threatened Species has categorized this species as endangered (Massa et al., 2006) which makes essential studies concerning *M. schmitti* population.

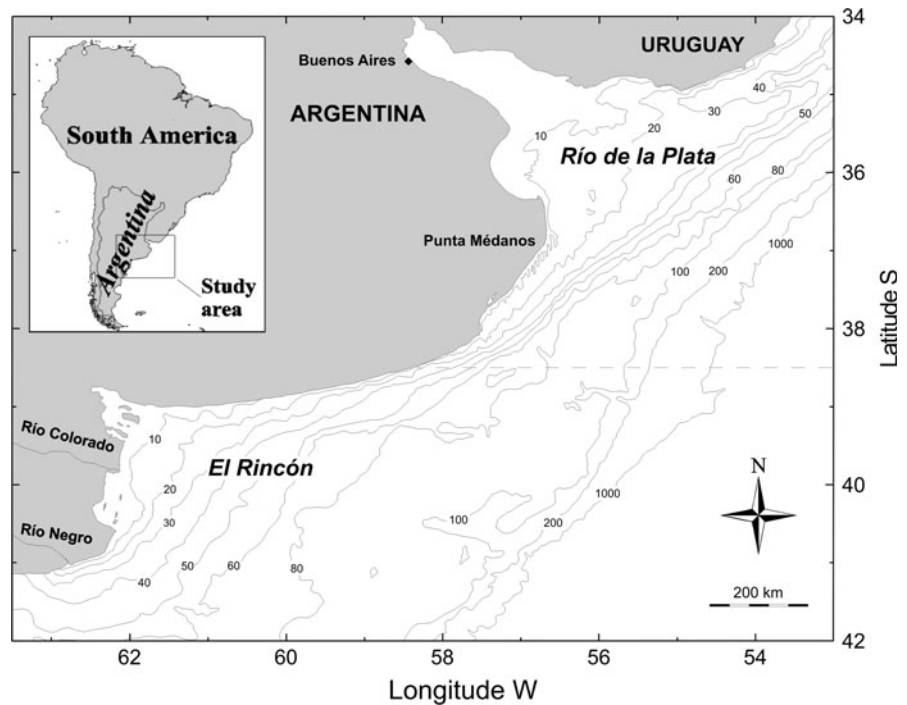
Although both SACE areas are influenced by freshwater discharges and delimited by relatively high-salinity mid-shelf waters (Guerrero & Piola, 1997; Lucas et al., 2005), there are spatial and seasonal differences in oceanographic patterns and environmental forcing factors between the two regions (Guerrero et al., 1997; Lucas et al., 2005). These seasonal oceanographic changes could influence habitat selection and utilization by *M. schmitti* within the SACE, affecting its habitat availability and fishing pressure. Here we determine the ontogenetic habitat preferences of *M. schmitti* in these two main SACE areas examining the distribution of size classes along environmental gradients.

Methods

Data

Biological [total length (TL), and sex] and oceanographic (depth, bottom temperature and bottom salinity) data were obtained from Instituto Nacional de Investigación y Desarrollo Pesquero fishery evaluation cruises carried out in SACE (34°S–42°S < 50 m depth, Fig. 1) during winter and spring between 1993 and 2006. In this period a total of

Fig. 1 Map showing the location and bathymetry of the study area. The *dashed line* indicates the division of the Río de la Plata and El Rincón regions. The *solid lines* indicate isobaths (m)



nine surveys in Río de la Plata (four during winter and five during spring) and eight surveys in El Rincón (two during winter and six during spring) were carried out (Table 1). The surveys covered an area of 130,968 km² using a stratified random sampling design (Fig. 2).

Mustelus schmitti were collected in 719 bottom trawl sets (40.3 m footrope, 35.3 m headrope, 103 mm codend mesh size, 22 mm inranet mesh size, 7.4 km h⁻¹ average trawl speed, 15 min trawl duration; Table 1 and Fig. 2). *M. schmitti* were binned by sex and TL. Five TL classes were defined; Individuals smaller than 40 cm TL corresponded mostly to neonates and young of the year (Cousseau, 1986; Massa, 1998), individuals between 40 and 49 cm TL were assumed to be juveniles and those between 50 and 59 cm TL were maturing individuals (Menni et al., 1986; Cousseau et al., 1998; Cortés, 2007). The TL classes between 60 and 69 cm and larger than 70 cm correspond to small and large adults, respectively (Menni et al., 1986; Cousseau et al., 1998; Cortés, 2007). In each tow, abundance of each size class was estimated using the swept area method (Alverson & Pereyra, 1969) and oceanographic data were obtained using a Sea-Bird Electronics conductivity–temperature–depth (CTD) unit.

Data analysis

Due to differences in continental runoff, fresh water balance, and the spatial distribution of salinity signals (Lucas et al., 2005), the Río de la Plata and El Rincón regions were analyzed independently. In order to obtain seasonal distribution patterns, annual surveys were pooled in winter (from July to August) and spring (from October to December) seasons (Table 1).

To examine the horizontal distribution of environmental variables in each study area, bottom salinity and bottom temperature were mapped for each season. Parameters were interpolated onto a 0.3° latitude × 0.3° longitude grid using an inverse distance squared algorithm (SURFER[®] version 8.02, Golden Software Inc.). In order to detect problems with collinearity between environmental variables the variance inflation factor values (VIFs) were estimated following Zur et al. (2010). The estimated VIFs were lower than three in both Río de la Plata (Winter: depth = 1.58, bottom temperature = 1.29, and bottom salinity = 1.54; Spring: depth = 1.98, bottom temperature = 2.14, and bottom salinity = 1.55) and El Rincón (Winter: depth = 2.59, bottom temperature = 2.76, and bottom salinity = 1.66; Spring:

Table 1 Summary of trawls with *Mustelus schmitti* (with Ms) carried out in each area by season (years with surveys in each area and season)

Area	Season (years)	Trawls (with Ms)	Julian day (duration)	No. of ind. (measured %)	TL range (cm)
Río de la Plata	Winter (1993, 2001, 2004, 2006)	342 (181)	192 (17)	8,701 (93)	27–99
	Spring (1994, 1998, 1999, 2003, 2005)	425 (205)	328 (18)	12,143 (78)	27–95
El Rincón	Winter (1993, 2004)	139 (85)	217 (19)	6,180 (99)	27–93
	Spring (1994, 1998, 1999, 2000, 2003, 2005)	379 (248)	338 (13)	19,362 (93)	27–99

Survey date is present as median Julian day of the total surveys (survey duration in Julian days)

No. of ind., number of specimens caught (measured individuals percentage), TL range, total length range of sampled individuals

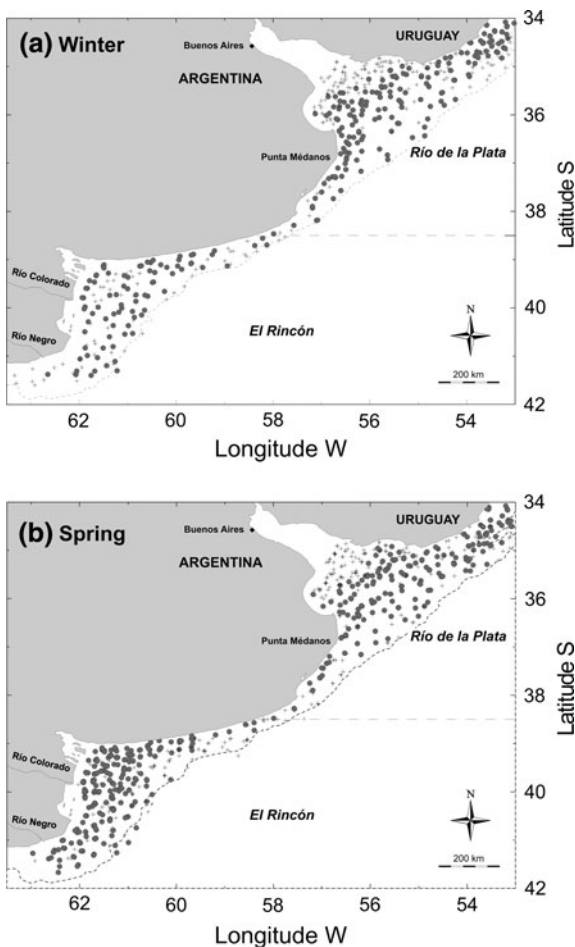


Fig. 2 Maps showing locations of bottom trawl sets conducted in Río de la Plata and El Rincón for winter (a) and spring (b). Gray circles represent trawls with *Mustelus schmitti* caught, and plus represent trawls without *Mustelus schmitti* caught. Oceanographic data were recorded in all trawls. The dashed line represents 50 m depth isobaths

depth = 2.12, bottom temperature = 1.73 and bottom salinity = 1.32), indicating that high levels of collinearity were not detected (Zur et al., 2010); therefore, all environmental variables were included in the analyses.

To know the population structure within each area and season the relative frequencies of each TL class by sex were plotted. Chi-square goodness-of-fit test with Yates continuity correction were applied to determine if the sex ratios were biased to 0.5 proportions with a level of significance of 0.05 (Zar, 1996).

Canonical correspondence analyses (CCA) were employed to examine how *M. schmitti* size classes were distributed along environmental gradients (depth, bottom temperature, and bottom salinity). This method assumes a unimodal response between abundance and environmental gradients (Jongman et al., 1995). The statistical significance of the ordination method was obtained by Monte-Carlo permutations test (199 permutations). The size class scores and intraset correlations obtained by CCA were plotted using a biplot. Environmental variables were represented by vectors. The lengths of the vectors on the biplot indicate the magnitude of their relative importance in the ordination, and the position and direction of the vectors indicate how they are correlated with each other and with each axis. The relative position of size classes along the vectors reflects how size classes are associated with each factor relative to the other size classes (Zur et al., 2007). The abundance data were transformed by $\log_{10}(x + 1)$ to minimize the influence of extreme values and zeros. All statistical analyses were

performed using the R statistical software, version 2.7.2 (R Development Core Team, 2008).

Results

Environmental conditions

During winter, the Río de la Plata bottom temperature was lowest (11°C) in the southern and inner area of the estuary, whereas slightly warmer temperatures (14°C) were observed at the northern and outer central areas of the estuary (Fig. 3a). El Rincón bottom temperature showed a weak increase in temperature with depth, with minimum values (8°C) observed at the coast and maximum values (10°C) in the outer region (Fig. 3a). During spring, stronger horizontal gradients were observed at both study areas. The position of warm and cold zones was reversed from winter, with maximum bottom temperatures (20°C in Río de la Plata and 17°C in El Rincón) located in shallow areas, and minimum values (12°C in Río de la Plata and El Rincón) at the mid shelf (Fig. 3b).

In both seasons, bottom salinity was higher in El Rincón (between 31 and 34.4; Fig. 3c, d) than in Río de la Plata (between 0.6 and 34.15; Fig. 3c, d). Horizontal distributions of bottom salinity showed an increase toward mid shelf in both areas. In the Río de la Plata the salinity gradients were weaker during spring relative to winter, whereas El Rincón showed weak gradients during winter as compared to spring (Fig. 3c, d).

Structure and spatial distribution pattern

The TL classes structure were similar in the El Rincón and Río de la Plata, with both study areas showing seasonal differences. Winter was dominated by individuals smaller than 60 cm TL (Fig. 4a, b). During spring, the proportion of individuals with TL larger than 60 cm increased (Fig. 4c, d). Sex ratios were biased to males in TL classes lower than 70 cm, this biased increased during spring, a pattern that was more evident in Río de la Plata (Fig. 4).

Canonical correspondence analysis and Monte-Carlo permutations tests indicated that environmental factors are related to the distribution pattern of *M. schmitti* size classes in the Río de la Plata and El

Rincón (Table 2). During winter, the total variance explained by the first two CCA axes was 11.94 and 20.63% in the Río de la Plata and El Rincón, respectively (Table 2). The first two CCA axes accounted for 97.27 and 99.23% of the species–environment relations in the Río de la Plata and El Rincón, respectively (Table 2). Separation along the first axis reflected an increase in fish size with depth (Fig. 5a, b; Table 3). The smallest *M. schmitti* (<40 cm TL) were common in shallow waters (<25 m) whereas medium and large individuals were most abundant in deeper waters (>25 m). Along CCA axis 2, separation was indicative of an increase in abundance of larger individuals with temperature (Fig. 5a, b; Table 3).

In spring, variations in data and species–environment relations explained by the first two axes were lower than in winter (Table 2). Separation along the first axis was mainly associated with depth in the Río de la Plata (Fig. 5c; Table 3), whereas in El Rincón it was associated with temperature (Fig. 5d; Table 3). Along CCA axis 2, separation was associated to salinity and depth in the Río de la Plata and El Rincón, respectively (Fig. 5c, d; Table 3). Small *M. schmitti* (<40 cm TL) were most abundant in shallower, warmer, and less saline waters. In the Río de la Plata, medium-sized females (40 cm TL) and males were more prevalent in intermediate depths. Large *M. schmitti* females (>60 cm TL) were most abundant in deeper, colder, and saltier waters (Fig. 5c). In El Rincón the opposite pattern was observed, with large females being more abundant in the coastal zone (Fig. 5d).

Discussion

Although the entire *M. schmitti* ontogeny occurs within the Southwest Atlantic Coastal Ecosystem, this study supports the statement that the spatial distribution of different size classes is correlated to environmental variables. Taking into account the birth size (27 cm TL; Cortés, 2007), neonates' mean TL (35 cm TL; Massa, 1998) and size at first maturity (50–60 cm TL; Menni et al., 1986; Cousseau et al., 1998; Cortés, 2007), this study suggests that size classes corresponding to neonates and juveniles (individuals between 27 and 40 cm TL and between 40 and 50 cm TL, respectively) have a persistent

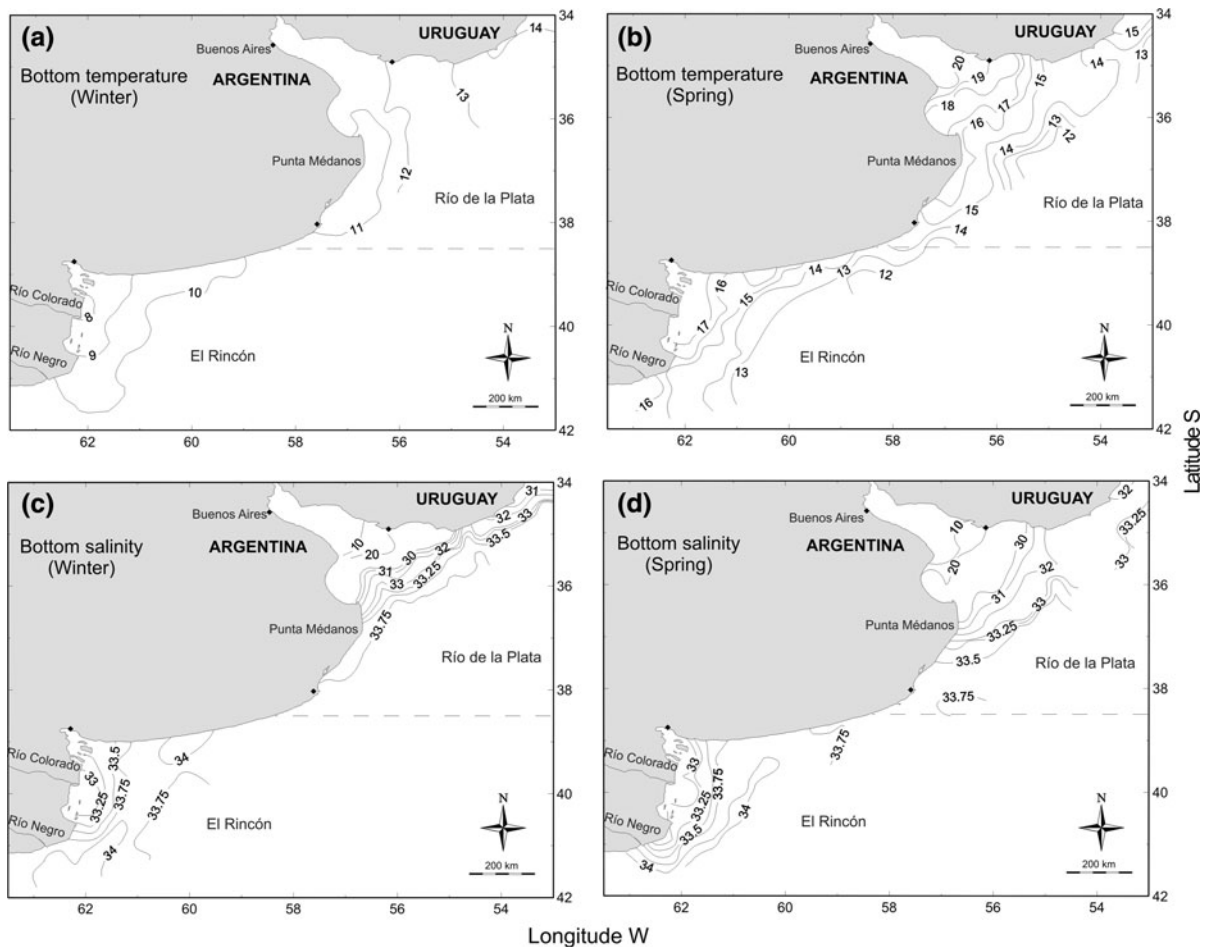


Fig. 3 Mean bottom temperature and bottom salinity distributions for winter (a, c) and spring (b, d). Temperature isoline intervals every 1°C. Salinity isoline intervals: every 10 from 0 to 30, every 1 from 30 to 33, every 0.25 from 33 to 34

environmental association. In contrast, size classes corresponding to adults show seasonal changes in environmental associations and sex segregation during reproductive seasons.

The CCA showed that in both coastal areas, environmental variables have a significant association with the spatial size class pattern. In both areas, salinity was more closely associated than temperature when salinity showed weak horizontal gradients (spring in Río de la Plata and winter in El Rincón). The weakening of gradients occurs in the Río de la Plata by the influence of onshore winds that force water to drift southward (Guerrero et al., 1997). This spring condition generates a freshwater tongue along the Argentine coast, allowing the penetration of relatively homogenous high-salinity shelf water along the Uruguayan coast (Fig. 2d). Instead, the weak

salinity gradients in El Rincón are related to the dominance of homogeneous salty water advected from San Matías Gulf during winter and the confinement of the high gradient area to the coast due to minimal continental runoff (Lucas et al., 2005; Fig. 2c).

The abundance of neonates (<40 cm TL) decreased from the shallow coastal waters to deeper marine waters. The juveniles were associated with mean conditions, while adults were associated with saltier and deeper marine waters with increasing size. The high abundance of neonates and juveniles in shallow waters, the persistent preference of this kind of habitat through the seasons (Menni, 1985; Cousseau, 1986), and its repeated use by *M. schmitti* agree within Heupel et al. (2007) criterion to identify the Río de la Plata inshore (e.g., Punta Medanos) and the

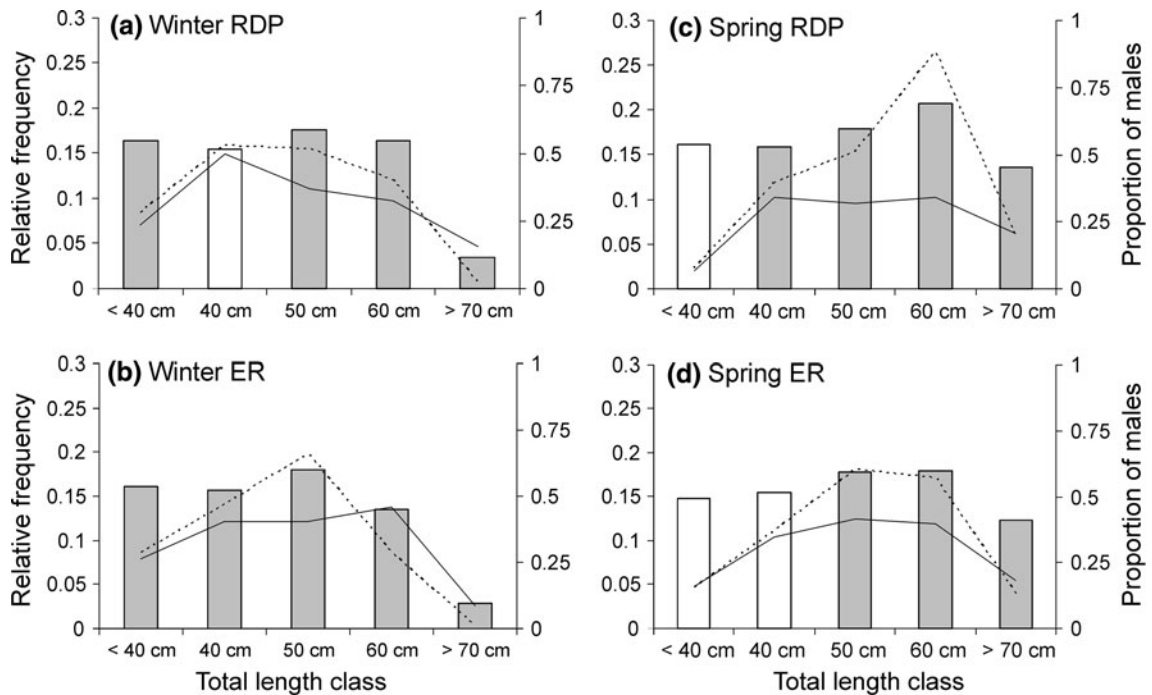


Fig. 4 Abundance distribution by sex and TL length classes, and proportion of males of *Mustelus schmitti* in Río de la Plata (a, c) and El Rincón (b, d) during winter (a, b) and spring (c, d). Labels refer to the minimum TL in a 10 cm size class.

Solid lines represent females and dashed lines represent males. Bars represent the proportion of males in each size classes, gray bars and white bars represent proportions significantly and non-significantly biased to 0.5, respectively

Table 2 Summary of the CCA analysis for Río de la Plata and El Rincón during winter and spring

	Río de La Plata		El Rincón	
	Winter	Spring	Winter	Spring
Significance of CCA axis	0.005	0.015	0.005	0.043
Total inertia	0.982	1.022	1.142	0.754
Cumulative percentage variance				
Of species data	11.946	4.322	20.63	3.033
Of species–environment relation	97.274	86.877	99.236	88.209

Significance of the first two CCA axes from permutation test. CCA total variation (total inertia), percentage of total variance explained by the first and second CCA, and percentage of species–environment relations accounted by the first two CCA axes

inner part of El Rincón as *M. schmitti* nursery areas, as suggested by Cousseau (1986) and Massa (1998).

The selection of shallow water by neonates and juveniles in estuaries and bays may be driven by protection from predators, food availability or environmental conditions which promote faster growth (Branstetter, 1990; Castro, 1993; Holland et al., 1993; Morrissey & Gruber, 1993; Simpfendorfer & Milward, 1993; Heupel & Hueter, 2002). *Mustelus schmitti* is an important prey item for large sharks

that use coastal areas as feeding, nursery and mating grounds (*Notorynchus cepedianus*, Lucifora et al., 2005a; *Carcharhinus brachyurus*, Lucifora et al., 2009a; *Carcharias taurus*, Lucifora et al., 2009b). Predators can influence prey populations, inducing antipredator responses such as shifts in habitat use (Heithaus et al., 2008). These effects are particularly strong in large-bodied and long-lived species where the fitness consequences of an early death are particularly high (Warner, 1998). Small coastal

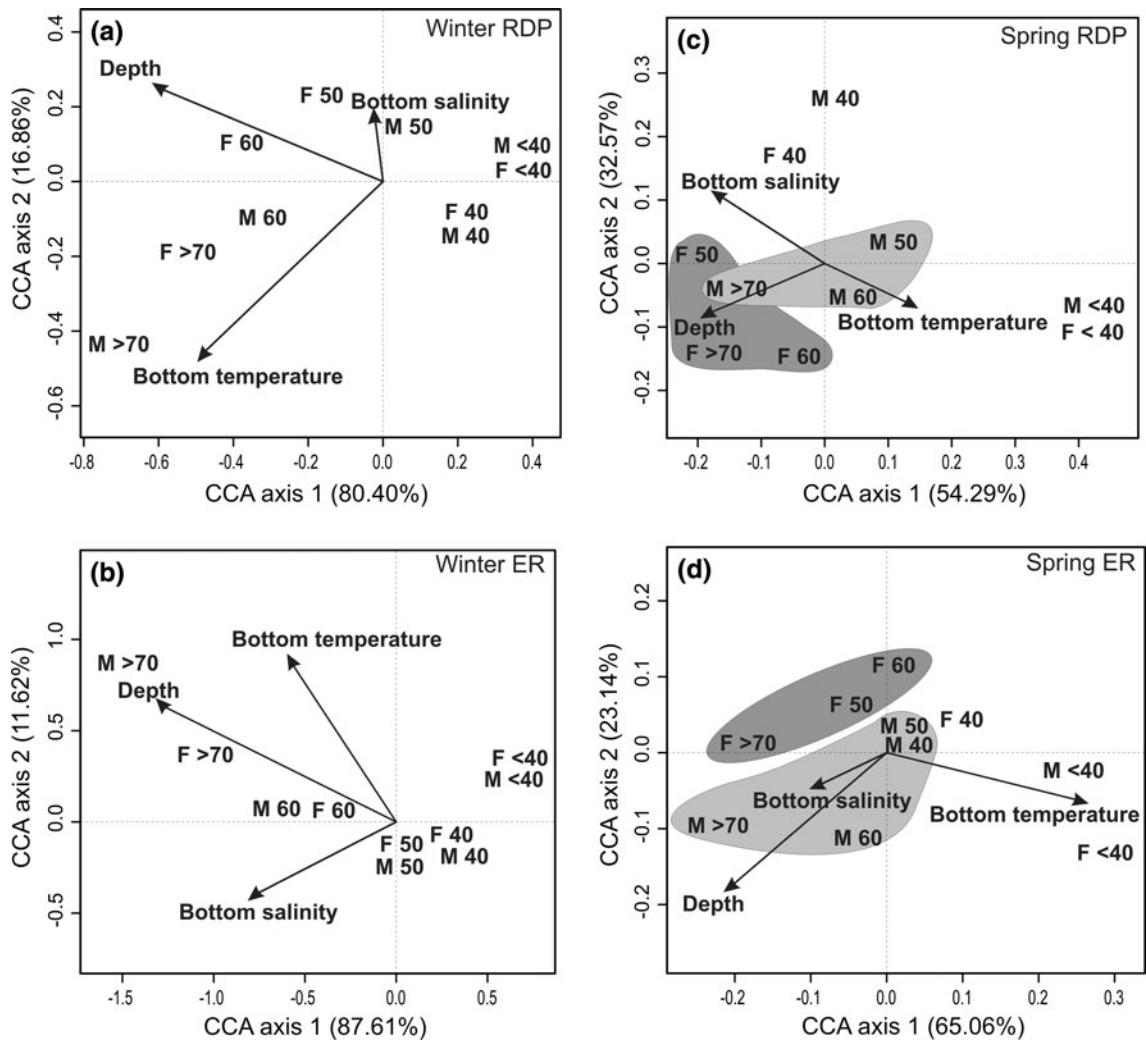


Fig. 5 Canonical correspondence analysis ordination diagrams showing *Mustelus schmitti* habitat preferences by sex and TL classes. Light gray shading indicates adult males and dark gray shading indicates adult females. M and F labels refer

to male and female, respectively. <40 and >70 labels refer to *M. schmitti* smaller than 40 cm TL and larger than 70 cm TL, respectively. The other labels refer to the minimum TL in a 10 cm size class

Table 3 Intra-set correlation of environmental variables with the first two axes of canonical correspondence analysis for each area and season

Variable	Río de La Plata				El Rincón			
	Winter		Spring		Winter		Spring	
	CCA axis 1	CCA axis 2	CCA axis 1	CCA axis 2	CCA axis 1	CCA axis 2	CCA axis 1	CCA axis 2
Depth	-0.885	0.370	-0.886	-0.381	-0.825	0.410	-0.751	-0.645
Temperature	-0.712	-0.680	0.645	-0.306	-0.372	0.566	0.931	-0.230
Salinity	-0.034	0.270	-0.812	0.524	-0.499	-0.257	-0.342	-0.164

sharks, like *M. schmitti*, are species with productive life history strategies and high rates of population growth among sharks (Smith et al., 1998; Cortés, 2002). These characteristics provide a relative tolerance to mortality during the juvenile stage. Therefore, the benefits of having protected nursery areas could be limited (Heupel et al., 2007). *M. schmitti* neonates feed mainly on euphausiacean and decapod crustaceans (Chiaromonte & Pettovello, 2000; Van der Molen & Caille, 2001) such as *Artemesia longinaris*, which is one of the most abundant shrimp species in the benthic assemblages of North-Argentinean and Uruguayan coastal waters (Giberto et al., 2004). Hence, the preference for shallower, warmer waters with high food availability for neonates and juveniles during the reproductive season could be more related to maximizing growth rates, rather than predator avoidance. This selection would allow juveniles to attain reproductive maturity at an earlier age or greater sizes, with evident implications on the rate of population increase (Smith et al., 1998). The nursery area selection driver for *M. schmitti* do not coincided with the drivers for another juvenile sharks such as hammerhead (*Sphyrna lewini*) in Kaneohe Bay, Hawaii (Holland et al., 1993); lemon (*Negaprion brevirostris*) in Bimini island, Bahamas (Morrissey & Gruber, 1993) and blacktip sharks (*Carcharhinus limbatus*) in Terra Ceia Bay, Florida (Heupel & Hueter, 2002) where the avoidance of predators is more important than the food availability as habitat selection driver. However, these studies were realized in complex habitats such as shallower (0–9 m depth) or semi-enclosed bays (<10 km²) whit coral or mangrove fringes that limit the circulation of predators and provide several refuges for juvenile sharks (Holland et al., 1993; Morrissey & Gruber, 1993; Heupel & Hueter, 2002). In coastal water without high habitat complexity that could limit the predator circulation or provide refuges (e.g., this study), the predator avoiding strategy is less probable, and the habitat selection driver appear to be more related with the food availability and environmental condition that allow a faster growth.

The adult stage also presented different environmental associations related to size, mainly associated with depth and temperature. Larger adults were associated with the deepest coastal waters during winter, which coincides with the period (autumn–winter) of highest abundance in the outer shelf waters

(between 50 and 130 m depth) (Pereyra et al., 2008). The observed predominance of neonates and juveniles in coastal waters, and larger individuals in outer shelf waters (Menni, 1985; Oddone et al., 2005), indicates that the size class distribution patterns of *M. schmitti* seem to be associated with ontogenetic movements from the nursery areas to deeper waters through development. Although adults show a general spatial pattern related to body size, there is evidence of sexual segregation, as was previously discussed (Menni, 1985; Cousseau, 1986). Sexual segregation is common in sharks and the tendency for segregation varies according to life history characteristics with live-bearing species showing a considerable degree of sexual segregation (Klimley, 1987; Wearmouth & Sims, 2008). Sexual segregation has been related to intraspecific competition, prey availability, refuge from mating, reproductive strategies associated with pre or post mating behaviors, or through differing seasonal habitat and resource requirements (Sims, 2003; Wearmouth & Sims, 2008). This study shows that segregation in *M. schmitti* occurs during the reproductive season and may be related to the reproductive strategies associated with pre or post mating behaviors.

The spatial patterns of sexual segregation during the reproductive season differed between the two coastal areas, with females inhabiting deeper and colder waters than males in the Río de la Plata, whereas in the El Rincón the opposite pattern was observed. As with several other shark species, the latitudinal differentiation in timing of reproductive events is related to differences in seasonal temperature and photoperiod (Parsons, 1993; Lessa et al., 1998; Menni & Lessa, 1998; Lombardi-Carlson et al., 2003), and may explain the opposite patterns. *Mustelus schmitti* reproduces at different times along its Argentinean distribution at large scales, from late November at the northern distribution (Río de la Plata and El Rincón; Menni et al., 1986; Cortés, 2007) to middle December at southern distribution (Puerto Deseado creek; Chiaromonte & Pettovello, 2000), but these differences have not been observed at small scales. Therefore, the opposite segregation pattern and the differences in size class structure between Río de la Plata and El Rincón may be related to differences in the sampling time (9 days, see Table 1). The Río de la Plata was sampled during early November, when the males dominated the

population structure and females were found with full-term embryos (Cortés, pers. obs.), whereas the El Rincón was sampled at the end of the month, when size class sex proportions were similar and females were in post-partum stage. Size structure patterns and maturation stage of populations indicate that the Río de la Plata was sampled at the beginning of the reproductive season, whereas El Rincón was sampled when the reproductive season was advanced. Considering this difference, the results suggest that males arrive in the inshore coastal areas earlier than females. Females arrive in the inshore waters at the end of November to give birth and migrate to deeper waters after the mating event. The earlier arrival of males to breeding and mating areas than females is a common pattern of sexual segregation in many animal taxa (Morbey & Ydenberg, 2001). Although this phenomenon is likely to be present in *M. schmitti*, further studies are required to understand its ecological determinants.

This study indicates that different habitats in the coastal environment are selected by different size classes of *M. schmitti*. The occurrence of adults in offshore waters during the non-reproductive season (winter) and their migration to nearshore waters during the reproductive season (late-spring) fit within Springer's (1967) strategy of coastal habitat use. However, *M. schmitti* life history does not fit within Springer's species, which were mainly large-sized sharks that used discrete nearshore nursery areas for short periods. Therefore, this result indicates that Springer's (1967) strategy could also be observed in sharks with small-size, high population growth rate and nursery areas distributed over different nearshore habitats. This pattern was observed in other *Mustelus* species, e.g., *M. lenticulatus* (Francis, 1988) and *M. mustelus* (Saidi et al., 2008), in which reproductive movements to shallow waters by adults make the species particularly sensitive to harvest during late spring. Stage-based models show that juveniles and medium-sized adults (37–75 cm TL) are the most influential stages in *M. schmitti* population growth rate (Cortés, 2007). Hence, the year-round presence of neonates and juveniles and the seasonal occurrence of adults (mainly in spring) in nearshore waters make this habitat essential to *M. schmitti* population dynamics since total size classes will be vulnerable if a direct impact occurs there. The explanatory power of this study's analysis appears comparable to previous study in other ecosystems (Methratta &

Link, 2007; Rodríguez-Cabello et al., 2007). It is believed that the spatial and temporal descriptions of the habitat used by *M. schmitti* in this study are critical to understanding the role of coastal areas in the life history of this shark, leading to the protection of critical habitats to achieve long-term conservation of this species.

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