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Distribution and population structure of the pelagic stingray, *Pteroplatytrygon violacea* (Dasyatidae), in the south-western Atlantic

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Abstract – The present study analyses the spatial and temporal distribution of the pelagic stingray (*Pteroplatytrygon violacea*) in the south-western Atlantic Ocean, based on data collected between April 1998 and March 2006 by the National Observers Program of the Uruguayan Tuna Fleet. During this period, data were recorded on 51 commercial fishing trips, in which a total of 2 306 851 hooks were set and 2740 stingrays captured. Of these, the sex was determined for 1329 individuals and the size for 944. The average disc width was 47 ± 8 cm (range: 24–82 cm) for females and 44 ± 5 cm (range: 28–84 cm) for males. The results indicate that the species seems to prefer warm temperate and tropical waters. There were no capture records in waters at <15.3 °C. The data collected suggest a mating season in late spring with a gestation period of 2 to 4 months and births occurring during late summer and early autumn. The increasing bycatch of this ovoviviparous species in pelagic longline fisheries, with an unknown survival rate after discard, coupled to its low reproductive potential, call for better monitoring in order to accurately determine its current conservation status.

Key words: Pelagic stingray / CPUE / Distribution / Reproduction / SW Atlantic Ocean

Résumé – Distribution et structure de la population de la pastenague pélagique, *Pteroplatytrygon violacea* (Dasyatidés) en Atlantique sud-ouest. Cette étude analyse la distribution spatio-temporelle de la pastenague pélagique (*Pteroplatytrygon violacea*) dans l'océan Atlantique sud-ouest, basée sur des données collectées entre avril 1998 et mars 2006 par le Programme national d'observations de la flotte thonière uruguayenne. Durant cette période, les données de 51 sorties de pêche commerciale ont été enregistrées, et pour lesquelles, un total de 2 306 851 hameçons ont été examinés et 2740 pastenagues capturées. Le sexe a été déterminé sur 1329 individus et la taille d'après 944 individus. La largeur moyenne du disque est pour les femelles de 47 ± 8 cm (gamme de taille : 24–82 cm) et pour les mâles de 44 ± 5 cm (28–84 cm). Les résultats indiquent que cette espèce semble préférer les eaux chaudes tempérées et les eaux tropicales. Il n'y a pas de captures dans des eaux inférieures à 15.3 °C. Les données collectées laissent présumer que l'accouplement s'effectue à la fin du printemps austral avec une période de gestation de 2 à 4 mois, et les naissances durant la fin de l'été et le début de l'automne. L'augmentation des captures accessoires de cette espèce ovovivipare par les pêches palangrières pélagiques, avec un taux de survie inconnu au niveau des palangres, couplé à un faible potentiel de reproduction, appellent à un meilleur contrôle afin de déterminer de façon plus précise son statut actuel de conservation.

1 Introduction

Pelagic stingray, *Pteroplatytrygon violacea* (Bonaparte 1832), is the only pelagic species of the Dasyatidae family (Chondrichthyes: Elasmobranchii). The first records of this species were from the Mediterranean Sea, where it was thought to be endemic (Mollet 2002; Hemida et al. 2003). Bigelow and Schroeder (1962) first reported the species in the Northwest Atlantic, and Sadowsky and Amorim (1977) reported it in the South Atlantic.

Although there are still zones for which information is scarce, it is now known that this species is widely distributed in all oceans, frequently in tropical, subtropical and temperate zones (Mollet 2002). In the south-western Atlantic, the species prefers areas and seasons with a predominance of warmer water (Domingo et al. 2005).

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P. violacea is a relatively small ovoviviparous species with a gestation period of two months for specimens in captivity, and four to five months for specimens in the wild (Mollet et al. 2002; Hemida et al. 2003). Newborn pups born in captivity have a disc width (DW) of 14 to 24 cm (Mollet et al. 2002). In the south-western Atlantic, Ribeiro-Prado and Amorim (in press) found that the size at which 50% of the sampled males were mature was 39.7 cm DW: a measure slightly larger than that reported for the Mediterranean Sea (37.5 cm) (Hemida et al. 2003). According to Wilson and Beckett (1970), females in the western Atlantic begin to mature at 40 to 50 cm DW, which agrees with the data from Ribeiro-Prado and Amorim (in press) who found that females mature at 46 cm.

P. violacea is captured as bycatch with other species in various pelagic fisheries (e.g. surface gill net, pelagic drift gill net), although very occasionally it is captured in demersal gears (Mollet 2002; Hemida et al. 2003). It is mainly caught by pelagic longline vessels targeting swordfish (*Xiphias gladius*), tunas (*Thunnus albacares* and *T. obesus*) and sharks (*Prionace glauca* and others). It is always discarded, but it has not been possible to assess the survival rate of the discarded individuals (Mollet 2002; Domingo et al. 2005).

The Uruguayan tuna longline fishery started operating in 1969 with a single vessel, which was active until 1974 (Nion 1999). In 1981, the fishery restarted and has been active ever since. The fleet currently comprises vessels that use American-type monofilament longline gear and land the fish fresh, with the exception of a single vessel that uses Spanish-type multi-filament longline and freezes the fish.

Since the implementation of the National Observers Program of the Uruguayan Tuna Fleet (Programa Nacional de Observadores de la Flota Atunera Uruguaya: PNOFA) in 1998, more information has become available on the target species of the longline fleet and on its bycatch, including *P. violacea*. (Domingo et al. 2005; Mora and Domingo 2006).

This study presents further information about the spatial and temporal distribution of *P. violacea* in the south-western Atlantic Ocean, updating the preliminary studies of Domingo et al. (2005), and addresses size and sex structure and aspects of the reproductive biology. It also remarks the high bycatch rates of this species and the need of close monitoring to ascertain the stock status of this species, currently listed by the International Union for Conservation of Nature (IUCN) as "Least Concern".

2 Materials and methods

The information analysed was obtained by scientific observers of the PNOFA during 51 trips made between April 1998 and March 2006 with 2 306 851 hooks observed. We used the geographical position (latitude and longitude) and sea surface temperature (SST) in degrees Celsius recorded at the beginning of each set, as well as the effort in number of hooks. The total capture was quantified and classified as retained, discarded (alive or dead) or lost (Mora and Domingo 2006). The catch per unit of effort (CPUE) was calculated as the number of individuals per thousand hooks (individuals/1000 hooks).

The measurements presented in this work are the following: disc width (DW), disc length (DL), total length (TL), clasper inner length (CLI) and clasper outer length (CLO), all of which were taken throughout the period of study. Measures of DW, DL and TL were taken according to Hubbs and Ishiyama (1968), while measures of CLI and CLO were taken according to Compagno (2001). When possible, sex of the captured specimens was determined, and the number, sex and size of embryos were recorded for some of the gravid specimens.

The spatial distribution of the captures was analysed using maps generated with ESRI ArcMap 8.3 software. For the analysis of the spatial distribution, two zones were considered (Fig. 1). These zones were determined by their oceanographic characteristics and the distribution of fishing effort. Zone 1, which was mainly fished by vessels landing fresh fish, covers the continental slope and adjacent waters. It extends from the 150 m isobath east to 29° 40' W and from 26° 37' S to 40° 55' S. In this zone, two major temperature changes can be observed during the year, since it is strongly influenced by the subtropical convergence (confluence of the subtropical Brazilian current and the sub-Antarctic Malvinas current) (Acha et al. 2004). Zone 2, where the freezer vessel operated, overlaps with the northeastern corner of zone 1. It extends from 35° 58' S to 19° 18' S and from 47° 18' W to 20° 88' W. This zone is characterized by a lower temperature variability during the year. The differences in CPUE between zones were determined by the Mann-Whitney U test.

For the seasonal analyses, sets were grouped in the following way: summer (January–March); autumn (April–June); winter (July–September); spring (October–December). Size distribution was analysed per sex and per season for each zone. Individuals were grouped in classes of 5 cm, with each class named after its upper limit. Deviation from an assumed 1:1 sex ratio was tested by season using a Chi – square test (X^2).

3 Results

In total, 2740 individuals of *P. violacea* were captured throughout the area fished by the fleet (Fig. 1). Of the total sets observed (1155), *P. violacea* captures were recorded in 598 sets (52%), and multiple specimens were recorded in 437 (73%) of these sets. Of the stingrays captured, 35% were discarded dead, 50% were discarded alive and 8% were discarded in undetermined condition. The remaining 7% correspond to lost individuals or those for which there was no information regarding their final destination. The longer-term survivorship of discarded stingrays is unknown.

Of the 614 sets observed in zone 1, *P. violacea* was captured in only 185 (30%). In zone 2, stingrays were captured in 412 (76%) of the 541 sets. No captures were recorded to the south of 39° S, and only three individuals were captured between 37° S and 39° S. The overall temperature range observed during the study period was 9.33–28.80 °C. All captures of the species were recorded in waters over 15.3 °C, although 31 sets (3%) were deployed in cooler waters.

The highest annual CPUE values were recorded in 1998 and 1999, reaching 2.36 and 5.60 individuals/ 1000 hooks, respectively (Fig. 2). The CPUE in zone 1 had a mean value of 1.60 ± 5.30 (range: 0–78.20), while in zone 2 it was 1.10 ± 1.70 (range: 0–22.50). CPUE values in zone 1 were significantly higher than those in zone 2 ($U = 107\,691$, $p < 0.05$). In

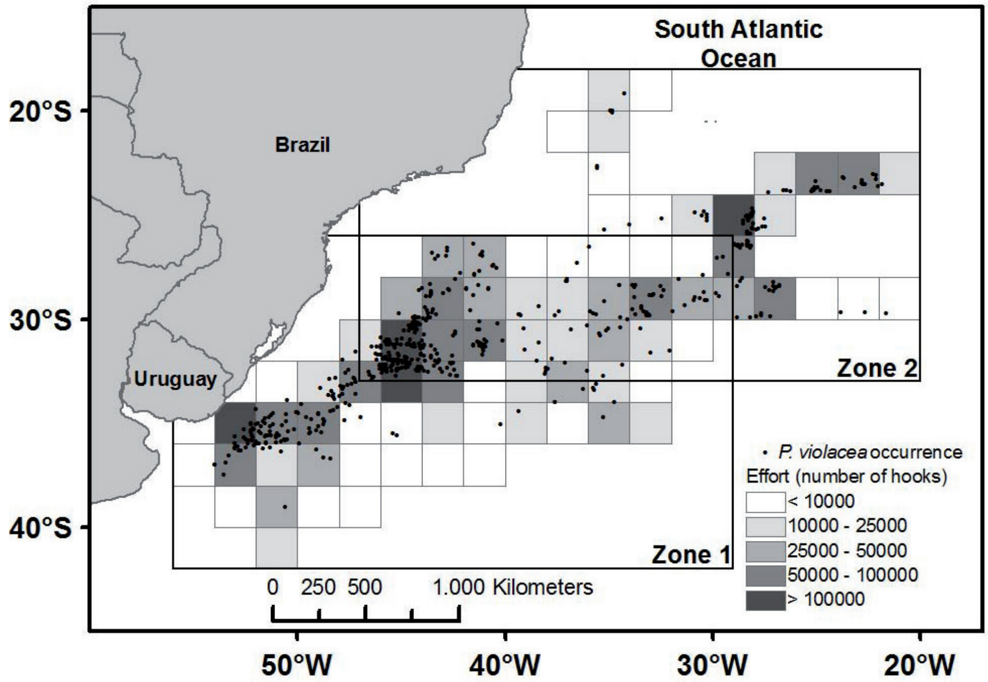

Fig. 1. Spatial distribution of the monitored longline effort (aggregated in blocks of 2 by 2 degrees), and occurrence of sets with captures of *P. violacea*. The two zones analysed are shown; zone 1, sets made mostly by fresh-fish vessels; zone 2, sets made by the sole freezer vessel.

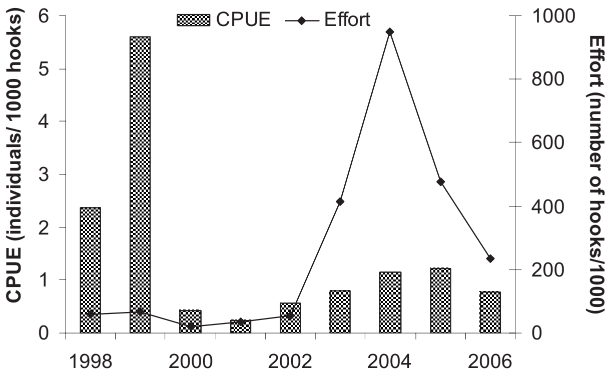

Fig. 2. Annual distribution of the total fishing effort in both zones and CPUE of *P. violacea*.

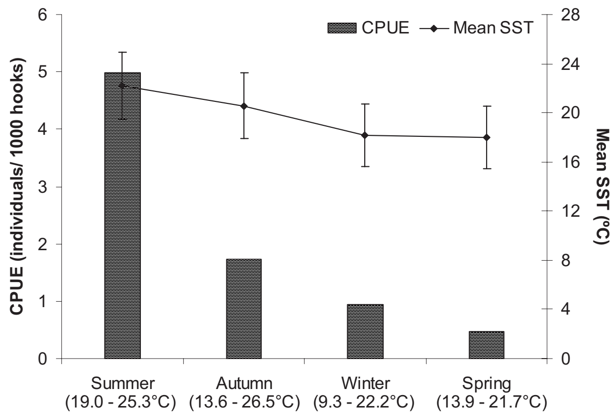

Fig. 3. Distribution of CPUE of *P. violacea* by season and mean sea surface temperature (SST) in zone 1. Range and standard deviation of SST are shown.

zone 1, the highest CPUE values were recorded in summer (5 individuals/1000 hooks), in waters with the highest SST (Fig. 3). Both CPUE and SST values decreased towards the spring, when CPUE was 0.47 and average SST was 18 °C. In zone 1 therefore, a direct relationship between CPUE and SST could be observed (0.2 individuals/1000 hooks at 17 °C, and 12.87 individuals/1000 hooks at 24 °C) (Fig. 4a). No great variations in the CPUE were observed in relation to SST in zone 2. Most of the effort was made with SST ranging from 18 °C to 27 °C (Fig. 4).

Of the 944 specimens measured, 607 were males, 324 were females and the sex of 13 was not recorded. The DW of the analysed specimens ranged from 24 to 84 cm (45 ± 6 cm). The average sizes of females and males were 47 ± 8 cm (range: 24–82 cm) and 44 ± 5 cm (range: 28–84 cm), respectively (Fig. 5). The measurements of the largest female were 82 cm DW, 59 cm DL, 106 cm TL, and those of the largest male were 84 cm DW, 63 cm DL, 19 cm CLI and 12 cm CLO. Regarding the seasonal size distribution in zone 1, as the available data corresponds to only 40 measured specimens, we chose to present the mean DW per season per sex. The mean DW in summer was 53 cm for males (n = 3), only one female of 54 cm was measured in this season; in autumn, 44 cm for males (n = 12) and 49 cm for females (n = 13); and in winter, 44 cm for males (n = 6) and 52 cm for females (n = 4). Only one specimen was measured in spring, a 46 cm female. The seasonal size class distribution per sex was analysed in zone 2 (Fig. 6). The most frequent size classes were 45 cm and 50 cm in summer, 45 cm and 45 cm in autumn, 50 cm and 50 cm in

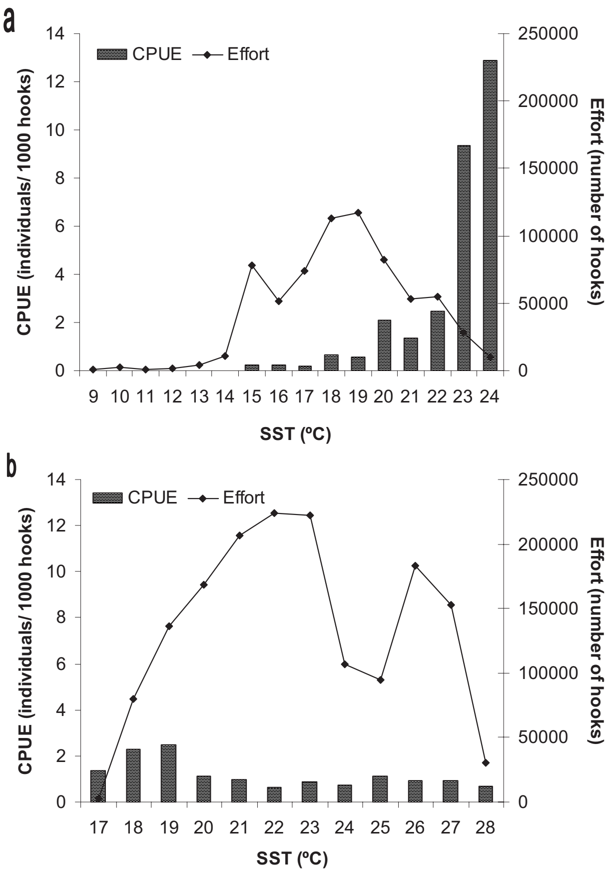

Fig. 4. Fishing effort and CPUE of *P. violacea* analysed by SST (a) in zone 1 and (b) in zone 2.

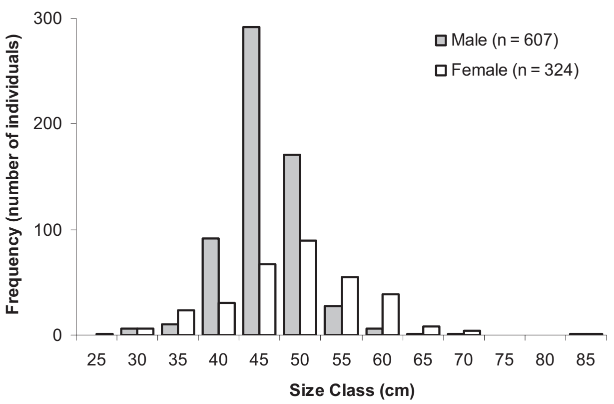

Fig. 5. Size distribution (disc width, DW) of male and female *P. violacea* caught off the coast of Uruguay throughout the period of study.

winter and 50 cm and 60 cm in spring, for males and females respectively.

Out of the 2740 specimens observed, the sex was determined for 1329 of which 854 (64.3%) were male and 475 (35.7%) female. The sex ratio (males: females) over the entire study period was 1.8:1 (X^2 = 108.7, $p < 0.05$), with varying proportions in each season. In summer the sex ratio was 3.9:1 (X^2 = 145.1, $p < 0.05$), in autumn 1.5:1 (X^2 = 14.0, $p < 0.05$), in winter 1.3:1 (X^2 = 8.1, $p < 0.05$) and in spring 1.1:1 (X^2 = 0.3, $p > 0.05$).

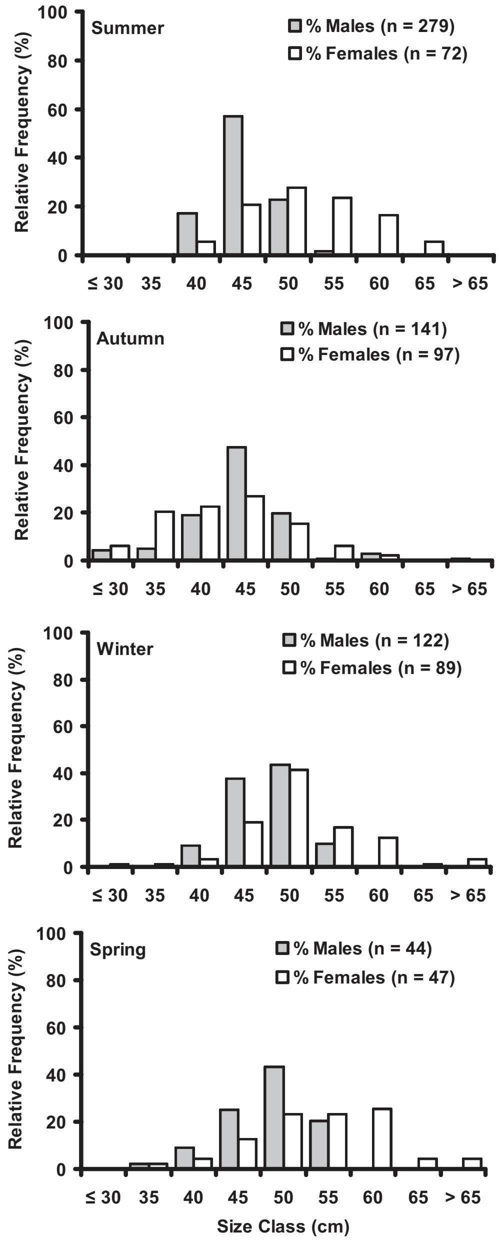

Fig. 6. Seasonal size (disc width, DW) distributions of male and female *P. violacea* caught in zone 2 throughout the period of study in South Atlantic Ocean.

Out of 44 females examined in summer, 50% carried embryos. Although other females were analysed in the remaining seasons (autumn: n = 15; winter: n = 26; spring: n = 8), only one, captured in the first day of autumn, carried embryos. Mid-term embryos (6.5 cm DW) and near-term embryos (15 cm DW) were found in early summer (Fig. 7a,b). Females with embryos at the latest development stages were captured at the lower latitudes and in the easternmost zone where the fleet operated. The average number of embryos per female was 4 (range: 1–7; n = 23). The smallest embryos were 4 cm,

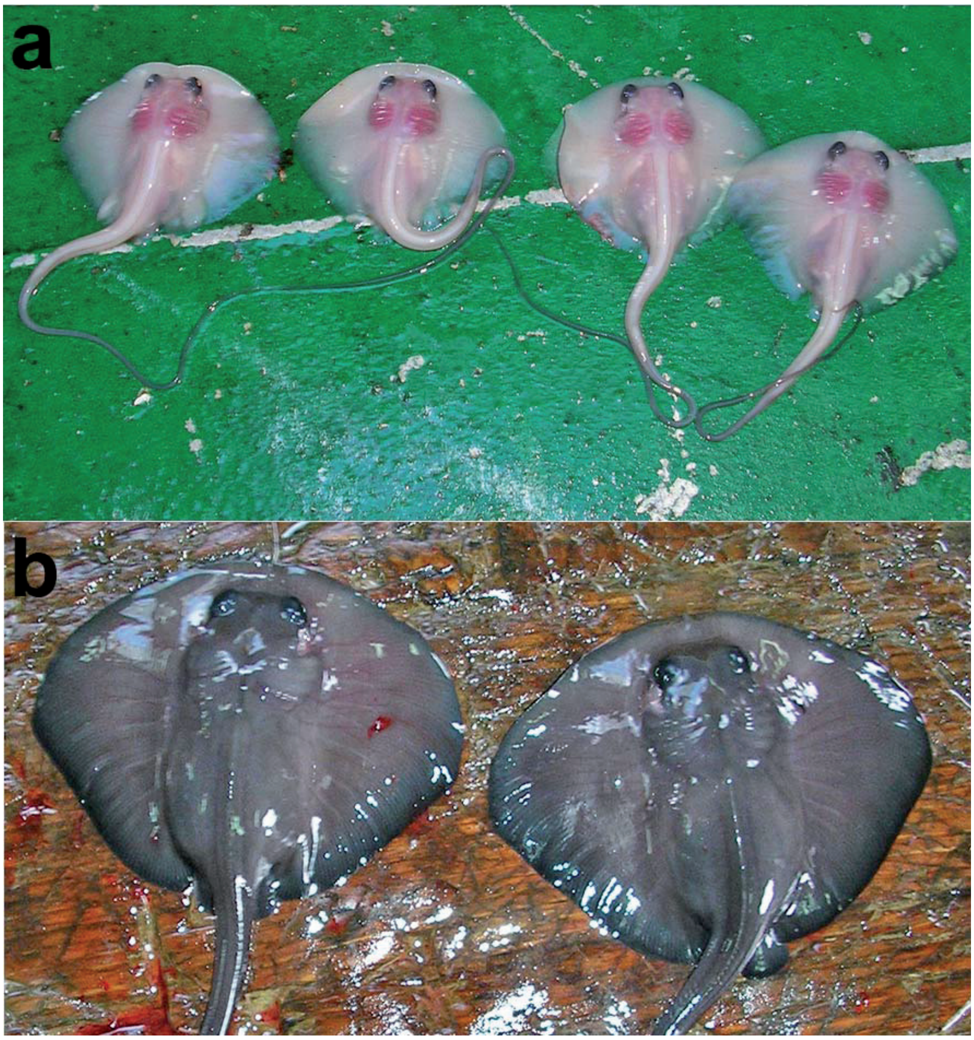

Fig. 7. (a) *P. violacea* mid-term embryos (two males and two females, disc width DW = 6.5 cm) in a female captured on January 13, 2006 in zone 2; (b) *P. violacea* near-term embryos (one male and one female, DW = 15 cm) in a female captured on January 16, 2006 in zone 2.

while the largest had attained 15 cm DW and were already pigmented.

4 Discussion

Though *P. violacea* is distributed throughout the study area, its distribution is not homogeneous. Upon comparing the two zones, differences were found both in the proportion of sets with stingray captures and in the CPUE.

The proportion of sets with stingray captures is lower in zone 1 than in zone 2, but there were sets with CPUE values reaching 78 individuals/1000 hooks in zone 1. In contrast, zone 2 presented a higher proportion of sets with stingray captures, and CPUE values lower than those in zone 1. The larger number of sets with captures of *P. violacea* in zone 2 could be explained by the preference of this species for waters with SST over 17 °C, which occur year-round in this zone.

The high CPUE values observed in zone 1 are possibly due to the influence, mostly in summer, of the tropical Brazilian current. As pointed out by Domingo et al. (2005), the captures of *P. violacea* in the south Atlantic are directly related to water temperature (Figs. 3 and 4a). A southward movement of stingrays following the tropical currents and the high CPUE values observed in some small areas could be due to a high concentration of individuals in locally warmer waters.

The records reported herein, added to existing data (Menni et al. 1995; Bañón et al. 1997; Bañón 2000; Menni and Stehmann 2000; Mollet 2002; Domingo et al. 2005; Ellis 2007), indicate that this species is widely distributed in the Atlantic Ocean, between latitudes of 39° S and 55° N.

The maximum sizes recorded for both sexes in this study are the largest known worldwide for specimens in their natural habitat. The size distribution for males and females found here (Fig. 5) differs from the one presented by Neer (2008), who found that both males and females are more frequent in the same size class (45.0–49.9 cm). This difference may be due to the different size and distribution of the samples of both studies.

The sex ratio found was 1.8:1, this differs with what was found by Ribeiro-Prado and Amorim (in press), who reported a higher ratio of males (3.8:1) in an area that almost overlaps with zone 2 of the present study. The difference, however, could be explained by the fact that their analysis did not include data from spring, which is when we found the lowest male:female ratio (1.1:1). This ratio is possibly related to a mating season, which is also supported by the fact that spring was the season when both males and females of the larger size classes (50 cm and 60 cm respectively) were more frequent (Fig. 6). In addition, females with embryos were found mainly during summer, which could be explained by a mating season taking place in spring. However, this cycle is probably not synchronized, as mating and parturition occur over several months as shown by the fact that both mid-term embryos (6.5 cm DW) and near-term embryos (15 cm DW) were found in early summer, in the same area, at only a five-day interval (Fig. 7). A similar case is reported by Ribeiro-Prado and Amorim (in press) who, in January, found a female that had probably given birth recently, along with other females with embryos of 5 cm DW. This agrees with the duration of the gestation period (2 to 4 months) observed in captive specimens, as well as with the parturition season and area reported for individuals captured far off the central coast of Brazil (Mollet 2002). The smallest female carrying embryos had a DW of 46 cm, which agrees with the smallest size at maturity reported by Ribeiro-Prado and Amorim (in press).

The information presented here suggests that *P. violacea* might have just one reproductive cycle per year with a gestation period of two to four months, a mating season in spring and parturition taking place in summer and at the beginning of autumn.

A second reproductive event, as suggested by Mollet (2002), might possibly occur in captivity due to special controlled conditions. Hemida et al. (2003) observed a possible diapause in *P. violacea* from the Mediterranean Sea, during winter (December to May in northern hemisphere), due to lower water temperatures, or even sperm storage during the same period. The same could occur in the south-western Atlantic between the months of May and October, corresponding to late autumn and winter.

The pelagic stingray was also the second most commonly observed elasmobranch species in pelagic longline fisheries after the blue shark (*Prionace glauca*). The total number of stingrays captured (2043), in the period 2001–2005, represented one fifth of the total catches (10 976) of the main target species of the fleet, swordfish, in the same period (Domingo et al. 2006).

Although a high proportion of specimens are discarded alive (50%), mortality rate after discarding is probably high, due to the way in which they are released: mainly by smashing the stingray against the rail to remove the hook. In many cases this removes the jaw, which remains hooked, or causes serious damage to the mouth and/or ventral part of the body, as described in other studies (Domingo et al. 2005). Although some of the released individuals do not present visible injuries, due to shock they are often stunned and swim with difficulty. Furthermore, the tail is frequently cut off before bringing a stingray aboard, in order to make handling on deck easier and to avoid injuries to fishermen. Observers have reported the capture of several specimens with no tail, which would indicate that individuals with the tail removed can survive, and evidence of healed jaws has been observed in other longline-caught elasmobranches. Further studies are required to assess the longer-term discard survival.

5 Conclusion

As the effort in the pelagic longline fishery increases due to the decreasing abundance of the target species, more attention should be paid to elasmobranch bycatch. As previously well documented, the life-history characteristics of these species make them very vulnerable to overfishing.

According to Dulvy et al. (2008), *P. violacea* is currently classified as "Least Concern". Reasons for this are that, together with the blue shark, this species has the highest annual rates of population increase. However, this information is mainly based on data obtained from captive specimens, which differs from the information presented in the present study. In their natural habitat, in the south-western Atlantic, this species presents only one reproductive event per year, with a maximum of seven embryos, i.e. the species produced less young in the wild than in captivity. This low reproduction rate, added to the lack of information in log-books, total discards difficult to assess even by observers, and the unknown post-release survival rate (with probable high mortality), mean that implementation of research and management measures is required for this species.

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