Aspects of the biology of the leaf-scale gulper shark *Centrophorus squamosus* (Bonnaterre, 1788) off Madeira archipelago

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Severino, R.B., I. Afonso-Dias, J. Delgado & M. Afonso-Dias 2009. Aspects of the biology of the leaf-scale gulper shark *Centrophorus squamosus* (Bonnaterre, 1788) off Madeira archipelago. *Arquipélago*. Life and Marine Sciences 26: 57-61.

A total of 206 *Centrophorus squamosus* (Bonnaterre, 1788) with a total length ranging from 89 to 146 cm were captured at an average depth of 1200 metres. Of the 61 females sampled, 34% were gravid, showing an absolute individual fecundity of two to ten embryos (pups). The results clearly indicated that this deepwater shark spawns in the Portuguese waters off Madeira archipelago.

Key words: deepwater shark, spawning, fecundity, gravid females

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INTRODUCTION

The leaf-scale gulper shark, *Centrophorus squamosus* (Bonnaterre, 1788) (Elasmobranchii, Centrophoridae), is an important component of the deepwater fisheries (longline and trawl) off the Faeroe Islands, Ireland, Spain, Portugal and France (Gordon et al. 2003; White 2003), mainly by the value of its liver (Gordon et al. 2003), although its flesh is also marketable in many areas, e.g. eastern Atlantic and eastern Indonesia (White 2003). Even though there is an increasing interest in this deepwater shark (Girard & Du Buit 1999; Girard et al. 2000; Clarke et al. 2001a; Girard 2001; Clarke et al. 2002) there is little information regarding its spawning areas and early stages of development.

MATERIAL AND METHODS

In Portugal, although leaf-scale gulper shark is landed occasionally as part of the catch of a longline fishery in the mainland, which targets other deepwater sharks (Gordon et al. 2003), this species is by-caught regularly in the Portuguese waters off Madeira Archipelago in the drifting longline fishery for black scabbard-fish (*Aphanopus carbo,* Lowe 1839) (Figueiredo et al. 2002), one of the oldest deepwater fisheries in the world (Noronha & Sarmento 1948; Merrett & Haedrich 1997). Two sea trips carried out by one of the authors (R. Severino) on board these commercial longliners in February and April 2004 (Fig. 1) showed that leaf-scale gulper shark represented 69% (in weight) of the non target species but only 5.8% in weight and 1.6% in number of the total catch (mainly composed by

the target species *A. carbo*). During the fishing sets the mainline and snoods of the gear were active in the water column, the effective fishing depth ranging between 1000 and 1300 m.

During these two trips 112 leaf-scale gulper shark were sampled. An extra sample of 94 individuals was also obtained in April 2004 from the landing of another fishing trip where no leaf-scale gulper shark caught was discarded.

RESULTS

The 206 fully developed specimens sampled during this study were restricted to a small size range from 89 to 146 cm and were mainly males (2:1). This seems to be a common trend in many fish species (Cortés 2000) and it has been reported before for this species (Clarke et al. 2002) and for other related sharks (Jakobsdóttir 1998, 2001).

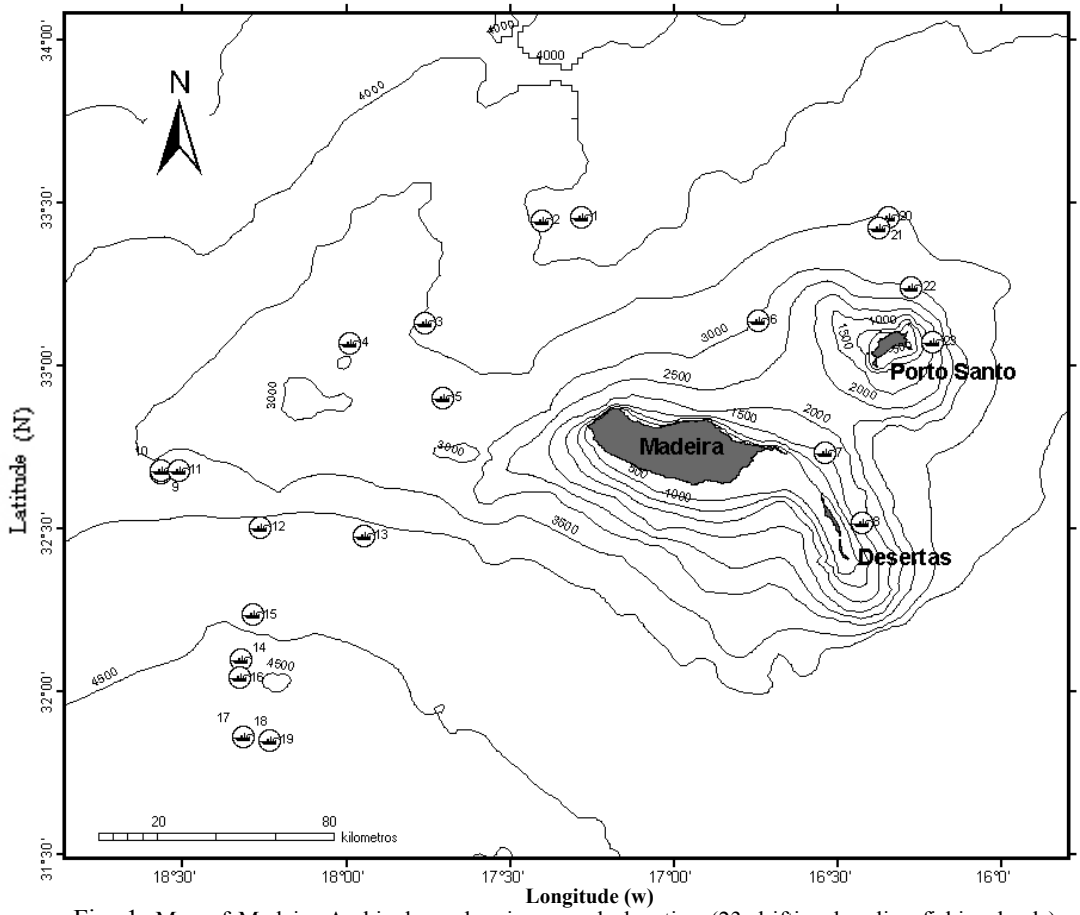

Fig. 1. Map of Madeira Archipelago showing sample location (23 drifting longline fishing hauls) along the different depth contours.

However, females outnumbered males in size classes greater than 115 cm and no male larger than 120 cm was found. The size range of leaf-scale gulper shark varied between 92 and 146 cm in females (n=61) and from 89 to 118 cm in males (n=145). Sex related differences in leaf-scale gulper shark size may be associated with the need to have more space to support pups (Cortés 2000) or it may be associated with depth stratification (Yano & Tanaka 1984; Clarke et al. 2001b).

The sample taken for this study contained males and females in all stages of maturity. Approximately 94% of males and 70% of females were considered to be mature (maturity stage 3

and above). Maturity stages were assigned by eye inspection using a four-stage maturity scale for males and a seven-stage maturity scale for females (three ovarian and four uterine) adapted from the maturity scale for aplacental and placental viviparous sharks proposed by Stehmann (2002). Only 13% of females were in post-natal stage. Although it was not possible to estimate the length at first maturity, the smallest mature female had 116.1 cm of total length and 50% of mature males were found between 95 and 100 cm. The smallest mature male had a total length of 96 cm.

The individual absolute fecundity of gravid (n=21) leaf-scale gulper shark was defined as the number of yolk balls and embryos found in the uterus, per female, during differentiating and expecting stages (Clarke et al. 2001b) and varied between two and ten (an average of 5.4 pups per female; n=75). Differences in the embryos' (pups) sex ratio were tested by using chi-square (χ^2) statistic (Zar 1984) under the null hypothesis of 1:1. Overall, the sex ratio of the pups counted inside the uterus did not departure greatly from 1:1 (χ^2 test, n=2, P>0.05) (41 females and 30 males). Only 5% (n=4) of specimens in embryonic stage did not show sex differentiation, and their total length ranged from 11.4 to 12.4 cm. The size range of the pups varied between 22.4 and 38.6 cm for females and 19.8 and 37.6 cm for males. Although no correlation was found between the number of pups and female length (Pearson's correlation test, n=14, P>0.05), that does not necessarily means that the two variables are not correlated. The small sample size and the possibility of females loosing their pups during hauling procedures, makes it very seldom to find a significant correlation between the two variables.

The occurrence of 21 gravid females (about 34% of the total females, of which 13% differentiating and 21% expecting) off Madeira archipelago during this study indicates that this area is possibly a nursery area for leaf-scale gulper shark. This idea is reinforced by the fact that during this study not only all ovarian development stages but also uterine stages were observed. Even though Girard & Du Buit (1999), Clarke et al. (2001b) and Girard (2001) observed a large number of females from bottom trawl and longline catches in the Northeast Atlantic, west of the British Isles, no females in uterine stage were found. This might indicate a large-scale migration related with reproductive strategy. The absence of smaller specimens of this species in this area, not explained by the selectivity of the fishing gears used, also supports this hypothesis (Clarke et al. 2001b).

In this study it is reported, for the first time, the occurrence of gravid females of leaf-scale gulper shark in Portuguese waters off Madeira Archipelago. Although there are previous scattered records of gravid females being found in Portuguese waters, off Senegal (see Clarke et al. 2002) and in Galician waters (Bañón et al. 2006) hitherto there was no evidence to the occurrence of gravid females off Madeira Island. However, Clarke et al. (2001b) quotes a personal communication by Hareide and Stehnman on the occurrence of gravid females off Madeira Island. The maximum size of embryos reported so far for this species was 40 cm (Bañón et al. 2006). Since the size of the largest embryo found during this study in gravid females was 38.6 cm and still with yolk, it is possible that the size at birth may be even larger than the size reported by Bañón et al. (2006). This leads to assume that it may be possible to find small specimens of leaf-scale gulper shark in the region off Madeira Archipelago. The selectivity of the hooks in the longline does not seem to constrain the capture of small leaf-scale gulper shark, because several specimens of a small squalidae like *Etmopterus pusillus* (Lowe, 1839), with just 38.7 cm of total length, were captured with the same hook size. Maybe there is a depth distribution pattern associated with size, which may justify the absence of small free living specimens of leaf-scale gulper shark in the catches. In view of what has been previously discussed coupled with the fact that the gear that captures the large specimens of leaf-scale gulper shark is a drifting device (not close to the bottom) it can also be hypothesized that it only captures the specimens that have more autonomy to reach the device. The small specimens are either close to the steep bottom floor or in more superficial waters (Ebert et al. 1992) off Madeira Island and will not incur such distances looking for food as their larger congeners.

CONCLUSIONS

A species whose individual fecundity is low giving 2 to 10 pups by female and, with a longevity varying between 54 and 70 years (Clarke et al. 2002), can be extremely vulnerable to commercial exploitation (Stevens et al. 2000; Haedrich et al. 2001). It appears that leaf-scale gulper shark is a highly migratory shark and its study, as suggested by Clarke et al. (2002) requires international cooperation to ensure that our knowledge about this species improves beyond data deficient to try to prevent over-exploitation.

ACKNOWLEDGEMENTS

We wish to thank the DRP-Madeira, in particular the Fisheries Laboratory Director Dalila Carvalho, for making this study possible and to Mafalda Freitas (Funchal Marine Biological Station) for her advice in the early stages of this study. We acknowledge Rui Sargo, Ricardo Sousa, Francisco Fernandes, Sara Ferreira, Patricia Freitas and Ricardo Antunes for their help during different stages of this study. To the owners, captains and all crewmembers of the "Helder José" and "Ricardo Cristina" we wish to express our deepest thanks for allowing the collection of biological information and for taking R. Severino on board.

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Accepted 21 October 2009.