

**ASPECTS OF THE REPRODUCTIVE BIOLOGY OF THE SANDBAR SHARK,
CARCHARHINUS PLUMBEUS (NARDO, 1827), IN COASTAL WATERS
OFF PERNAMBUCO, BRAZIL**

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SUMMARY

A total of 28 sandbar sharks, 11 males and 17 females, caught off the coast of Pernambuco, northeast Brazil, from December 1994 to January 1996, were examined. Total length (TL) ranged from 154.0 to 196.0 cm, for males, and from 108.5 to 208.0 cm, for females. All specimens were already adults. The monthly distribution of sexual stages shows that parturition and ovulation happen in the same months, suggesting a 12-month gestation cycle, in alternate years. Litter size ranged from 7 to 10, with a mean value of 8.6, and the sex ratio of embryos was 1:1.4 (male: female).

RÉSUMÉ

Un total de 28 requins gris, 11 mâles et 17 femelles, capturés au large de la côte de Pernambuco, Nord-Est du Brésil, de décembre 1994 à janvier 1996, ont été examinés. La longueur totale s'est établie entre 154,0 et 196,0 cm pour les mâles et entre 108,5 et 208,0 cm pour les femelles. Tous les spécimens avaient déjà atteint le stade adulte. La répartition mensuelle des stades sexuels indique que la parturition et l'ovulation surviennent au cours des mêmes mois, ce qui suggère un cycle de gestation de 12 mois, au cours d'années alternées. La taille de la portée fluctuait entre 7 et 10, avec une valeur moyenne de 8,6 et le sex-ratio des embryons s'établissait à 1 : 1,4 (mâle : femelle).

RESUMEN

Desde diciembre de 1994 hasta enero de 1996 se examinó un total de 28 tiburones trozo, 11 machos y 17 hembras, capturados en las aguas situadas frente a costa de Pernambuco, nordeste de Brasil. La longitud total osciló entre 154,0 y 196,0 cm para los machos y entre 108,5 y 208,0 cm para las hembras. Todos los ejemplares eran ya adultos. La distribución mensual de las fases sexuales muestra que el parto y la ovulación se producen en los mismos meses, lo que sugiere un ciclo de gestación de 12 meses, en años alternos. El tamaño de las camadas osciló entre 7 y 10 crías, con un valor medio de 8,6, y la ratio de sexos de los embriones fue 1:1.4 (macho: hembra).

KEYWORDS

*Reproductive cycle, Carcharhinidae, Carcharhinus plumbeus,
sandbar shark; Pernambuco, Brazil*

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1. Introduction

The genus *Carcharhinus* has the largest number of species among all shark genus: 29 species, 10 of which are present in the Southwestern Equatorial Atlantic Ocean. The sandbar shark, *Carcharhinus plumbeus* (Nardo, 1827), is a medium-sized grey shark, viviparous with a yolk-sac placenta, found in continental and insular shelves, as well as in deep waters adjacent to them (Compagno, 1984). Being present in the entire Brazilian coast, they are highly migratory, with reported movements of over 2,900 km (Merson and Pratt, 2001).

Data on the distribution, biology and reproduction of the sandbar shark have been reported from USA (Bigelow and Schroeder, 1948; Springer, 1960; Clark and von Schmidt, 1965; Branstetter, 1981), Hawaii (Wass, 1978), China (Taniuchi, 1971), South Africa (Bass *et al.*, 1973), Australia (Mcauley *et al.*, 2005), Chinese Taipei (Joung and Chen, 1995) and Mediterranean (Saïdi *et al.*, 2005). In Brazil, however, only Amorim *et al.* (1998) have provided, so far, biological information on the species.

Mattos and Hazin (1997) examined sharks caught in the coast of Pernambuco, northeast Brazil, between September 1994 and May 1996 and identified the presence of 9 species. Of these, the blacknose shark, *Carcharhinus acronotus*, and the sandbar shark, *Carcharhinus plumbeus*, were the most abundant ones, accounting together to about 70% of all specimens. Besides, Wanderley Jr. *et al.* (1998), studying the distribution of sharks in the same area, identified a pattern of species segregation by depth, with a clear predominance of the sandbar shark in deeper areas (between 50 and 60 m), next to the continental slope, whilst the blacknose shark showed a much shallower distribution, being common only in waters with less than 20-m depth. The higher abundance of the sandbar shark in the continental slope, as well as in the adjacent oceanic waters, results in its sporadic catch by longliners targeting tunas and swordfish off Brazilian coast. Nevertheless, the lack of a targeted fishery for the species in Brazil, associated to its seldom occurrence in the longline catches, make the study of its biology very difficult. Aiming at filling this gap, at least in part, in the present paper preliminary information on the reproductive biology of *C. plumbeus* specimens caught by bottom longline in the coast of Pernambuco has been provided.

2. Material and methods

A total of 28 sandbar sharks, 11 males and 17 females, caught in the coast of Pernambuco (7° to 10°S; 34° to 35°W), from December 1994 to January 1996, were examined. All specimens were caught with a bottom longline, close to the edge of the continental shelf and slope. Sharks were dissected and examined immediately after capture. The reproductive organs of both males and females were collected and preserved in 10% sea-water formalin solution. From females, both oviducal glands and the ovary were collected, weighted and measured, and the stage of ovarian development was observed. The number of vitellogenic follicles was counted and the diameter of the largest one was measured using a Vernier caliper. Both uteri were measured and their contents observed, following dissection. Whenever there were eggs or embryos present, they were counted, measured, weighted, and sexed (embryos). Male testes were also collected and measured, including width, length and weight. Clasper length was measured and the calcification stage was observed.

3. Results and discussion

Total length (TL) of the sandbar sharks examined ranged from 154.0 to 196.0 cm, for males, and from 108.5 to 208.0 cm, for females, with females being consistently larger than males (**Figure 1**). Maximum reported total length for males and females is 224 cm and 234 cm, respectively, with females, therefore, also attaining a larger size (Compagno, 1984). All males examined seem to be adult, with fully developed sexual organs and well calcified claspers (**Table 1**). Females were separated into 5 different sexual stages, according to distinctive characteristics of their reproductive organs (**Table 2**), as follows: maturing, pre-ovulatory, pregnant, post-partum and resting. The only maturing female already had vitellogenic follicles in the ovary, but their relatively small size, with the largest one measuring less than 2.0 cm in width, indicated that it was not yet ready to ovulate. Pre-ovulatory females, in turn, had ripe ova, with the largest oocyte measuring 2.7 and 2.8 cm, for both specimens, respectively, being thus very close to ovulation, since ovulation happens at an oocyte diameter from about 3.0 cm (Springer, 1960). Pregnant females had either eggs or embryos in their uteri. All of them, however, irrespective of embryo size, had very small ovarian follicles, with the largest one measuring 0.5 to 0.6 cm, and no sign of vitellogenesis. Post-partum females had ovaries in a similar condition to those of pregnant females. Their uteri, however, were empty, flaccid and dilated, with signs of a recent parturition. Resting females, in turn, showed no sign of sexual activity, showing an undeveloped ovary and thin uteri.

Size at first sexual maturity for the species has been provided by numerous authors (Bigelow and Schroeder, 1948; Springer, 1960; Clark and von Schmidt, 1965; Bass *et al.*, 1973; Branstetter, 1981; Saïdi *et al.*, 2005), ranging, in general, from about 160 to 185 cm, for males, and from 170 to 190 cm, for females. This information confirms that most of the examined specimens were already adults.

Pregnant females were caught from December to May. Litter size ranged from 7 to 10, with a mean value of 8.6 (**Table 3**). Amorim *et al.* (1998) found an identical range for the number of embryos per litter, in 15 females caught off southern Brazil. These figures are also pretty much within the range of litter size reported in the literature: 9, in North Carolina (Springer, 1960); 4 to 11, with a mean of 9, in Florida (Clark and von Schmidt, 1965); 4-12, in South Africa (Bass *et al.*, 1973); 6-11, in Gulf of Mexico (Branstetter, 1981); 1-8, with a mean of 5, in Hawaii (Wass, 1973); 2-10, mean of 5.6, in China Sea (Taniuchi, 1971); 4-10, mean of 6.9, in the Gulf of Gabès (Saïdi *et al.*, 2005); 4-12, mean of 7.5, in Taiwan (Joung and Chen, 1995); 4-10, mean of 6.5, in Australia (Mcauley *et al.*, 2005).

Most of the specimens (5) had well developed embryos, the largest one in each litter measuring more than 50.0 cm, up to 57.0 cm. These embryos were probably near term, since size at birth ranges from about 56 to 75 cm (Compagno 1984). One female had only eggs in the uteri, another one had both eggs and embryos of a maximum TL of 10.0 cm, and a third one had relatively small embryos, with TL ranging from 14.0 to 17.0 cm. Sex ratio (male: female) was 1: 1.4, with a predominance of females, which was very similar to the sex ratio of the adult specimens caught (1: 1.5). Amorim *et al.* (1998) found a similar sex ratio of embryos (1:1.4), off southern Brazil. In North Carolina and Central Gulf of Florida, however, females seem to outnumber males in a much larger proportion, with sex ratios of 1:5 (Springer, 1960) and 1:6 (Clark and von Schmidt, 1965), respectively, being reported. Springer (1960), nevertheless, suggested that the much larger number of females in U.S. coast could be due to a feeding inhibition by males. In northeast Taiwan, in turn, a sex ratio very close to the present case, 1:1.6, was described by Joung and Chen (1995). Wass (1973), on the other hand, reported a sex ratio for the sandbar shark from Hawaiian waters very close to 1.

The monthly distribution of sexual stages (**Figure 2**) shows that parturition and ovulation happens in similar months, from December to March, during austral summer, suggesting thus a 12-month gestation cycle. In Hawaii, mating, ovulation and parturition also seem to occur in the same period, between July and September, coinciding thus with summer in the northern Hemisphere. A similar cycle seems also to happen in the east coast of USA (Springer, 1960). In that region, pregnant females of sandbar shark usually invade lagoons and bays of shallow waters to give birth to pups (Castro, 1993). It's likely, therefore, that Pernambuco coast also constitutes a parturition and nursery ground for the species. The presence of resting females, together with a maturing specimen in August, provide some indication that gestation might happen in alternate years, or even every 3 years. The fact that pregnant, post-partum and resting females show small ovarian follicles (**Figure 3**) indicates that vitellogenesis is not concurrent with embryo development, giving further support to a two or three years reproductive cycle. Off Hawaii, Wass (1973) also noted that only about half of adult females were pregnant, suggesting a two year reproductive cycle for the species, with alternate gestations each year. A two-year reproductive cycle for the sandbar shark has also been supported by several other authors (Springer 1960; Wass 1973; Bass *et al.* 1973; Branstetter 1981; Joung and Chen 1995; Castro 1996; Saïdi *et al.* 2005).

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References

- AMORIM, A.F., Arfelli, A and Fagundes, L. 1998. Pelagic elasmobranchs caught by longliners off southern Brazil, during 1974-97: an overview. *Mar. Fresh. Res.*, 49(7): 621-632.
- BASS, A.J., D'Aubrey, J.D. and Kistnasamy, N. 1973. Sharks of the east coast of southern Africa. I. The genus *Carcharhinus* Carcharhinidae). *Invest. Rep. Oceanog. Res. Inst. Durban* 33:168 pp.
- BIGELOW, H.B. and Schroeder, W.C. 1948. Sharks. In: *Fishes of the Western North Atlantic*. Mem. Sears Fdn. Mar. Res. 1(1): 59-576.

- BRANSTETTER, S. 1981. Biological notes on the sharks of the north central Gulf of Mexico. *Contrib. Mar. Sci.*, 24: 13-34.
- CASTRO, J.I. 1993. The shark nursery of Bulls Bay, South Carolina, with a review of the shark nurseries of the south-eastern coast of the United States. *Env. Biol. Fish.*, 38: 37-48.
- CLARK, E. and Von Schmidt, K. 1965. Sharks of the central Gulf of Florida. *Bull. Mar. Sci.*, 15: 13-83.
- COMPAGNO, L.V.J. 1984. FAO species catalogue, vol. 4. Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date, part 2. Carcharhiniformes. FAO Fish. Syn. (125), Part 2: 251-655.
- GADIG, O.B.F. 1994. Fauna de tubarões da costa norte/ nordeste do Brasil (Chondrichthyes, Elasmobranchii). Tese de Mestrado. Universidade Federal da Paraíba, João Pessoa, 230 pp.
- HAZIN, F.H.V., P.G. Oliveira and M.K. Broadhurst. 2002. Reproduction of the blacknose shark (*Carcharhinus acronotus*) in coastal waters off northeastern Brazil. *Fish. Bull.*, 100:143-148.
- HAZIN, F.H.V., A. Fischer, and M. Broadhurst. 2001. Aspects of Reproductive Biology of the Scalloped Hammerhead Shark, *Sphyrna lewini*, off Northeastern Brazil. *Env. Biol. of Fish.* 61 (2) 151-159.
- JOUNG, S.J and C.T. Chen. 1995. Reproduction in the sandbar shark, *Carcharhinus plumbeus*, in the waters off Northeastern Taiwan. *Copeia* 1995:659-665.
- MATTOS, S.M.G., F.H.V. Hazin and B.M.J. Pedrosa. 1995. Análise econômica da pesca de tubarões no litoral do Estado de Pernambuco. VII Encontro do grupo de trabalho sobre pesca e pesquisa de tubarões e raias no Brasil. Resumos. Rio Grande-RS. Pg. 54.
- MATTOS, S.M.G., F.H.V. Hazin, J.A.M. Wanderley, Jr. 1997. Distribuição e abundância relativa de tubarões na plataforma continental do talude dos Estados da Paraíba, Pernambuco e Alagoas. I Reunião da Sociedade Brasileira para Estudos dos Elasmobrânquios. Resumos. Ilhéus-BA. Pg. 26.
- MATTOS, S.M.G. 1999. Aspectos da biologia e dinâmica populacional de *Rhizoprionodon porosus* (Poey, 1861) (Pisces, Elasmobranchii, Carcharhinidae) na plataforma continental do estado de Pernambuco. Boletim da SBEEL, N° 4, Pg.1.
- MATTOS, S.M.G. 1998. Aspectos da biologia e dinâmica populacional de *Rhizoprionodon porosus* (Poey, 1861) (Pisces-Elasmobranchii-Carcharhinidae) na plataforma continental do Estado de Pernambuco. Dissertação de mestrado, Universidade Federal de Pernambuco. 99 pp.
- MATTOS, S.M.G. and F.H.V. Hazin. 1997. Análise de viabilidade econômica da pesca de tubarões no litoral do Estado de Pernambuco. *Bol. Técnico-Científico do CEPENE*, 5(1):89-114.
- MATTOS, S.M.G. and J.A. Pereira. 2002. Parâmetros de crescimento do tubarão rabo-seco, *Rhizoprionodon porosus* (Poey, 1861), no litoral de Estado de Pernambuco, Brasil. *Arquivos de Ciências do Mar* 35: 57-66.
- MATTOS, S.M.G., M.K. Broadhurst, F.H.V. Hazin D.M. and Jonnes, D.M. 2001. Reproductive biology of the Caribbean sharpnose shark, *Rhizoprionodon porosus*, from northern Brazil. *Marine and Freshwater Research* 52: 745-752.
- MCAULEY, R., R. Lenanton, J. Chidlow, R. Allison and E. Heist, E. 2005. Biology and stock assessment of the thickskin (sandbar) shark, *Carcharhinus plumbeus*, in Western Australia and further refinement of the dusky shark, *Carcharhinus obscurus*, stock assessment, Final FRDC Report-Project 2000/134, Fisheries Research Report No. 151, Department of Fisheries, Western Australia, 132p.
- MONTEALEGRE, S.Q. 2002. Idade, crescimento e análise demográfica do cação *Rhizoprionodon porosus* (Poey, 1961) (Elasmobranchii: Carcharhinidae) na plataforma continental do Estado de Pernambuco, Brasil. Tese. Universidade Federal de Pernambuco.

- NATIONAL MARINE FISHERIES SERVICE. 1991. The shark tagger. Annual Report of the NMFS Cooperative Shark Tagging Program. Apex Predators Program, Narragansett, Rhode Island. 14 pp. *In*: MERSON, R. & H.L. PRATT, Jr. 2001. Distribution, movements and growth of young sandbar sharks, *Carcharhinus plumbeus*, in the nursery grounds of Delaware Bay. *Env. Biol. Fish.* 61: 13–24.
- SAÏDI, B, M.N. Bradai, A. Bouain, O. Guélorget and C. Capape. 2005. The reproductive biology of the sandbar shark, *Carcharhinus plumbeus* (Chondrichthyes: Carcharhinidae), from the Gulf of Gabès (southern Tunisia, central Mediterranean). *Acta Adriat.*, 46 (1): 47 - 62, 2005.
- SPRINGER, S. 1960. Natural history of the sandbar shark *Eulamia milberti*. *Fish. Bull., Fish Wildl. Ser. US*, 178: 1-38.
- SUDENE. 1983. Avaliação do potencial de tubarões da costa nordeste do Brasil. *SUDENE, Sér. Est. Pesca*, 10:1-31.
- TANIUCHI, T. 1971. Reproduction of the sandbar shark, *Carcharhinus milberti*, in the east China Sea. *Jpn. J. Ichthyol.*, 18(2): 94-98.
- WANDERLEY, JR., J.A.M. 1998. Distribuição e abundância relativa de tubarões no litoral do Estado de Pernambuco. Monografia de Graduação. Universidade Federal Rural de Pernambuco, Recife. 75 pp.
- WASS, R.C. 1973. Size, growth, and reproduction of the sandbar shark *Carcharhinus milberti*, in Hawaii. *Pac. Sci.* 27: 305–318.

Table 1. Monthly distribution of sexual stages of male and female sandbar sharks, caught off Pernambuco, northeast Brazil, from December 1994 to January 1996.

	<i>Sexual Stage</i>	<i>Dec.</i>	<i>Jan.</i>	<i>Feb.</i>	<i>March</i>	<i>April</i>	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug.</i>	<i>Total</i>
Males	Adult	3	2	-	2	-	1	2	-	1	11
	Maturing	-	-	-	-	-	-	-	-	1	1
	Pre-ovulatory	-	-	2	-	-	-	-	-	-	2
Females	Pregnant	2	1	1	2	-	2	-	-	-	8
	Post partum	-	-	-	1	-	3	-	-	-	4
	Resting	-	-	-	2	-	-	-	-	-	2
	Subtotal	2	1	3	5	0	5	0	0	1	17
Total		5	3	3	7	0	6	2	0	2	28

Table 2. Main characteristics of sexual stages of female sandbar sharks, caught off Pernambuco, northeast Brazil.

	<i>Maturing</i>	<i>Pre-ovulatory</i>	<i>Pregnant</i>	<i>Post-partum</i>	<i>Resting</i>
Number of specimens	1	2	8	4	2
Uterus width	4.0	5.6 and 5.5	7.1 - 27.5	4.7 - 6.5	2.3 and 2.5
Oviducal gland width	2.8	4.5 and 4.0	2.4 - 4.0	2.5 - 2.9	2.7
Ovary width	7.5	7.2 and 10.7	5.0 - 7.5	4.9 - 6.2	5.0
Largest ovarian follicle diameter	1.8	2.7 and 2.8	0.5 - 0.6	0.5 - 1.0	0.5 and 0.6
TL (cm)	204.0	195.0 and 197.7	193.0 - 208.0	180.5 - 202.0	194.5 and 204.0

Table 3. Litter size, sex ratio and range of total length of embryos of 8 pregnant females, caught off Pernambuco, northeast Brazil, from December 1994 to January 1996.

	<i>Month</i>	<i>Litter Size/ Sex Ratio (males: females)</i>	<i>TL range (cm)</i>
1	December	9/ 5: 4	50.0 - 56.0
2	December	9/ 4: 5	49.0 - 55.0
3	January	9/ 5: 4	52.0 - 54.0
4	February	-	Egg
5	March	8/ 3: 5	53.0 - 56.0
6	March	7/ 2: 5	53.5 - 57.0
7	May	10/ 4: 6	14.0 - 17.0
8	May	8/ 2: 6	Egg - 10.0

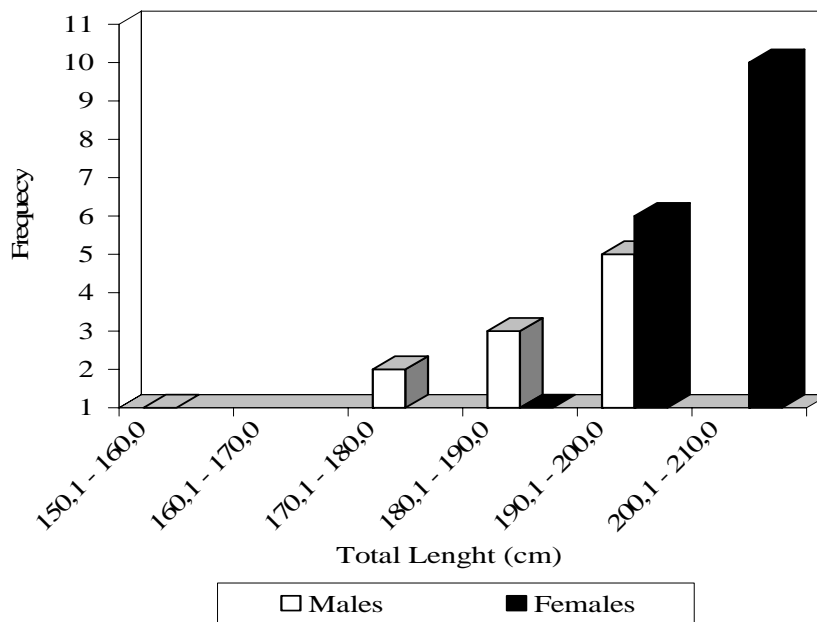


Figure 1. Length-frequency distribution of male and female sandbar sharks, caught off Pernambuco, northeast Brazil, from December 1994 to January 1996.

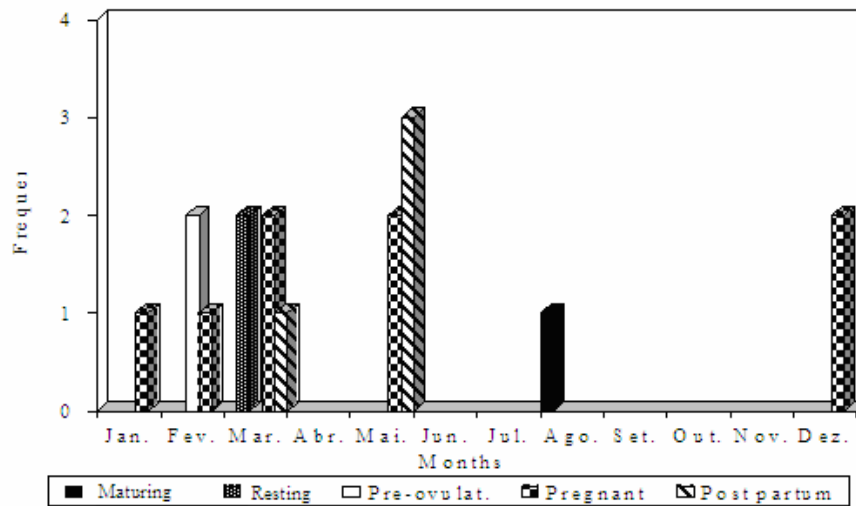


Figure 2. Monthly distribution of sexual stages of female sandbar sharks caught off Pernambuco, northeast Brazil.

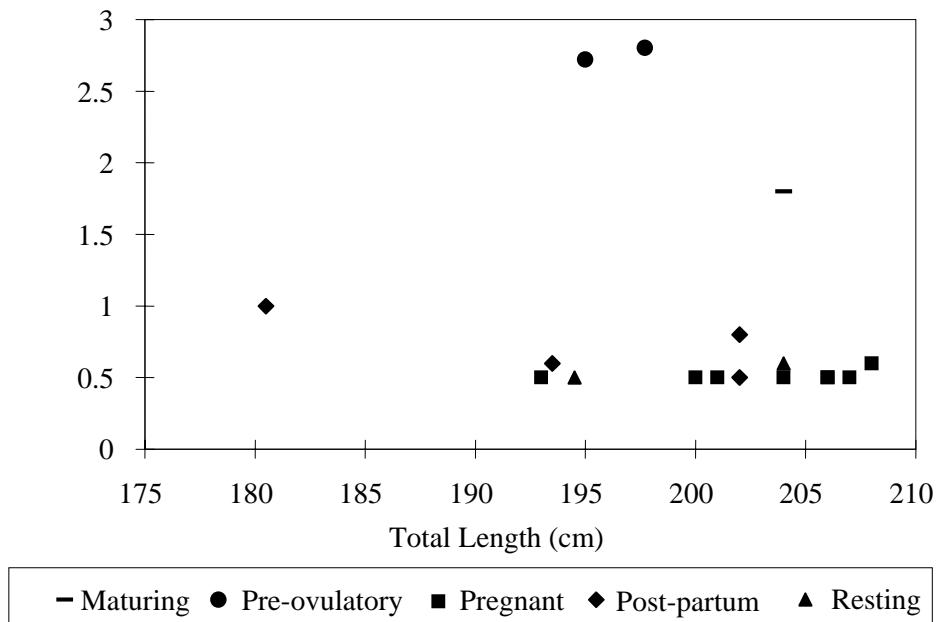


Figure 3. Relationship between largest ovarian follicle diameter and total length of female sandbar sharks, by sexual stages.