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- DUELLMAN W. E. & L. TRUEB, 1986. Biology of Amphibians. Mc Graw-Hill Book Co., XVII + 670.
- DUESBERG A., 1907. Contribution à l'étude des phénomènes histologiques de la métamorphose chez les amphibiens anoures. - Arch. Biol. **22**: 163.
- GIMÉNEZ H. R.; M. ACIAR & M. C. DE MARTÍN, 1991. Histological and length changes of *Bufo arenarum* digestive tube, during normal and induced metamorphosis. - Rev. Brasil. Biol. **51** (1): 57-64.
- GOSNER K. L., 1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetológica **16**: 183-190.
- GRIFFITHS I., 1961. The form and function of the fore-gut in anuran larvae (Amphibia, Salientia) with particular reference to the «Manicotto glandulare». - Proc. zool. Soc. London **137**: 249-283.
- HOURDRY J. & A. BEAUMONT, 1985. Les métamorphoses des Amphibiens. Masson. Paris, XI + 273 pp.
- JAMES R. G., 1934. Studies on the amphibian digestive system. Histological changes in the alimentary tract of anuran larvae during evolution. - J. Exp. Zool. Philadelphia **67**: 73-88.
- KAWIN L., 1936. A cytological study of the digestive system of anuran larvae during accelerated metamorphosis. - Anat. Rec., Philadelphia **64**: 413-437.
- LAMBERTINI G., 1929. Il manicotto glandulare di *Rana esculenta*. - Ric. Morfol. Roa **9**: 71-88.
- MARCELIN R. H., 1903. Histogenese de l'epithelium intestinal chez la granoville (*R. esculenta*). - Rev. suisse Zool. **11**: 367-392.
- MARTOJA R. & M. MARTOJA-PIERSON, 1970. Técnicas de histología animal. Ed. Torray-Masson, Barcelona, XII + 350 pp.
- MC MANNUS J. F. A., 1961. Periodate oxidation techniques. General Cytochemical Methods, II. Ed. by J. F. Danielli. New York, Academic Press.
- RADA D. & R. BELLO, 1988. Morfología e histología del sistema digestivo de la larva de *Pseudis paradoxus caribensis* Gallardo, 1961 (Amphibia, Pseudidae). - Iheringia Sér. Misc. Porto Alegre **2**: 69-91.
- REEDER W., 1964. The digestive system. In Physiology of the Amphibia. - More J. A. (ed.), Academic Press **4**: 99-149.
- SAVAGE R. M., 1955. The ingestive, digestive and respiratory systems of the microhylid tadpole, *Hypopachus aguae*. - Copeia **2**: 120-127.
- TERÁN H. R. & A. MICHEL DE CERASUOLO, 1988. Estudio histomorfológico del tracto digestivo larval de *Gastrotheca gracilis* Laurent (Anura, Hylidae). - Neotropica **34**: 115-123.
- TERÁN H. R. & A. A. MICHEL. Estudio histológico de la transición del «manicotto» al estómago adulto en *Gastrotheca gracilis* Laurent (Anura, Hylidae). - Acta zool. lilloana (en prensa).

## The chondrichthyan community off Maranhão (northeastern Brazil)

### II. Biology of species

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#### Summary

We describe the biological traits of shark and batoid species belonging in a chondrichthyan community occurring along the coast of the Maranhão state in northeastern Brazil, South America. They are based on the composition of 49 samples with a total of 1,807 specimens, obtained from a gillnet artisanal fishery mostly during 1984 and 1985. Thirteen species of sharks from two families (Carcharhinidae and Sphyrnidae) and six batoid species from four families (Rhinobatidae, Dasyatidae, Myliobatidae and Gymnuridae) were considered. According to a previous analysis, the elasmobranch fauna of Maranhão includes two constant species (*Carcharhinus porosus* and *Sphyrna tiburo*); eleven common species and six rare species. Three batoid species were common (*Dasyatis guttata*, *Rhinoptera bonasus* and *Aetobatus narinari*). In terms of continuity of presence and abundance, the association composed by *Carcharhinus porosus*, *Sphyrna tiburo*, *S. lewini*, *Rhizopriondon lalandii*, *R. porosus* and *S. tudes* is the most important. These species spend all or most of their life cycles within the area, so pregnant females and adult males in all of them, as also newborn specimens of most, were observed, as well as lower degrees of sexual segregation than in other species. These traits are also displayed by *Isogomphodon oxyrinchus*, *Carcharhinus acronotus*, *Aetobatus narinari*, *Carcharhinus limbatus*, *Dasyatis guttata* and *Rhinoptera bonasus*, with lower frequencies of occurrence, may or may not have pregnant females and adult males are scarce, newborn specimens are rare and sexual segregation is high. The rare species *Dasyatis geijkesi*, *Gymnura micrura*, *Rhinobatos lentiginosus*, *Carcharhinus perezii*, *C. plumbeus* and *C. obscurus*, have no specimens in reproductive stages within the area, adult males are generally absent and newborn specimens were not obtained. Possible differences in biological parameters between Maranhão populations and those from other areas are suggested for *R. lalandii*, *S. lewini*, *C. acronotus* and *R. bonasus*.

#### Introduction

Studies of fish community ecology in South America (Lowe McConnell, 1962; Menni and Gosztonyi, 1982; Menni and López, 1984) refer to global faunas in wide areas, and do not discuss chondrichthyans in particular. Methods of com-

munity ecology have been only applied to patterns of association in chondrichthyans by Muñoz Chapuli (1985 a, b). The chondrichthyan fauna of Maranhão provides a field for this kind of analysis, because of the relative abundance of

species and the peculiarities of the environment. In a previous paper (Lessa and Menni, 1994), we described the structural patterns of the chondrichthyan community at Maranhão in terms of co-occurrences of species and temporal distribution of species and species abundance. Several chondrichthyan species have been reported from the south equatorial Atlantic off northeastern Brazil in the past (Bigelow and Schroeder, 1948, 1953), but more comprehensive local reports are relatively recent. Lessa and Araujo (1984), reported the elasmobranchs from the Araoca and Cumá bays in Maranhão, based on material from artisanal fisheries with gillnets. There the dominant species were *Isogomphodon oxyrhynchus*, *Carcharhinus porosus* and *Dasyatis guttata*.

Lessa (1986) reported 22 chondrichthyan species obtained off Maranhão state and a list of species from the same area, comprising both chondrichthyans and teleosts, is provided by Garrido Martins-Juras *et al.* (1987). On account of these data, Lessa and Menni (1994) state that shark and batoid species represent a 16.7% of fish species richness in the area. Other recent information is briefly revised in this paper.

The aim of this work is to analyze the biological features of the species composing the chondrichthyan community from Maranhão coast, referred mainly to reproductive stages. These are discussed in the context of the community structure described by Lessa and Menni (1994), and based on original data on fourteen species. Other information available on this Brazilian fauna is briefly discussed.

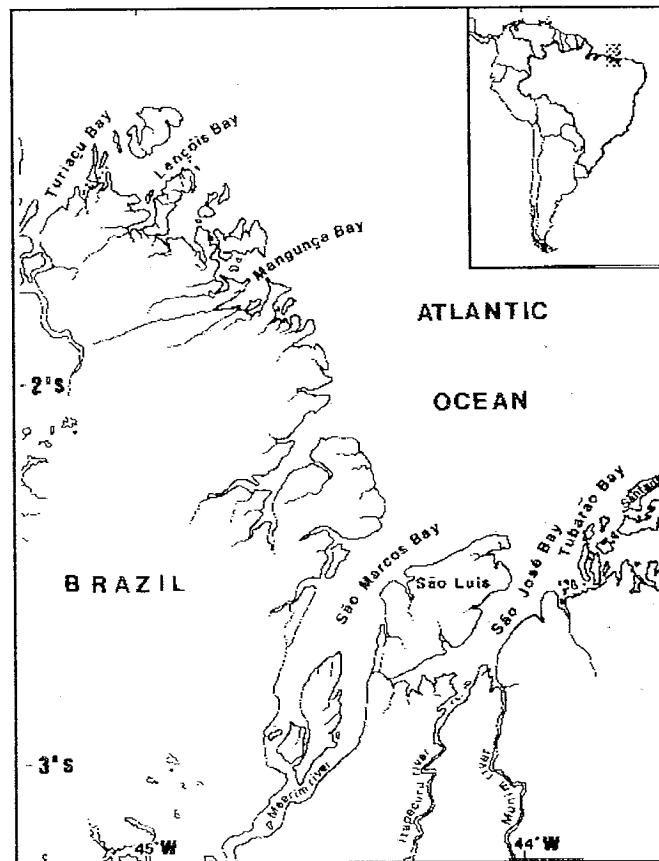


Fig. 1

### Studied area

The coast of the Brazilian state of Maranhão, as concerned to this work (fig. 1), runs in a NW direction between Baía de Turiacó in the SE and Baía de Turiacu in the NW. This littoral line is a low coast with mangrove. It is deeply indented because of the large number of islands and rivers, with estuaries, sandy beaches and cliffs. Due to the large number of indentations, the area is called «zona das reentrâncias maranhenses». There are few real «rias» or flooded valleys. They are mostly channels made by the development of sandy banks perpendicular to the coast, left over eroded land and colonized by mangrove. The most influential factor in this process are tidal currents. Important geographical features in the

southern part of the area are two large bays, São Marcos (westerly) and São José (easterly) at each side of the large island of São Luis. The São Marcos bay is an active estuary where the Mearim and Pindari rivers enter dredging a deep channel. The São José bay is relatively shallow. Tides amplitude is 7 meters. Tidal currents reach to 7.5 knots at São Marcos bay. Available data give salinity values of 36.8‰ for oceanic waters and 33.8‰ in coastal waters. At very coastal locations salinity ranges from 13.9‰ during the rainy season to 33.6‰ during the dry one. Salinity values obtained during this work, at the same time as fishing operations, gave a range between 20.0 and 34.41‰ (Mean 27.52‰, N= 18). Surface water temperature is 28 °C. Toward the coast it ranges from 21.1 to 31.5 °C. The rainy season (winter), runs from December to May, the dry one from June to November (summer) (Sudepe, 1976; Palma, 1979; Lessa, 1986; Stride, 1992).

### Material and methods

Samples were taken between 6 and 35 meters depth by an artisanal local fleet. This was composed by 6–7 m length simple-hull sailing boats. They spent about a week at sea, lodging about a ton of fish preserved with ice bars. The fishery is carried on with a gill net locally called «çaçoeira», measuring, depending on boat size, between 180 to 900 m, 4.5 m high and 7 cm mesh. The fishery is intended for middle water fishes like *Scomberomorus brasiliensis* and species of *Cynoscion*. Then probably batoids were underestimated in samples.

For the present paper we considered 19 species, 13 shark species and 6 batoid species (table 1). *Ginglymostoma cirratum*, *Carcharhinus leucas*, *Narcine brasiliensis*, *Pristis perotteti* and *Mobula hypostoma* were also captured. As precise data of capture of these species were not available, they were not considered in the analysis. Of the 19 species, 1,048 male and 759 female specimens were considered, in all 1,807

specimens.

Forty nine samples were taken at 14 locations off Maranhão. Thirty seven samples were taken from June 1984 to December 1985, thus providing a mean of over three samples each month. Eleven samples were taken from January 1986 to January 1987, and a single sample on May 1988 (table 2). All the specimens in each capture were considered, so it can be assumed that samples represent a good estimation of the occurrence and relative abundance of species, as indeed, nearly a weekly samples was obtained for the first period. More probable bias in the net is its lesser efficiency in collecting bottom strong related species.

Frequency of occurrence for each species was calculated as the ratio between the number of samples in which a species occurs and the total number of samples.

Total length (TL, cm), total weight (TW, g) and liver weight were obtained for all specimens. Length x width and/or weight of testes, epididymides width and clasper length (from cloaca to clasper tip) were obtained for males, as well as presence or not of liquid in the seminal vesicle. Maturity in males was determined according to size and calcification degree of claspers and testis development. Ovary size and/or weight, number and stage (vitellogenic or not) of oocytes, characteristics of the uterus and size and number of embryos were obtained for females. Females were considered mature when they have uterine eggs or embryos (Ketchen, 1972; Menni, 1985). Disc width (DW, cm) and total length (TL, cm) were used for batoids.

### Results and discussion

**The chondrichthyan community at Maranhão.** According to Lessa and Menni (1994), chondrichthyan species in Maranhão show a regular distribution in terms of number and weight of individuals. Frequencies of occurrence of spe-

**Table 1** Species occurring off the Maranhão coast.  
Number of specimens, number of stations and percentage of occurrence.

| Species                | Males | Females | Total | N° of Stations | Percent |
|------------------------|-------|---------|-------|----------------|---------|
| <i>C. porosus</i>      | 517   | 431     | 947   | 41             | 52.4    |
| <i>S. tiburo</i>       | 98    | 106     | 204   | 31             | 11.2    |
| <i>R. porosus</i>      | 168   | 28      | 196   | 19             | 10.8    |
| <i>R. lalandii</i>     | 85    | 50      | 135   | 20             | 7.4     |
| <i>S. lewini</i>       | 53    | 48      | 101   | 16             | 5.5     |
| <i>Isog. oxy.</i>      | 43    | 22      | 65    | 13             | 3.5     |
| <i>D. guttata</i>      | 29    | 17      | 46    | 9              | 2.5     |
| <i>S. tudes</i>        | 17    | 19      | 36    | 17             | 1.9     |
| <i>S. mokarran</i>     | 6     | 12      | 18    | 5              | 0.9     |
| <i>C. acronotus</i>    | 6     | 9       | 15    | 7              | 0.8     |
| <i>R. bonasus</i>      | 10    | 2       | 12    | 8              | 0.6     |
| <i>A. narinari</i>     | 6     | 5       | 11    | 7              | 0.6     |
| <i>C. imbatus</i>      | 5     | 5       | 10    | 9              | 0.5     |
| <i>D. geijkesi</i>     | 1     | 3       | 4     | 4              | 0.2     |
| <i>G. micrura</i>      | —     | 3       | 3     | 2              | 0.1     |
| <i>C. obscurus</i>     | 1     | —       | 1     | 1              | 0.05    |
| <i>C. perezii</i>      | 1     | —       | 1     | 1              | 0.05    |
| <i>C. plumbeus</i>     | 1     | —       | 1     | 1              | 0.05    |
| <i>R. lentiginosus</i> | 1     | —       | 1     | 1              | 0.05    |

**Table 2** Chondrichthyan community of Maranhão. List of samples.

| Month     | N° of Stations | Month         | N° of Stations    |
|-----------|----------------|---------------|-------------------|
| 1984:     |                | 1985 (cont.): |                   |
| June      | 1 - 2          | August        | 31 - 32           |
| July      | 3 - 4          | September     | 33                |
| August    | 5              | October       | 34 - 35           |
| September | 7 - 8 - 9      | November      | 36                |
| October   | 10             | December      | 37                |
| November  | 11 - 12 - 13   | 1986:         |                   |
| December  | 14 - 15 - 16   | January       | 38 - 39 - 40 - 41 |
| 1985:     |                | March         | 42                |
| January   | 17 - 18        | July          | 43 - 44           |
| February  | 19 - 20        | August        | 45                |
| March     | 21 - 22        | December      | 46                |
| April     | 23 - 24        | 1987:         |                   |
| May       | 25 - 26 - 27   | January       | 47 - 48           |
| June      | 28             | 1988:         |                   |
| July      | 29 - 30        | May           | 49                |

cies according to the Guille' system (1970) showed that the Maranhão fauna includes a pair of constant species, 11 common species and 6 rare species (table 3). Common species include two evident subgroups, one with frequencies over 0.20 (common I group), and another with lesser values (common II group).

A cluster analysis based on Jaccard coefficient resulted in a well defined main group and a few minor groups (fig. 2). The main group is composed by *C. porosus* + *S. tiburo* + *S. lewini* + *R. lalandii* + *R. porosus* + *S. tudes*. We call this group the core species (or Core group). Two other groups at about the same level are formed by *C. limbatus* + *S. mokarran* and *D. guttata* + *R. bonasus*, and *D. geijkesi* + *G. micrura*. Other species joint these groups at lower levels. Core species occur in Maranhão practically all the year, *C. porosus* and *S. tiburo* being the most continuous; other species in the group appear in a more intermittent way, but within all the span of the year. The common I species in the Core group show a rather different temporal pattern that the common II species (those with lesser frequencies). *I. oxyrhynchus*, though occurs in abundance at several moments, differs in its pattern of presence respect to the core species.

Neither Stride (1992) nor Lessa and Menni (1994) perceived any strong seasonality in the occurrence of the chondrichthyans of Maranhão, with the exception of the loose one between the less frequent common II species and the rain cycle.

**Biology.** Within the chondrichthyan assemblage occurring in Maranhão, species display, as commented above, regular patterns of presence and distribution of abundance and weight. Some species are present all the year round in the area, others appear with some regularity, and some are only occasional. As expected, their biology is related to these differences. Of the ten most abundant species (table 1), only the seventh (*D. guttata*) and the ninth (*S. mokarran*, no data), as well as the rest of nine species, do not perform reproductive activities in the area. Eight of the most abundant species, *C. porosus*, *S. tiburo*, *R. porosus*, *R. lalandii*, *S. lewini*, *I. oxyrhynchus*, *S. tudes* and *C. acronotus*, plus *C. limbatus* (13th), spend there at least some parts of their life cycles. *R. porosus* is represented only by males in this regard. Species are discussed in the order provided by the cluster analysis (fig. 2, Lessa and Menni, 1994).

**Table 3** Frequency distribution of Maranhão chondrichthyans according to Guille's system.

| Constant species      | Frequency > 0.50          | Common species (cont.) | Frequency 0.50 > f > 0.10 |
|-----------------------|---------------------------|------------------------|---------------------------|
| <i>C. porosus</i>     | 0.83                      | <i>A. narinari</i>     | 0.14                      |
| <i>S. tiburo</i>      | 0.63                      | <i>C. acronotus</i>    | 0.14                      |
|                       |                           | <i>S. mokarran</i>     | 0.10                      |
| Common species        | Frequency 0.50 > f > 0.10 | Rare species           | Frequency < 0.10          |
| <i>S. lewini</i>      | 0.48                      | <i>D. geijkesi</i>     | 0.08                      |
| <i>R. lalandii</i>    | 0.40                      | <i>G. micrura</i>      | 0.04                      |
| <i>R. porosus</i>     | 0.38                      | <i>C. obscurus</i>     | 0.02                      |
| <i>S. tudes</i>       | 0.34                      | <i>C. perezii</i>      | 0.02                      |
| <i>I. oxyrhynchus</i> | 0.26                      | <i>C. plumbeus</i>     | 0.02                      |
| <i>D. guttata</i>     | 0.18                      | <i>R. lentiginosus</i> | 0.02                      |
| <i>R. bonasus</i>     | 0.16                      |                        |                           |
| <i>C. limbatus</i>    | 0.16                      |                        |                           |

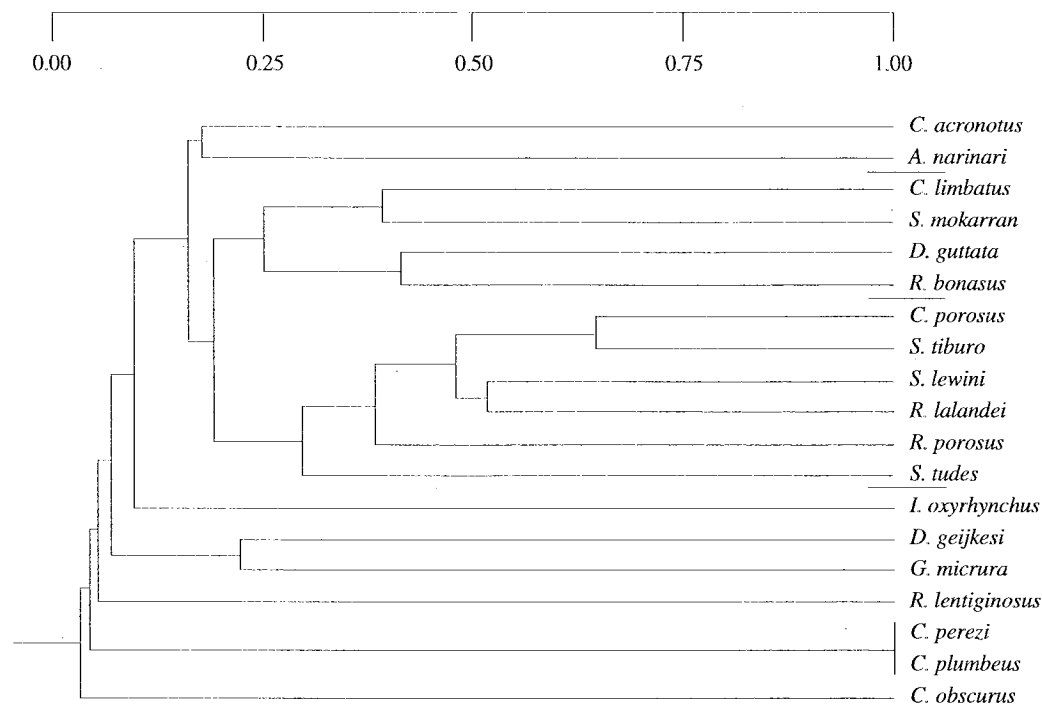


Fig. 2.

### Reproductive traits of the shark fauna

*Carcharhinus porosus* is widely distributed in the coastal Brazilian waters from Marajó island (Pará) to Cananeia (São Paulo). It is rather common in the Maranhão area, from where it has been reported by Lessa and Araujo (1984), Lessa (1986; 1987a) and Garrido-Martins Juras (1987). This species was the most abundant (table 1) in Maranhão during the sampling period, occurring throughout the year. It was captured in 41 samples.

Lessa (1987a) studied the reproductive biology of 184 male specimens captured with the same type of gillnet referred in this paper. Samples were obtained between October 1983 and January 1984. Evidence that the species reproduces in the area is given by the capture of newborn specimens with umbilical scars. Besides,

12 specimens were smaller than the lesser size reported for Cananeia (Sadowsky, 1967). The relationship between the total length and the clasper growth shows three stages. The juvenile stage, during which the clasper length grows slowly, ends about 60 cm TL. This is followed by a rapid increase in clasper size from 2.5 to 6.0 cm. The third stage involves developed claspers (6.5 to 8.4 cm) of the adults.

Growth of testicles and epididymides and the relationship liver weight - total length do not show discontinuities, while the relationship liver weight - total weight has a change in the slope when the individuals reach 2,200 g or 75 cm.

On account of clasper growth and production of spermatozooids, first maturity size in *C. porosus* of Maranhão was established at 71 cm TL, and the 100% of maturity at 75 cm TL.

Data from 517 males and 430 females of *C. porosus* were considered for the present re-

search, the species being, as commented above, the most abundant and permanent in Maranhão. *C. porosus* shows a low level of sexual segregation, with only 8 samples (19%) composed by one sex. We consider that this feature is related to the fact that the species spend all the stages of its life cycle within the area.

Reproductive stages of one hundred eighty seven female specimens of *C. porosus* were examined. Size ranged from 30 to 120 cm TL, with weights from 250 to 5,800 g. From newborn specimens with umbilical scars to pregnant ones were observed.

From 30 to 46 cm TL (N= 30), 9 specimens showed umbilical scars indicating they were born in the area. Within this range nidamental glands measured from 0.1 to 0.4 cm. First important size increase appears at 72 cm TL, when the glands reach 1.5-1.6 cm width. At larger sizes, the gland varied from 0.5 to 1.7 cm, but changed much according to the sexual cycle.

The uterus was threadlike, measuring less than 0.1 cm width in a specimen 30.2 cm TL. From 37 cm TL on it ranges from 0.1 to 0.2 cm, but it can be described as filiform up to 67.9 cm TL.

Ovary weights (without the epigonal organ) were markedly variable. Table 4 includes ovary weights in each 10 cm class showing the increasing weight of the organ with size up to 99 cm TL, and decreasing after.

First macroscopic evidence of oogenesis appears within the 50-59 cm class, with white oocytes < 1 mm in a specimen 52 cm TL, and the ovary as a granular mass in another one 55 cm TL. First vitellogenic oocytes appear in a specimen 64 cm TL. Below 60 cm TL the ovary appears as an undifferentiated mass or has 4 to 15 small white oocytes < 1 mm (3 specs.). From 64 cm TL up, vitellogenic oocytes are common, co-occurring with white ones. Within the 60-69 and 70-79 cm classes, white oocytes 0.1-0.5 cm (maximum amount around 12) and vitellogenic ones 0.1-0.35 cm (maximum amount 15) were

common, together with quantities of smaller ones which give the organ a granular appearance.

The smallest specimens in the class 80-89 cm TL had an ovary 4 g weight with 12 white (0.3 cm) and 12 vitellogenic (0.2 cm) oocytes. The smallest pregnant female (80 cm TL) had 8 vitellogenic oocytes < 0.5 cm. The following pregnant (80.2 cm TL) had more than 10 white and 15 vitellogenic (> 0.2 cm) oocytes. Pregnant females measuring 91, 92.3 and 94.8 cm TL have respectively 20, 4 and 20 small vitellogenic oocytes (0.2-0.5 cm).

Six pregnant females were in all observed. Data on the embryos are summarized in the table 5. Note that both the number and size of embryos increase with mother size. That uterine fecundity increases with mother size, has been already observed by Stride *et al.* (1992). Up to a mother size 80.2 cm TL, the embryos are within the capsule.

Most specimens in both sexes sampled by Stride *et al.* (1992) (N= 78) were mature. Male data agree with those reported by Lessa (1987a). Pregnant females were observed by those authors from March to November, measuring at least 88 cm TL; uterine fecundity was 4 to 9 embryos, these numbers having a linear relationship with mother size.

In spite of number of specimens and variety of sexual development stages, available data do not allow to perceive a definite cycle in females. Mean values of the GSI (Wg/Wt x 1,000) for each capture range from 0.24 (October 84) to 7 (May 85) (table 6). The only indication of regularity is given by the repetition of high values of the index during April and May 1985 and May 1988 (May values for 1986 and 1987 lacking).

Newborn specimens were observed on June (N= 2), July (N= 1) and September (N= 1) 1984; May (N= 1), July (N= 2), September (N= 1) and October (N= 1) 1985, then with the same slight periodicity.

Pregnant females appeared on January and October 1985, July 1986 and May 1988, not

**Table 4** *C. porosus* from Maranhão, ovary weights (g) by female class.

| Class (cm) | Range        | Mean  | N  |
|------------|--------------|-------|----|
| 30 - 39    | 0.43         | 0.43  | 1  |
| 40 - 49    | 0.13 - 1.05  | 0.51  | 9  |
| 50 - 59    | 0.21 - 8.00  | 2.61  | 19 |
| 60 - 69    | 0.36 - 6.00  | 2.71  | 20 |
| 70 - 79    | 0.90 - 6.00  | 3.03  | 9  |
| 80 - 89    | 3.00 - 13.30 | 6.08  | 9  |
| 90 - 99    | 4.60 - 31.40 | 12.04 | 5  |
| 100 - >10  | 3.50 - 9.00  | 7.16  | 3  |

**Table 5** *C. porosus* from Maranhão. Features of embryos.

| Mother size (cm) | Uterus | Total weight (g) | Weight without umb. c & plac. (g) | TL   | Sex | Clasper size (cm) |
|------------------|--------|------------------|-----------------------------------|------|-----|-------------------|
| 80.0             | R      | 61.9             |                                   | 23   | M   | 0.4               |
| 80.2             | R      | 126.0            | 124.4                             | 28   | M   | 0.5               |
|                  | R      | 134.0            | 131.0                             | 27.5 | M   | 0.5               |
|                  | L      | 120.0            | 119.0                             | 27   | F   | -                 |
| 91.0             | R      | 121.0            | 120.0                             | 27   | M   | 0.5               |
|                  | R      | 122.0            | 100.0                             | 26.5 | M   | 0.4               |
|                  | R      | 121.0            | 100.0                             | 26.6 | M   | 0.4               |
|                  | L      | 141.0            | 140.0                             | -    | F   | -                 |
|                  | L      | 130.0            | 120.0                             | -    | F   | -                 |
| 92.3             | R      | 198.0            | 188.9                             | 32.5 | F   | -                 |
|                  | R      | 167.0            | 155.0                             | 30.6 | M   | 0.8               |
|                  | L      | 184.0            | 177.0                             | 30.5 | F   | -                 |
|                  | L      | 177.0            | -                                 | 30.3 | F   | -                 |
| 94.8             | R      | 190.0            | 180.0                             | 32.5 | F   | -                 |
|                  | R      | 190.0            | 180.0                             | 30.5 | F   | -                 |
|                  | R      | 180.0            | 170.0                             | 31.5 | F   | -                 |
|                  | L      | 200.0            | 180.0                             | 31.4 | F   | -                 |
|                  | L      | 180.0            | 170.0                             | 31.0 | F   | -                 |
|                  | L      | 190.0            | 180.0                             | 31.2 | M   | 0.7               |
|                  | L      | 190.0            | 180.0                             | 30.7 | M   | 0.7               |

**Table 6** *C. porosus*. Variation of the GSI during sampling period. Mean values for each capture.

| Date           | N spec. | Av. GSI | Date         | N spec. | Av. GSI |
|----------------|---------|---------|--------------|---------|---------|
| June 1984      | 3       | 1.00    | January 1985 | 1       | 1.32    |
| June 1984      | 3       | 1.45    | March 1985   | 10      | 2.34    |
| July 1984      | 2       | 1.21    | March 1985   | 1       | 1.55    |
| September 1984 | 5       | 1.85    | April 1985   | 8       | 3.06    |
| September 1984 | 2       | 1.40    | May 1985     | 11      | 3.20    |
| September 1984 | 3       | 0.29    | May 1985     | 2       | 7.00    |
| October 1984   | 2       | 0.24    | August 1985  | 2       | 1.98    |
| November 1984  | 1       | 0.83    | August 1985  | 9       | 1.82    |
| December 1984  | 1       | 2.72    | October 1985 | 1       | 1.52    |
| December 1984  | 1       | 0.69    | July 1986    | 1       | 1.22    |
| January 1985   | 1       | 1.58    | May 1988     | 3       | 3.80    |

overlapping with presence of newborn specimens. At Maguari cape (Marajó bay mouth) (Barthem, 1985) newborn specimens 35–40 cm TL of *C. porosus* are captured with gillnets in summer.

***Sphyrna tiburo*.** Both juveniles and adults of *S. tiburo* occur in the Maranhão area throughout the year, being the second species in abundance in the artisanal captures. Silva and Lessa (1991) and Lessa and Silva (1992) studied the sexual development of this species based on 191 specimens, measuring from 38 to 96 cm TL (males) and from 35.6 to 125 cm TL (females). Males within the 80 cm TL length class were considered fully mature, on account of clasper condition and content of the seminal vesicle. Vitellogenic oocytes firstly appear in females over 70 cm TL. The smallest pregnant specimen measured 90 cm TL, and the largest embryo measured 31 cm TL. A noticeable time gap was observed between vitellogenesis and pregnancy, during which the females grow around 30% of their total length.

No relationship was observed between female body size and ovarian fecundity. The uterine fecundity ranged from 3 to 23 embryos or eggs, increasing with female size. Uterine fecundity at

Maranhão is higher than any other report for other areas, and may be explained by the large size of northern Brazil females (maximum 125 cm TL).

In the Maranhão area ovulation takes place from August to October, when fully developed oocytes are found, at the same time as fecundation. Embryonic growth occurs between August and February, so pregnancy lasts about 6 months. This relatively short period is attributed by the authors to higher water temperatures (average 29°C in the area). Females bearing embryos have pre-vitellogenic oocytes. Birth probably takes place in December–January. After this, females seem to start an offshore movement, which explains the lack or low number of catches from March to May. *S. tiburo* has a definite cycle in the tropical area of Maranhão.

***Rhizoprionodon porosus*.** Information on this species in southern Brazil was published by Sadowsky (1967). Paixao (1984), Garrido-Martins Juras (1987) and Lessa (1986) reported it from the Maranhão area. Bezerra *et al.* (1990) reported female schools from northern Brazil, composed by specimens with sizes between 65 and 84 cm TL, including pregnant females (N= 7) with 2 embryos in all cases.

*R. porosus* is the third species in order of abundance in the Maranhão area, and is recorded practically during all the year. The degree of sexual segregation is very high, with 15 samples composed by one sex only (78.9%), only one by a female.

Data on 92 male specimens were available for this paper, measuring from 49 to 85.2 cm TL, with weights from 700 to 2,600 g. The smallest individual with well calcified clasper (6 cm) measured 61 cm TL (W= 1,100 g), but over this size up to 69 cm TL (N= 39) specimens could (N= 15) or could not (N= 20) have the organ calcified (no data N= 4). The largest individual with undeveloped clasper measured 82 cm TL (W= 2,300 g) being an exception, since from 69 cm TL (W= 1,440 g) up (N= 38) nearly all specimens have consistently well calcified claspers (N= 35). Increase in the width of the epididymides is rather irregular. When calcified claspers appear (61 cm TL) they measured 0.3–0.4 cm. They reach 0.7–0.8 and 1.0–1.1 cm in individuals measuring 64 cm TL, when well calcified clasper are common. Larger measurements, in only one specimen (73.5 cm TL), were 1.8–1.9. Testes weight ranged from 3 (52 cm TL) to 20.2 g (85.2 cm TL), weighing 8.1 g when males reached 63 cm TL, 10 g at 64 cm TL, 14 g at 65 cm TL and 18.2 at 69 cm TL with wide variations. Testes measured 10.6 x 0.9 cm at 66.2 cm TL and 16 x 1.5 cm at 77.5 cm TL, also with variations. Presence of liquid in the seminal vesicle preceded the calcification of the clasper. Liver weight ranges from 28 to 130 g.

No data on females from Maranhão have been reported. Ferreira and Da Silva Santos (1984), based on samples from the Rio de Janeiro environs down to 30 m depth, stated that *R. porosus* has the left ovary functional, low fecundity, higher in the left uterus and that parturition time is in winter. Undeveloped eggs and embryos co-exist in the uterus. After first maturity, reached between 70 and 80 cm TL, the species is in a

continuous reproductive state. Parturition time is in winter, when larger concentrations of adults occur. During spring recent mated females are the most abundant, together with small specimens. It is supposed that adults migrate to deeper waters in summer, females returning to the area in autumn, with well developed embryos (Ferreira, pers. comm.).

*Rhizopriondon lalandii* is widely distributed in the western Atlantic, from the Panamá coast to southern Brazil (Compagno, 1984).

Reproductive biology of 284 specimens of *R. lalandii* in the Maranhão area has been studied between June 1984 and August 1986 (Lessa, 1988). The length–weight relationship is significantly different between sexes, indicating a larger weight increase with size in females than in males. Vitellogenesis begins at 49 cm TL, and first pregnancy was observed from 53 to 56 cm TL, with an ovarian fecundity from 2 to 6 eggs and 2 to 5 embryos. There is not a significant relationship between fecundity and size in females. Sperm production started at 48 cm TL, but only males over 51 cm TL are able to copulate, because of clasper development. Liver weight in near term females is twice that in other specimens. *R. lalandii* (as *C. porosus*) does not exhibit an annual reproductive cycle in the area.

Some differences were observed between length at first maturity and size of embryos among samples from Maranhão and data from Rio de Janeiro and from Compagno (1984). While females mature at 49 cm TL at Maranhão, Compagno (1984) mentioned 54 cm, and Ferreira (pers. com.) 50–60 cm for Rio de Janeiro. Moreover, 27 cm size embryos from Maranhão are developed enough to suggest a birth size about 30 cm. Compagno (1984) states a size at birth of 33–34 cm, the size for Rio de Janeiro being 34 cm. There may be some differences in natural history traits between temperate and tropical populations of *R. lalandii*. It must be noted that water temper-

atures at Rio de Janeiro are between 15 and 18°C against 27–30°C at Maranhão.

*Isogomphodon oxyrinchus*. It is somewhat curious that a species with the obvious morphology of *I. oxyrinchus* has been overlooked during recent times. Compagno (1978), who quoted the same distribution as Bigelow and Schroeder (1948) (Surinam, Guianas and Trinidad) suggested its possible occurrence in Brazil, and particularly (Compagno, 1984), in Bahia. Schools of this species were reported by Barthem (pers. com., 1985) from Maguari cape (Marajó Bay, Pará state) where gravid females were obtained. Lessa and Araujo (1984) reported it from two bays in Maranhão, where they found a 100% females 124–129 cm TL, including pregnant specimens with 6 embryos (22–24.2 cm TL) in November.

Lessa (1987b) reports *I. oxyrinchus* as an abundant species in Maranhão during the Amazonian summer (July–December) and provides information on its biology. It is captured when salinity in coastal waters reaches to 33‰. Males reach shallow coastal waters earlier than females. The complete population enters bays and low waters during summer, with sexes evenly represented in captures. Adult males appear more vulnerable to the fishery than adult females, which live during most of the gestation period in deep waters where they can not be targeted by the artisanal fleet.

Eighty eight males and 38 females were studied with sizes ranged from 61 to 115 cm TL (males) and from 56 to 130 cm TL (females). Length–weight relationship does not show differences between sexes. Clasper growth shows three development stages, the juvenile ending around 88.5 cm TL. A rapid growth stage occurs at sizes between 90 and 102 cm TL, and the adult one beginning at 95 cm TL with clasper reaching at least 8 cm length. Two stages were identified in the relationship between testes

weight and eviscerated weight though the correlation is low ( $r= 0.50$ ;  $P < 0.05$ ). The first includes specimens up to 3,000 g, with testes weight less than 12 g; and the second individuals over that weight, with testes weight between 15 and 33 g. Two stages were also identified in epididymides growth. Based on clasper condition and sperm presence, the 100% maturity size was 103 cm TL, first maturity size being 95 cm TL.

Females are immature up to 105 cm TL. Vitellogenic oocytes were observed between 105 and 112 cm TL, with larger oocytes reaching 1.3 cm diameter. Pregnancy was observed at 118 cm TL, with 4 embryos, 120 cm TL with 5 and 128–130 cm TL with 6 embryos, suggesting an increase of litter size with mother size. Pregnant females occurred between July and December (Summer), embryos measuring 2.8 cm TL in August and 26 to 28 cm TL in November. Barthem (pers. comm.) observed term embryos 37 cm TL in Pará in November, suggesting that they born at the end of summer (December).

Newborn specimens were not observed neither in Maranhão nor in Pará (Barthem, pers. comm.), also supporting that birth takes place at the end of summer, when salinity falls to values incompatible with shark commercial captures.

Lessa (1987b) concluded that birth, ovulation and mating happen throughout the year, but that the knowledge of the complete cycle required winter data. Stride *et al.* (1992) state that the cycle implies an annual litter, but that each year has its own chronology, with similar rates of embryonic growth but different periods within the year. They suggest these differences may be related to salinity changes. According to Stride *et al.* (1992), though known from several parts of the Maranhão coast, this species appears to have not a wide distribution and abundance, which may be subjected to commercial fishery. These traits explain the low degree of association of *I. oxyrinchus* with other species found by Lessa and Menni (1994).

*Sphyrna tudes*. In South America *S. tudes* occurs from Venezuela to Uruguay, having a relatively wide distribution off the Maranhão coast. Its higher concentrations are probably localized in the deeper area off the Cumá Bay (Stride *et al.*, 1992). At Maguari cape (Marajó bay), specimens between 57–120 cm TL were obtained in summer, including pregnant females (Barthem, 1985).

Thirty six specimens were obtained in 17 samples. Sexes were evenly represented. Size range was from 48 to 117 cm TL for males and from 38 to 129 cm TL for females. No significant differences were found between sexes in length-weight relationship. The equation for males and females together is  $TW = -5.936 + 3.13 \ln TL$  ( $r = 0.97$ ,  $N = 35$ ).

Ovaries in females from 32 to 72 cm TL appear as an undifferentiated mass. It was well defined, weighting 46 g, in a female 120.5 cm TL. Vitellogenic oocytes were observed at sizes over 120.5 cm TL.

Pregnant females were captured during March, October and June, between 13.5 and 16 m depth. The largest one (120.5 cm TL) had uterine eggs with a mean diameter 4.37 cm. Another specimen 115 cm TL had 6 embryos (3 males and 3 females) in the left uterus, the largest 15 cm TL; and 5 embryos (3 males, 2 females) in the right one, the largest 17 cm TL. Largest embryos were seen in a female 119 cm TL with 5 embryos in the left uterus (3 males, 2 females), the largest measuring 23 cm TL, and 4 in the right uterus.

*Sphyrna lewini*. In the Atlantic coast of South America *S. lewini* occurs from Colombia to Uruguay (Compagno, 1984; Menni, 1976, 1981). Stride *et al.* (1992) and Lucena *et al.* (1993) found off Maranhão low captures composed mainly by immature specimens.

Fifty three males (47 to 173 cm TL) and 48 females (45 to 149 cm TL) were captured in 24

samples. A high degree of sexual segregation was observed, 66.7% of the samples being composed by one sex only. This is more than twice the values observed for *Squalus acanthias* and *Schroederichthys bivius* in the South Atlantic (Menni *et al.*, 1979; Menni, 1985, 1986). Klimley (1987) suggested that one of the causes of segregation in *S. lewini* would be feeding differences between sexes.

No differences were observed in the length-weight relationship between males and females.

Captures were composed mainly by juvenile specimens. Recent born specimens, juveniles of both sexes and mature males were observed, but no mature females. A 50.5% of the capture was composed by specimens between 45 and 58 cm. Two males and 3 females showed umbilical scars. The smaller examined specimen was a female 45 cm TL. This size is somewhat smaller than the minimum reported by Stevens and Lyle (1989). Clarke (1971) reported embryos from 42.9 to 56.2 cm TL. Our specimens from 47.6 to 55.6 with umbilical scars, agree with Clarke (1971) and Bass *et al.* (1975) statement that size at birth is around 40–50 cm TL.

Twenty seven of 30 male specimens showed uncalcified claspers. The clasper length shows a little increase up to 135 cm TL, the increasing rate being higher from this size up. Meandered epididymides were noted from 151 cm TL. Presence of liquid in the seminal vesicle was observed over 93 cm TL. Mature males measuring 94, 150 and 173 cm TL made a mere 2.8% of the capture. The largest immature male measured 155 cm TL. Sizes of male first maturity provided by Bass *et al.* (1975) and Stevens and Lyle (1989) are 145 to 165 cm TL and 140 to 160 cm TL respectively. So, it seems that the first maturity size of males at Maranhão is smaller than in other areas.

From 48 examined females, 46 have ovaries without noticeable oocytes. A female measuring 89 cm TL showed a granular ovary. First evi-

Table 7 *C. acronotus*. Features of embryos.

| Left uterus  |                             |                   |                     |
|--------------|-----------------------------|-------------------|---------------------|
| Sex          | Weight without vitellus (g) | Total length (mm) | Clasper length (cm) |
| F            | 155.24                      | 300               | –                   |
| F            | 258.35                      | 300               | –                   |
| F            | 167.54                      | 310               | –                   |
| M            | 155.72                      | 300               | 0.5                 |
| M            | 166.85                      | 310               | 0.6                 |
| Right uterus |                             |                   |                     |
| Sex          | Weight without vitellus (g) | Total length (mm) | Clasper length (cm) |
| F            | 144.73                      | 290               | –                   |
| F            | 150.00                      | 290               | –                   |
| M            | 142.39                      | 290               | 0.5                 |
| M            | 160.18                      | 310               | 0.5                 |

dence of ovary development appears at 149 cm TL, with no vitellogenic oocytes. Stride *et al.* (1992) examined *S. lewini* off the coast of Maranhão, finding gravid females from 140 cm TL on. This is a considerable smaller size than those reported by Compagno (1984) (212 cm TL) and Branstetter (1987) (250 cm TL). Also litter sizes were smaller at Maranhão, with 5 and 6 embryos against 15 to 31 observed by Compagno (1984).

*Carcharhinus acronotus* is in the 10th place in abundance order in Maranhão, and its occurrence in the area is irregular, with an evenly distribution between the rainy and dry season. Sexual segregation is high, with samples with one sex only reaching 71.4%, though the number of samples is relatively low ( $N = 15$  stations). Schwartz (1984) stated that the catch in North Carolina (where differing from Maranhão, *C. acronotus* is captured with longline) varied among years and was probably affected by seasonal water temperature and salinity variations.

Six males were examined, with sizes between 78 and 99.2 cm ( $W = 1,920$  to  $5,300$  g). Only the

smallest male had well calcified claspers measuring 6 cm. Clasper length in the largest specimen was 6.1 cm, but the organ was still uncalcified. Specimens of intermediate size show clasper lengths from 3.0 to 3.5 cm.

Testes measured 1.5–1.6 cm width in the adult specimen, and 1.8 width x 9 cm length in an 84 cm TL ( $W = 3,260$  g) specimen. In other ones the width of the testes were about 0.5 cm. The epididymides width range between 0.5–0.6 and 1.7–1.8. Presence of liquid within the seminal vesicle was observed at 82.7 cm TL ( $W = 3,300$  g) with the maximum epididymis width (no clasper data). Total testes weight in the largest male (immature) was 30.3 g.

Liver weights range from 52.1 (the adult male) to 215 g. Nine females were examined from 82 to 170 cm TL ( $\bar{x} = 103$  cm), with weights from 2,800 to 5,400 g. Though the smallest specimen has an undifferentiated ovary, the following one in weight ( $W = 5,200$  g) was considered in a maturing state because of the beginning of uterus development and the presence of vitellogenic oocytes. These appear again at



170 cm TL, but both less and more developed stages were observed at intermediate sizes.

Nidamental gland widths 0.9–1.0 cm were first observed at 97 cm TL (3,000 g), progressively increasing to 2.0–2.1 cm in larger females. Ovary weights ranged between 7.8 g at 100 cm TL (W= 5,200) to 24.55 g at 170 cm TL (W= 5,400).

One female 110 cm TL (W= 7,700 g) was pregnant. Ovaries weighed 18.63 and 4.86 g, and nidamental glands measured 0.9–1.0 cm width these being haemorrhagic. Five embryos were found in the left uterus and 4 in the right (table 7).

Liver weights in females ranged from 73 to 271 g.

The *Carcharhinus acronotus* population in Maranhão includes several reproductive stages. Most males were immature but females comprised pregnant stages, suggesting, in spite of low captures, that the area is important for the early life of the species.

Samples included a female (78 cm TL) of size near that of the smallest free living known (71.5 cm TL, Schwartz, 1984). The largest male obtained at Maranhão was smaller than that reported by Schwartz from North Carolina, but the largest female (170 cm TL) exceeded that observed there (154 cm TL). These sizes agree with the range provided by Bigelow and Schroeder (1948). Both male and female seem to mature at smaller sizes in Maranhão. Male maturity was observed at 78 cm TL, against 110 cm TL in North Carolina, and a pregnant female recorded with 110 cm TL against 120.

Dental formulae values (N= 11) are coincident with those reported by Schwartz (1984). Upper jaws always counted 12–1–12, and lower mostly 11–1–11, but 12–1–11, 11–2–11, 10–1–11, and 16–1–11 also appear.

***Carcharhinus limbatus*.** This species is considered uncommon in north and northeastern Brazil (Bezerra *et al.*, 1990). Barletta and Correa (1989)

reported a join capture (about a ton) of this species and *C. brevipinna* from Paranaguá. In Cabo Maguari, at the mouth of Marajó bay, *C. limbatus* is captured with gillnets during summer, specimens ranged from 60 to 180 cm TL, and newborn specimens were observed (Barthem, 1985).

A small sample of 4 males and 5 females of this species was obtained from 9 stations. The two smallest males, 60 and 64.5 TL (W= 1,400 g each) still showed umbilical scars, therefore they were probably born in the area. A third specimen 65 cm TL (W= 1,600 g), with uncalcified clasper, showed some testicular development, testes weights being 5.0–6.0 g. Epididymides widths ranged from 0.3–0.4 to 0.4–0.5 cm. The largest male, 155 cm TL (W= 20,910 g) was mature, with a well calcified clasper measuring 15.5 cm, seminal vesicle full and epididymides 2.6–2.9 cm width.

Liver weights range from 50 to 1,250 g.

Five females were examined. A 64 cm TL specimen (W= 1,800 g) still showed umbilical scars. From this size to 95 cm TL (W= 5,320 g) nidamental glands measured from 0.5–0.6 to 0.7–0.8 cm, and the ovaries were undifferentiated in two specimens, and weighted 2.5 g in the other (including the epigonal organ). An specimen 114.2 cm TL (W= 9,100 g) shows an ovary (right one) weighing 15 g (without epigonal organ) without noticeable oocytes and with filiform uteri. The largest female, 179 cm TL (W= 40,000 g), has an ovary 25 g weight (without epigonal organ), with 15 small oocytes and 4 vitellogenic ones, 1.0 cm diameter. Uterus width was 3.2 cm.

Liver weight in females ranged from 169 to 2,100 g.

Males and females occur together in the same sample only once (11%), but total number was similar for both sexes.

Because of the presence of incipient maturing specimens and juveniles with umbilical scars, it is evident that reproductive activities are per-

formed by *C. limbatus* in the Maranhão area. Moreover, captures with gillnets with larger mesh (Stride *et al.*, 1992) provided 55 specimens (in 18 months) with a 163.9 cm mean TL. Full mature males measured over 152 cm TL as in our own data. Females up to 152 cm were immature, and one 200 cm TL was pregnant with 9 embryos.

***Carcharhinus obscurus*** has been reported from Maranhão by Lessa (1986) and from Rio Grande do Sul by Carneiro and Vooren (1986). An specimen 149 cm TL (W= 16,000 g) was captured on November 1986. It was a juvenile, with uncalcified claspers and epididymides 0.5–0.9 cm width. The liver weight was 980 g, and the stomach was empty.

***Carcharhinus perezii*.** The presence of *C. perezii* from Guiana to Rio de Janeiro was considered uncertain by Compagno (1984). Lessa (1986) reported it for Maranhão. The specimen reported here (which is the same referred by Lessa), captured on August 1986, was a juvenile measuring 94.5 cm TL (W= 4,500 g). The length of the uncalcified clasper was 3.1 cm, and the epididymides width was 1.4–1.5 cm. It had no content in the seminal vesicle. The liver weighted 495 g, and the stomach was empty. Gadig *et al.* (1989) report four males and four females captured between 35 and 50 m depth, over a hard calcareous algae bottom. One of the females, captured in November at the end of the amazonic summer, was pregnant, with 4 embryos (1 male, 3 females) measuring between 68.5 and 74.4 cm.

### Reproductive traits of the batoid fauna

The batoid fauna in the area of Maranhão is composed by nine species, namely *Rhinobatos lentiginosus*, *Pristis perotteti*, *Dasyatis geijkesi*, *D. guttata*, *Gymnura micrura*, *Aetobatus narinari*, *Rhinoptera bonasus*, *Narcine brasiliensis* and

*Mobula hypostoma*. For *R. lentiginosus*, *P. perotteti*, *N. brasiliensis* and *M. hypostoma* we have only the record of presence, with size data only for the first.

***Dasyatis guttata*** is found from the Gulf of Mexico and the Western Indies to southern Brazil (Cervigón, 1966). It was reported from the state of Paraná in estuarine and coastal waters (Barletta and Correa, 1989) and off Ubatuba, São Paulo (south of Rio de Janeiro) (Cunningham, 1989). It is a common species at the Bahia de todos los Santos (13° S), where a strong carnivorous habit has been demonstrated (Queiroz *et al.*, 1993).

According to Barthem (1985) it is captured with gillnets at Cabo de Maguari, off the Marajó Bay, during summer (June to December), specimens measuring about 26 cm (TL). Lessa and Araujo (1984) reported *D. guttata* as a dominant species for the Araoca and Cumá bays, within the studied area, where they found immature individuals from 50 to 53 cm DL. Paixao (1984) reported it from the Estreito dos Coqueiros and Rio dos Cachorros, at the São Luis island, also in Maranhão. The statement by Bigelow and Schroeder (1953) that *D. guttata* is to be expected anywhere in suitable localities from Rio de Janeiro to the Caribbean, is then to some extent confirmed.

We obtained *D. guttata* in 9 samples. In two of them (Sts. 22 and 34) females occurred alone, sexual segregation being low (22,22%).

Males (N= 29) were observed from 28 to 60.1 cm DW, weighing from 600 to 5,800 g. Males mature about 51.5 cm DW (W= 3,400 g), though slightly larger specimens were still immature. Three specimens over that size were mature.

Fifteen females (out of 17 measured) between 25 to 75 cm DW were examined, with weights from 420 to 23,130 g. Only the left ovary was functional.

Four (out of 15) females were in the beginning

of maturity (with a few vitellogenic oocytes and empty uterus) during the period between December and March (rainy season). No evidence of parturition was observed and the smallest specimens examined were larger than those reported by Bigelow and Schroeder (1953) with yolk sac.

*D. guttata* occurs in Maranhão from December to March and during September and October, being more abundant during the first period, coincident with the rainy season.

**Rhinoptera bonasus.** Bigelow and Schroeder (1953) state that there are two more or less distinct centers of population of *R. bonasus*; one in United States' waters in the Northern Hemisphere, and the other along the middle Brazil coast in the Southern Hemisphere. In spite of this, there are not so many records as expected. Captures of *R. bonasus* appear uncommon. It is not reported in comprehensive papers about Southern Brazil (Goes de Araujo and Vooren, 1986; Cunningham *et al.*, 1991). Barletta and Correa (1989) reported it for the Paranaguá bay area, where the species accounts for the 8.3% in weight among the chondrichthyans.

The species has been reported for the Maranhão area by Lessa (1986) and Garrido Martins-Juras (1987).

Our captures at Maranhão were made mainly during the rainy season, during December 1984 (3 samples) and January 1985. Larger specimens were observed from December 1984 to March 1985, two mature males being obtained in these samples. Males captured in early December 1984 and July 1986 were intermediate in weight, and the smallest ones were from August 1985, including an specimen 34 cm DW which appears to be the smallest free living known.

Males were clearly mature at 89.2 cm DW, with well developed and calcified claspers, seminal vesicles plenty and testicles weighting over 90 g in all.

A female specimen somewhat larger than that with embryos reported by Bigelow and Schroeder (1953) shows developing eggs in ovary and the usually called *corpora lutea* (but see Dodd and Dodd, 1985), indicating previous ovulation.

A considerable degree of sexual segregation was observed, with only one joint capture over seven (14.3%). Males were more common than females (5:1).

**Aetobatus narinari.** This species, a visitor in Maranhão, was reported from this locality by Lessa (1986) and for the Pernambuco state coast by Guedes *et al.* (1989). It was captured in 7 stations evenly distributed between the two climatic seasons. In all cases males and females were separated.

Six males were examined measuring between 110 and > 153 cm TL, 40.6 to 102 cm DW and weighting from 1,000 to 13,100 g. Claspers measured from 1.6 to 4.2 cm, all specimens being immature. Epididymides width range from 0.9–1.0 to 1.9–2.0. Liver weights were between 80 to 350 g.

Only size data were available for females, ranging from < 75 to 163 cm TL, 44 to 103 cm DW and with weights from 1,000 to 13,120.

It is interesting to note that Bigelow and Schroeder (1953) stated that no definite information was available on the numerical abundance of this species anywhere along the South American coast, but that it should be very abundant in Brazilian waters, to judge from the many specimens collected around Rio de Janeiro. This opinion is probably true, since we have also seen specimens from Cananeia (São Paulo) and Recife (Pernambuco).

**Dasyatis geijkesi.** This species was described by Boesman (1948) from Surinam (ex Dutch Guiana). The type was a juvenil male 360 mm DL. Bigelow and Schroeder (1953) quoted Boesman data.

The species is known also from the Maranhão state (Lessa, 1986; Garrido Martins-Juras *et al.*, 1987) and was listed by Roux (1979). Captures were made with igarapé nets (a type of gillnet) and longline, but capture of the species was not specifically related to any of these.

Cervigón (1966) provides measurements of two specimens 291 and 356 mm DW, from the Venezuelan Guyanas, but states that the largest specimen observed reached 1 m DW. According to this author, the species is very abundant between 3 to 10 fathoms off the Orinoco river mouth.

*D. geijkesi* was captured in only 4 stations from 37 during 1984 and 1985, and was not obtained in 12 samples during 1986 and 1988. Only one male, 58 cm DW was obtained, rather larger than the type (34 cm DW). It was an adult 219 cm TL and 4,200 g W. It had well calcified claspers and gonad measuring 4.2 x 0.8 cm. The liver weighted 60 g.

Three females were examined, measuring 50, 77 and 98 cm DW, weighting 2,600; 15,320 and 14,100 g respectively. The second specimen had an undifferentiated ovary and nidamental glands measuring 2.4–2.5 cm. The liver weight was 152 g. The largest female was in the beginning of maturity, with 2 vitellogenic oocytes 2.0 cm diameter, and 8 white ones. Width of nidamental glands were 1.8 and 2 cm. Liver weights 136 g.

**Gymnura micrura** was reported from Maranhão by Lessa (1986), Garrido Martins-Juras *et al.* (1987), and Paixao (1984, Coqueiros strait and Cachorros river). Only three female specimens, weighting 200, 900 and 1,200 g were collected. The largest one has nidamental glands 1.5–1.6 cm width. The ovary plus the glands weighted 25 g. The ovary showed vitellogenic oocytes, two 1 cm in diameter and 15 smaller ones. The liver weight was 20.3 g.

**Rhinobatos lentiginosus.** Only one male of this species was captured in the station 35 (October

1985). It measured 55.8 cm TL with a 510 g weight. The uncalcified clasper measured 8.6 cm. *R. lentiginosus* appears to have not been reported before from Maranhão.

### General reproductive traits

Table 8 shows synoptic biological data for the chondrichthyan species of Maranhão. Species are ordered as in the phenogram based in the Jaccard index (fig. 2). No data were available for *S. mokarran*, so 18 species were considered. Eight species (44.4%) have pregnant females in Maranhão in some moment of the year. Five of the six core species plus *I. oxyrhynchus* were observed in this stage, i.e., an 85.7% of the most important assemblage at Maranhão spend some part or all the pregnancy within the area. The single exception was *R. porosus*, in wich sexual segregation possibly related to oceanographic conditions precludes the presence of females.

Two (40.0%) of the species in the common II species group were also found in this stage, namely *C. limbatus* and *C. acronotus*, both being sharks, and the exceptions all batoids. None species of the rare species group was pregnant.

Data on embryo sizes were available for six species. For the three wich, as far as known, perform all their cycle or most of it in the area (namely *S. tiburo*, *S. tudes* and *I. oxyrhynchus*), embryo sizes have a wide range, from 5 to 31, 8 to 24 and 2.8 to 28 (37) cm respectively. The other species have had only relatively advanced embryos.

Mature males of 12 species were observed. All core species have mature males in the area, though they were scarce in *S. lewini*. An 80% of the common II species have also mature males, though in low numbers. *A. narinari* has not mature males. The opposite situation is displayed by the rare species (N= 5, no data available for *C. plumbeus*), with only one species, *D. geijkesi*, with mature males; the 80% lacking it. Besides, the degree of sexual segregation was 100% in

**Table 8** Synoptic biological features of Maranhão chondrichthyans. Species ordered as in figure 2.

| Species                | Abundance rank | Pregnant stage | Embryos size range (cm) | Mature males | Sexual segregation (%) | Spec. with umbil. scars |
|------------------------|----------------|----------------|-------------------------|--------------|------------------------|-------------------------|
| <i>C. acronotus</i>    | 10             | yes            | 29 - 31                 | yes          | 71.4                   | no                      |
| <i>A. narinari</i>     | 12             | no             | —                       | no           | 100.0                  | no                      |
| <i>C. limbatus</i>     | 13             | yes            | no data                 | yes          | 89.0                   | yes                     |
| <i>D. guttata</i>      | 7              | no             | —                       | yes          | 22.0                   | no                      |
| <i>R. bonasus</i>      | 11             | no             | —                       | yes          | 85.7                   | no                      |
| <i>C. porosus</i>      | 1              | yes            | 23 - 32.5               | yes          | 19.5                   | yes                     |
| <i>S. tiburo</i>       | 2              | yes            | 5 - 31.0                | yes          | 48.4                   | yes                     |
| <i>S. lewini</i>       | 5              | yes            | no data                 | yes          | 66.7                   | yes                     |
| <i>R. lalandei</i>     | 4              | yes            | - 27.0                  | yes          | 60.0                   | no                      |
| <i>R. porosus</i>      | 3              | no             | —                       | yes          | 78.9                   | no                      |
| <i>S. tudes</i>        | 8              | yes            | 8 - 34.0                | yes          | 52.9                   | yes                     |
| <i>I. oxyrinchus</i>   | 6              | yes            | 2.8 - 28 (37)           | yes          | 58.8                   | no                      |
| <i>D. geijkesi</i>     | 14             | no             | —                       | yes          | 100.0                  | no                      |
| <i>G. micrura</i>      | 15             | no             | —                       | no           | 100.0                  | no                      |
| <i>R. lentiginosus</i> | 19             | no             | —                       | no           | 100.0                  | no                      |
| <i>C. perezi</i>       | 17             | no             | —                       | no           | 100.0                  | no                      |
| <i>C. plumbeus</i>     | 18             | no             | —                       | no           | 100.0                  | no                      |
| <i>C. obscurus</i>     | 16             | no             | —                       | no           | 100.0                  | no                      |

this case. In the common II group segregation range from 22% in *D. guttata* to 100% in *A. narinari* (no males). Core species show intermediate degrees of sexual segregation, from 19.5% (*C. porosus*) to 78% (*R. porosus*), with a mean of 55%.

Newborn specimens were recorded for 4 species of the core group (67%), 20% in the common II group and none in rare species.

The biological results show a pattern which closely agrees with the structure of the chondrichthyan community of Maranhão as described by Lessa and Menni (1994), from the analysis of co-presences and abundance. A 38.8% of the species occurring at Maranhão perform all or an important part of their life cycle

within the area, as evidenced by its abundance, presence of pregnant females and of adult males, and a low degree of sexual segregation. A 27.7% of the species, apparently perform reproductive activities in the area, but specimens are not abundant, newborn specimens were observed in only one case and sexual segregation was high. Rare species were not represented by mature specimens of any sex (one exception) and sexual segregation is absolute.

According to Lessa (1986), the studied localities are an important growing area for sharks in the central tropical Atlantic, deserving protection and care. This statement is strongly supported by Lessa and Menni and by the present research.

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### References

- BARILETTA M. & M. F. M. CORREA, 1989. Chondrofauna da complexo estuarino da Baía de Paranaguá e adyacências, PR—Brasil. Levantamento e produtividade pesqueira. Res. IV Reunião Grupo Trabalho Tub. Arraias, Tamandaré, Pernambuco, p. 24.
- BARTHEM R. B., 1985. Ocorrência, distribuição e biologia dos peixes da Baía da Marajó, estuário amazônico.— Bol. Mus. Par. E. Goeldi, Zool. 2 (1): 50-68.
- BASS A. J.; J. D. D'AUBREY & N. KISTNASAMY, 1975. Sharks of the east coast of southern Africa. III. The families Carcharhinidae (excluding *Mustelus* and *Carcharhinus*) and Sphyrnidae.— Oceanogr. Res. Inst. (Durban), Invest. Rep. N° 38, 100 pp.
- BEZERRA M. A.; M. A. A. FURTADO NETO & O. B. F. GADIG, 1990. Nota sobre algunos tubarões da costa norte e nordeste de Brasil.— An. Soc. Nordest. Zool. 3: 301-314.
- BIGELOW H. B. & W. C. SCHROEDER, 1948. Cyclostomes, sharks.— In: Fishes of the Western North Atlantic. Sears Found. Mar. Res. 1 (1): I-XVII, 59-576.
- —, 1953. Sawfishes, guitarfishes, skates, rays, chimaeroids.— Fishes of the Western North Atlantic. Sears Found. Mar. Res. 1 (2): 1-588.
- BOESEMAN M., 1948. Some preliminary notes on Surinam sting rays, including the description of a new species.— Zoöl. Meded. 30 (2): 31-47.
- BRANSTETTER S., 1987. Age, growth and reproductive biology of the silky shark *Carcharhinus falciformis* and the scalloped hammerhead *Sphyrna lewini* from the northwestern Gulf of Mexico.— Environmental Biol. Fish. 19: 161-73.
- CARNEIRO M. H. & V. M. VOOREN, 1986. Identificação da pesca industrial em Rio Grande. RS. Res. II Reunião Grupo Trabalho Tub. arraias, Univ. Fed. Maranhão, São Luis, Maranhão (pages not numbered).
- CERVIGNON F., 1966. Los peces marinos de Venezuela.— Monog. N° 11, Fund. La Salle, Venezuela 1: 1-436.
- CLARKE T. A. The ecology of the scalloped hammerhead shark, *Sphyrna lewini*, in Hawaii, 1971.— Pacific Sci. 25: 133-145.
- COMPAGNO L. J. V., 1978. Sharks.— In: W. Fisher (ed.), FAO species identification sheets for fishery purposes. Western Central Atlantic, vol. 5.
- —, 1984. FAO species catalogue. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes.— FAO Fish. Synop., 125, Vol. 4, Pt. 2: 251-655.
- CUNNINGHAM P. T. M., 1989. Variações espaço temporais de cações e raias em Ubatuba. SP. IV Reunião Grupo Trabalho Tub. Arraias, Tamandaré, PE, p. 35.
- CUNNINGHAM P. T. M.; A. C. Saul; M. R. G. Cohen & M. A. L. Maciel, 1991. Observações sobre a comunidade de chondrichthyes em regiões costeiras de Ubatuba (SP). Resumos V Reunião Grupo de Trabalho Tub. Arraias, Instituto de Pesca, Santos, SP, pp. 10.
- DODD J. M. & M. H. I. DODD, 1985. Evolutionary aspects of reproduction in cyclostomes and cartilaginous fishes. Pp. 295-319. In: Foreman R. E.; A. Gorbman; J. M. Dodd & R. Olsson (eds.), Evolutionary biology of primitive fishes. Plenum Press, N.Y., London and NATO Scient. Aff. Div. Plenum Press, N.Y.
- FERREIRA B. P. & R. DA SILVA SANTOS, 1984. Algunas consideraciones sobre o ciclo de vida de *Rizoprionodon porosus* (Poey, 1861) e *R. lalandii* (Valenciennes, 1841) (Selachii, Carcharhinidae) da região de barra de Guaratiba, RJ. Res. Congr. Bras. Zool., Belem, Pará, p. 258.
- GADIG O. B. F.; M. A. A. FURTADO NETO AND M. A. BEZERRA, 1989. Informações sobre *Carcharhinus perezi* (Carcharhiniformes, Carcharhinidae) no Norte e Nordeste do Brasil. Res. IV Reunião do Grupo de Trabalho, Tamandaré, Pernambuco, p. 19.
- GARRIDO MARTINS—JURAS L. A.; A. A. JURAS & N. A. MENEZES, 1987. Relação preliminar dos peixes da Ilha de São Luis, Maranhão, Brasil.— Revta. bras. Zool., S. Paulo 4 (2): 105-113.
- GOES DE ARAUJO M. L. & C. M. VOOREN, 1986. Composição da pesca demersal de cações e arraias em Rio Grande—RS. Resumos II Reunião Grupo de Trabalho Tub. Arraias, Univ. Fed. Maranhão, São Luis, Maranhão.
- GUEDES D. S.; J. KOIKE; A. L. VASCONCELLOS FILIO &

- J. S. SILVA, 1989. Levantamento da ictiofauna de Pernambuco e estados vizinhos. Res. IV Reunião Grupo Trabalho Tub. Arraias, p. 13.
- GUILLE A., 1970. Bionomie benthique du plateau continental de la cote catalane française.- Vie et Milieu **21** (1B): 137-280.
- KETCHEN K. S., 1972. Size at maturity, fecundity and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters.- J. Fish. Res. Canada **29**: 1.717-1.723.
- KLIMLEY A. P., 1987. The determinants of sexual segregation in the scalloped hammerhead shark *Sphyrna lewini*.- Environmental Biol. Fish. **18** (1): 27-40.
- LESSA R. P., 1986. Levantamento faunístico dos elasmobrânquios (Pisces, Chondrichthyes) do litoral ocidental do estado do Maranhão, Brasil.- Bol. Lab. Hidrobiol. **7**: 27-41.
- —, 1987a. Contribuição ao conhecimento da biologia de *Carcharhinus porosus* Ranzani, 1839 (Pisces, Chondrichthyes) das recêntricas maranhenses.- Acta Amazonica **16/17**: 73-86.
- —, 1987b. Aspectos da biologia do cacoa quati, *Isogomphodon oxyrinchus* (Mueller & Henle, 1839) (Chondrichthyes, Carcharhinidae) das recêntricas maranhenses.- Bol. Ciênc. Mar. **44**: 1-18.
- —, 1988. Premières observations sur la biologie reproductive de *Rhizopriondon lalandii* (Valenciennes, 1839) (Pisces, Carcharhinidae) de la côte nord du Brésil, Maranhão.- Rev. Bras. Biol. **48**: 721-730.
- LESSA R. P. & J. B. ARAUJO, 1984. Sobre os elasmobrânquios da baía de Cumé e Araóca, Maranhão.- Res. XI Congr. Bras. Zool., Belem, Pará, p. 185.
- LESSA R. P. & R. C. MENNI, 1994. The chondrichthyan community off Maranhão (Northeastern Brazil).- An. Fourth Indopacific Fish Conference, Thailand. Pp. 138-172.
- LESSA R. P. & T. C. SILVA, 1992. Fecundação e ciclo reprodutivo do cação martelo *Sphyrna tiburo* (Linnaeus, 1758) do Norte do Brasil.- Rev. Bras. Biol. **52** (4): 533-545.
- LOWE MCCONNELL R. H., 1962. The fishes of the British Guiana continental shelf, Atlantic coast of South America, with notes on their natural history. J. Linn. Soc. London **44** (301): 669-700.
- LUCENA F. M.; R. C. MENNI & R. P. LESSA, 1993. Biologia do tubarão *Sphyrna lewini* no nordeste do Brasil, Maranhão.- Res. VIII Congr. Bras. engenh. pesca. Sec. Ind. Com. Tec. Med. Amb., Sergipe, p. 27.
- MENNI R. C., 1976. Presencia de *Sphyrna lewini* (Griffith & Smith, 1834) en el Uruguay (Chondrichthyes, Sphyrnidae).- Studies Neotrop. fauna environm. **11** (4): 199-203.
- —, 1981. Sobre la distribución de los peces marinos de la Argentina.- In: Symposia, VI Jorn. Arg. Zool., pp. 57-73.
- —, 1985. Distribución y biología de *Squalus acanthias*, *Mustelus schmitti* y *Galeorhinus vitamicus* en el Mar Argentino en agosto-setiembre de 1978 (Chondrichthyes).- Rev. Mus. La Plata (NS), Zool. **13**: (138): 151-207.
- —, 1986. Shark biology in Argentina: a review.- Pp. 426-436. In: T. Uyeno *et al.* (eds.), Indo-pacific fish biology. Ichth. Soc. Japan, Tokyo.
- MENNI R. C. & A. E. GOSZTONYI, 1982. Benthic and semidemersal fish associations in the Argentine Sea.- Studies neotrop. fauna and environm. **17**: 1-29.
- MENNI R. C.; A. E. GOSZTONYI & H. L. LÓPEZ, 1979. Sobre la ecología y biología de *Halaelurus bivius* (Chondrichthyes, Scyliorhinidae).- Rev. Mus. Arg. Cienc. Nat., Ecol. **2**: (3): 71-88.
- MENNI R. C. & H. L. LÓPEZ, 1984. Distributional patterns of Argentine marine fishes.- Physis, A, **42** (103): 71-85.
- MUÑOZ CHAPULI R., 1985a. Análisis de las capturas de escualos pelágicos en el Atlántico nororiental (15° - 40° N).- Inv. Pesq. **49** (1): 67-79.
- —, 1985b. Análisis de las capturas de escualos demersales en el Atlántico NE (27° N - 37° N) y mar de Alborán (Mediterráneo occidental).- Inv. Pesq. **49** (1): 121-136.
- PAIXAO I. M. P., 1984. Contribuição ao conhecimento da ictiofauna do estreito dos Coqueiros e Rio dos Cachorros, Área de implantação do consórcio Alumiar, Ilha de São Luis, MA, Brasil.- Res. XI Congr. Bras. Zool., Belem, pp. 183-184.
- PALMA J. C., 1979. Geomorfologia da plataforma continental norte brasileira.- Pp. 25-51. In: Projeto RE-MAC, Geomorfologia da margem continental brasileira e das áreas oceânicas adjacentes. PETROBRAS/CEN-PES/DINTEP, Rio de Janeiro.
- QUEIROZ E. L.; J. J. SOUZA FILHO & F. M. SIMOES, 1993. Estudo da alimentação de *Dasyatis guttata* (Bloch & Schneider, 1801), na área de influência da estação ecológica Ilha do Medo, Bahia, Brasil.- Res. VI Reunión do Grupo de Trabalho, Inst. Pesca UFRP, Recife, Brasil.
- ROUX Ch., 1979. Poissons chondrichthyens du plateau continental brésilien et du Rio de la Plata.- Résultats scient. campag. *Calypso*, Fasc. XI, **30**: 111-130.
- SADOWSKY V., 1967. Selachier aus dem littoral von São Paulo, Brasilien. Beitr. Neotrop. fauna **5**: 71-88.
- SCHWARTZ F. J., 1984. Occurrence, abundance, and biology of the blacknose shark, *Carcharhinus acronotus*, in North Carolina.- Northeast Gulf Science **7** (1): 29-47.
- SILVA T. C. & R. P. LESSA, 1991. Sexual development of the bonnethead shark *Sphyrna tiburo* (Linnaeus, 1758) in northern Brazil (Maranhão).- Rev. Bras. Biol. **51** (4): 747-754.
- STEVENS J. D. & J. M. LYLE. Biology of three hammerhead sharks (*Eusphyrna blochii*, *Sphyrna mokarran* and *S. lewini*) from northern Australia, 1989.- Australian J. Mar. Freshwater Res. **40** (2): 1-15.
- STRIDE R. K., 1992. Diagnóstico da pesca artesanal marinha do estado do Maranhão.- CORSUP/EDUFMA, São Luis, Brasil, 205 pp.
- STRIDE R. K.; V. DA SILVA BATISTA & L. A. B. RAPOSO, 1992. Pesca experimental de tubarão com redes de emalhar no litoral maranhense.- Publ. Projeto Pesca Artesanal, Univ. Fed. Maranhão, vol. **3**: 1-160.
- SUDEPE, 1976. Prospecção dos recursos pesqueiros das recêntricas maranhenses.- Natal, 124 pp.