

Near-term embryos in a *Pristis pristis* (Elasmobranchii: Pristidae) from Brazil

J. L. S. NUNES*†, G. RINCON‡, N. M. PIORSKI§|| AND A. P. B. MARTINS||

*Universidade Federal do Maranhão - UFMA, Departamento de Oceanografia e Limnologia, Av. dos Portugueses, s/n, Campus do Bacanga, São Luís, Maranhão, CEP 65080-040, Brazil,

‡Universidade Paulista – UNIP, Instituto de Ciências da Saúde, SGAS Quadra 913, s/n° Conjunto B, Asa Sul, Brasília - DF, CEP 70390-130, Brazil, §Universidade Federal do Maranhão - UFMA, Departamento de Biologia, Av. dos Portugueses, s/n, Campus do Bacanga, São Luís, Maranhão, CEP 65080-040, Brazil and ||Universidade Federal do Maranhão - UFMA, Programa de Pós-Graduação em Biodiversidade e Conservação, Av. dos Portugueses, s/n, Campus do Bacanga, São Luís, Maranhão, CEP 65080-040, Brazil

This paper describes the record of a gravid *Pristis pristis* from the north coast of Maranhão State (Brazil) in May of 2009 by an artisanal vessel. Size, mass and rostrum length of the adult female were estimated at 5000 mm, 75000 g and 1536 mm, respectively. Total length (L_T) of miscarried embryos ranged from 755 to 800 mm and total mass from 890 to 1120 g. Although this is a single record, it indicates that *P. pristis* births may be taking place during May or coming months and there may be population differences between Central and South America.

© 2016 The Fisheries Society of the British Isles

Key words: Batoidea; estuarine complex; largemouth sawfish; São Marcos Bay.

Sawfishes (family Pristidae) are distinct rays with an elongated rostrum margined by developed dermal denticles arranged in a saw shape (Compagno, 2005; Deynat, 2005; Last & Stevens, 2009; Faria *et al.*, 2013). These animals have a tropical and sub-tropical marine, euryhaline and freshwater distribution (Compagno & Cook, 1995; Faria, 2007; Simpfendorfer *et al.*, 2011). Due to its unique rostral structure, these rays become easily entangled in fishing nets and are often caught by artisanal fishermen (Simpfendorfer, 2000; Seitz & Poulakis, 2006; Morgan *et al.*, 2011). These animals are killed to provide food for the community as well as to supply the local saw trade and the oriental fin market (McDavitt & Charvet-Almeida, 2004; Robillard & Séret, 2006; Monte-Luna *et al.*, 2009). Pressure from fisheries and extensive habitat loss (NMFS, 2000) have led to species of the genus *Pristis* being declared as endangered or critically endangered by international and national institutions (Pogonoski *et al.*, 2002; Adams *et al.*, 2006; Carlson *et al.*, 2013b; Kyne *et al.*, 2013a, b; Simpfendorfer, 2013; MMA, 2014).

According to Compagno (2005), there are seven valid species of sawfishes. These species are commonly divided between *Anoxypristis cuspidata* (Latham 1794) and

†Author to whom correspondence should be addressed. Tel.: + 55 98 98117 0808; email: silvanunes@yahoo.com

two other groups: the largetooth group and the smalltooth group. The largetooth group included *Pristis microdon* Latham 1794, *Pristis perotteti* Müller & Henle 1841 and *Pristis pristis* (L. 1758); the smalltooth group included *Pristis clavata* Garman 1906, *Pristis pectinata* Latham 1794 and *Pristis zijsron* Bleeker 1851. Faria *et al.* (2013), however, found no significant morphological or genetic distinctions among museum specimens of the largetooth group and recognized these species as a single species, *P. pristis*, which is the senior synonym.

Based on the taxonomic classification proposed by Faria *et al.* (2013), two different sawfish species are reported for the Brazilian coast: *P. pristis* and *P. pectinata*. These two species have overlapping distribution in equatorial Brazil from the state of Amapá to the state of Maranhão (Lessa, 1986; Menni & Lessa, 1998; Lessa *et al.*, 1999a; Charvet-Almeida, 2002; Almeida *et al.*, 2006). Both have also been reported in the state of São Paulo (Figueiredo, 1977; Gadig, 1998; NMFS, 2009) and even in Argentina (Menni & Stehmann, 2000; McEachran & Carvalho, 2002; Charvet-Almeida *et al.*, 2011). There are also occasional reports of *P. pristis* in freshwater environments (Thorson, 1974), as occurred in the lower region of the Mearim catchment, Maranhão State (Soares, 2005).

The shallow waters off the coast of Maranhão are a known fishing ground for small to medium-sized elasmobranchs, such as *Rhizoprionodon porosus* (Poey 1861), *Carcharhinus porosus* (Ranzani 1839) and *Isogomphodon oxyrhynchus* (Müller & Henle 1839), as well as newborn sawfishes (Lessa, 1997; Lessa *et al.*, 1999a, b). These newborn animals are frequently sold as food in northern Brazil, as they can be consumed promptly by a regular-sized family, about four members, and need no refrigeration. In addition, rostrum and fins are removed and sold for high values, following the pattern observed in other parts of the world (McDavitt & Charvet-Almeida, 2004; Morgan *et al.*, 2011).

On the other hand, according to local artisanal fishermen, large sawfishes are rarely captured in Maranhão State, as well as along the northern coast of Brazil (Almeida, 1999). When landed intact, specimens are cut and sold quickly due to the fear of Brazilian environmental agents. Hence, researchers are rarely able to gather biological data (Almeida, 1999). Despite their scientific relevance to any biological study due to rarity and absence of data, few are analysed or even reported before their flesh and rostra are traded. Consequently, information on reproduction and fecundity is often lost. This paper describes the record of a pregnant *P. pristis* captured in shallow marine waters on the Amazonian equatorial coast of Brazil and reports reproductive aspects, such as fecundity, embryo size and developmental stage.

The present record is based on a gravid *P. pristis* captured in May of 2009 by an artisanal vessel near the city of Raposa, Maranhão State, north-eastern Brazil. The specimen was captured in a gillnet targeting teleosts of the families Ariidae and Sciaenidae. The estimated local depth was 20 m. Photographs and complete morphometric measurements of the gravid specimen were not taken due to the fishermen's hurry to process it before the flesh deteriorated and, mainly, to the fear of inspection teams. As a result of the immediate removal of the rostrum, total length (L_T) and total mass (M_T) were only estimated as 5000 mm and 750000 g, respectively. Using the relationship standard rostrum length in relation to L_T for *P. pristis* (Whitty *et al.*, 2014), the length of the rostrum was estimated at 1536 mm.



FIG. 1. Six embryos of *Pristis pristis* captured in Maranhão, Brazil.

Twenty near-term embryos had miscarried. Six were collected for morphometric and laboratory analysis at the Ichthyology Laboratory of the Department of Oceanography and Limnology of the Universidade Federal do Maranhão (Fig. 1) and the other specimens were sold as fish meat without their saws. The identification of embryos was confirmed later in the laboratory by the presence of the distinct ventral lobe of caudal fin and number of rostral teeth, which is a characteristic that develops prenatally (Thorson, 1973; Peverell, 2005; Thorburn *et al.*, 2007; Whitty *et al.*, 2014). This specific identification and the morphometric measurements followed Bigelow & Schroeder (1953) and Faria *et al.* (2013).

The embryos (three males and three females) ranged in M_T from 890 to 1120 g, and the L_T ranged from 755 to 800 mm, which corresponded to *c.* 15% of the maternal L_T (Table I). The prepectoral average length corresponded to 38% of L_T , while the prenatal length was 26.9–27.2% of L_T . All embryos analysed had a vestigial external vitellogenic vesicle (EVV) with diameters ranging between 80 and 100 mm. The EVV were measured and quickly removed from each individual due to putrefaction. Rostral teeth were covered by thin membranes and ranged from 16 to 19 pairs.

Specimens were apparently close to birth based on the dorsal pigmentation, the EVV and the L_T within the range suggested by Dulvy *et al.* (2014) of 600–900 mm L_T at birth (Fig. 2). The general dorsal colour was dark grey, fading slightly to the pectoral fins, but nearly absent from the dorsal and caudal fins, which were brownish. The rostrum

TABLE I. Morphometric measurements and mass of six embryos of *Pristis pristis* captured in Maranhão, Brazil

| ID number | 01 | 02 | 03 | 04 | 05 | 06 |
|---|-------|-------|-------|--------|--------|--------|
| Sex | Male | Male | Male | Female | Female | Female |
| Total mass (g) | 1.120 | 0.890 | 0.985 | 1.001 | 0.910 | 0.910 |
| Total length (mm) | 800.0 | 760.0 | 781.0 | 773.0 | 765.0 | 755.0 |
| Rostrum length (mm) | 186.2 | 171.2 | 176.2 | 173.5 | 171.4 | 168.0 |
| Furcal length (mm) | 730.0 | 705.0 | 705.0 | 713.0 | 705.0 | 685.0 |
| Upper labial fold (mm) | 5.9 | 5.6 | 6.0 | 5.0 | 7.0 | 7.0 |
| Mouth width (mm) | 23.0 | 23.0 | 20.0 | 21.0 | 21.0 | 20.0 |
| Mouth length (mm) | 41.0 | 46.0 | 51.0 | 47.0 | 46.0 | 46.0 |
| Distance between the orbits (mm) | 39.5 | 50.0 | 51.0 | 50.0 | 49.0 | 51.0 |
| Orbit diameter (mm) | 10.9 | 10.0 | 11.0 | 11.0 | 10.0 | 10.0 |
| Internal distance between the nostrils (mm) | 19.1 | 20.0 | 19.0 | 19.0 | 18.0 | 19.0 |
| Inter-nostril (mm) | 45.7 | 44.0 | 45.0 | 45.0 | 42.0 | 41.0 |
| Snout to nostrils (mm) | 220.0 | 210.0 | 208.0 | 213.0 | 202.0 | 204.0 |
| Snout to orbit (mm) | 230.0 | 218.0 | 218.0 | 222.0 | 220.0 | 215.0 |
| Snout to upper jaw (mm) | 255.0 | 244.0 | 243.0 | 245.0 | 240.0 | 243.0 |
| Snout to first gill slits (mm) | 325.0 | 318.0 | 310.0 | 316.0 | 311.0 | 291.0 |
| Snout to second gill slits (mm) | 332.3 | 325.0 | 322.0 | 322.0 | 318.0 | 306.0 |
| Snout to third gill slits (mm) | 339.3 | 330.0 | 327.0 | 328.0 | 323.0 | 312.0 |
| Snout to fourth gill slits (mm) | 347.9 | 335.0 | 332.0 | 332.0 | 329.0 | 318.0 |
| Snout to fifth gill slits (mm) | 353.8 | 340.0 | 338.0 | 338.0 | 334.0 | 323.0 |
| Snout to origin of pectoral fin (P1) | 310.0 | 300.0 | 300.0 | 305.0 | 293.0 | 295.0 |
| Snout to end of the base of pectoral fin (P1) | 390.0 | 387.0 | 380.0 | 388.0 | 385.0 | 375.0 |
| Snout to origin of pelvic fin (P2) | 490.0 | 468.0 | 470.0 | 470.0 | 470.0 | 455.0 |
| Snout to origin of first dorsal fin (D1) | 445.0 | 420.0 | 435.0 | 426.0 | 425.0 | 423.0 |
| Snout to origin of second dorsal fin (D2) | 585.0 | 590.0 | 565.0 | 575.0 | 555.0 | 553.0 |
| Snout to origin of caudal fin | 670.0 | 650.0 | 558.0 | 655.0 | 635.0 | 634.0 |
| D1 to D2 | 91.4 | 80.0 | 80.0 | 80.0 | 75.0 | 82.0 |
| Pectoral to pelvic fin | 69.6 | 92.0 | 93.0 | 94.0 | 77.0 | 80.0 |
| Second dorsal to caudal fin | 45.0 | 50.0 | 48.0 | 41.0 | 42.0 | 42.0 |
| Length of first gill slits | 147 | 130 | 120 | 120 | 120 | 120 |
| Length of third gill slits | 117 | 160 | 150 | 140 | 140 | 120 |
| Length of fifth gill slits | 98 | 100 | 110 | 110 | 110 | 110 |
| Width of the trunk in the pectoral-fin origins | 100 | 85 | 90 | 100 | 92 | 101 |
| Height of the trunk in the pectoral-fin origins | 39 | 32 | 31 | 30 | 35 | 32 |
| First to fifth gill slits | 26 | 23 | 29 | 25 | 27 | 27 |
| First dorsal fin | | | | | | |
| D1 base | 52.1 | 53.0 | 57.0 | 59.0 | 54.0 | 55.0 |
| Length of the posterior margin | 58.7 | 58.0 | 63.0 | 57.0 | 59.0 | 62.0 |
| Length of the anterior margin | 73.8 | 70.0 | 72.0 | 71.0 | 80.0 | 70.0 |
| Length of the internal margin | 23.2 | 22.0 | 22.0 | 22.0 | 23.0 | 22.0 |
| D1 height | 50.3 | 52.0 | 65.0 | 53.0 | 55.0 | 56.0 |
| Second dorsal fin | | | | | | |
| D1 base | 43.6 | 42.0 | 43.0 | 43.0 | 45.0 | 43.0 |
| Length of the posterior margin | 54.0 | 51.0 | 69.0 | 60.0 | 61.0 | 68.0 |
| Length of the anterior margin | 69.9 | 71.0 | 71.0 | 68.0 | 72.0 | 69.0 |
| Length of the internal margin | 20.5 | 23.0 | 24.0 | 23.0 | 23.0 | 23.0 |
| D2 height | 53.1 | 55.0 | 61.0 | 50.0 | 52.0 | 55.0 |
| Pectoral fin | | | | | | |
| P1 base | 92.2 | 90.0 | 90.0 | 94.0 | 90.0 | 78.0 |
| Length of the posterior margin | 119.0 | 102.0 | 107.0 | 108.0 | 109.0 | 106.0 |

TABLE I. Continued

| ID number | 01 | 02 | 03 | 04 | 05 | 06 |
|--------------------------------|-------|-------|-------|-------|-------|-------|
| Length of the anterior margin | 84.8 | 80.0 | 85.0 | 89.0 | 85.0 | 72.0 |
| Length of the internal margin | 39.5 | 40.0 | 29.0 | 34.0 | 36.0 | 40.0 |
| Pelvic fin | | | | | | |
| P2 base | 29.6 | 35.0 | 33.0 | 40.0 | 40.0 | 40.0 |
| Length of the posterior margin | 40.8 | 47.0 | 51.0 | 51.0 | 57.0 | 56.0 |
| Length of the anterior margin | 44.3 | 47.0 | 42.0 | 42.0 | 45.0 | 44.0 |
| Length of the internal margin | 35.1 | 35.0 | 32.0 | 36.0 | 32.0 | 38.0 |
| Claspers | 12.6 | 14.0 | 12.0 | – | – | – |
| Free margin of the clasper | 38.7 | 39.0 | 36.0 | – | – | – |
| Caudal fin | | | | | | |
| Dorsal caudal-fin lobe | 127.0 | 114.0 | 129.0 | 124.0 | 121.0 | 119.0 |
| Ventral caudal-fin lobe | 66.0 | 64.0 | 66.0 | 70.0 | 69.0 | 64.0 |

was dorsally brownish, with a greyish line extending from the tip to the base over the central cartilage. Ventrally, all embryos were cream to white, with no conspicuous pigmentation.

Although the embryos were near-term, they corresponded in size to full-term specimens found in Lake Nicaragua, where birth occurs when embryos reach between 730 and 800 mm L_T (Thorson, 1976; Thorburn *et al.*, 2007; Morgan *et al.*, 2011; Whitty



FIG. 2. Ventral view of a miscarried embryo of *Pristis pristis* captured by an artisanal vessel near the cities of Paço do Lumiar and Raposa on Maranhão Island, state of Maranhão, north-eastern Brazil.

et al., 2014). Thus, the present specimens were already at birth size and their mother was probably in the birth area when captured.

Local artisanal fishermen affirm that large specimens of *P. pristis* exceeding 5 m are rarely captured, but small specimens, including neonates, are often found in shallow warm waters, which gives support to the premise that the region may be used as a nursery. According to Simpfendorfer *et al.* (2008) and Norton *et al.* (2012), this may occur to avoid predators and maximize growth rates. This record also shows that birth may be taking place during May or the coming months. Thorson (1976) presumed parturition occurs especially during late October and early November in the Lake Nicaragua population of *P. pristis* (named *P. perotteti*), which may be evidence of population differences between Central and South America.

Despite being from only a single record, the information presented in this study is of great scientific importance due to the high degree of difficulty in obtaining details of critically endangered species for conservation needs (Thompson, 2004; Carlson *et al.*, 2013a). Thus, the aggregation of sporadic regional information could be an important, effective tool for the development of protective measures. Active protection of sawfishes is currently based on the extension of legislation regarding the reproduction patterns of some commercial teleosts. Despite the fact that the capture of *P. pectinata* and *P. pristis* is forbidden by Brazilian legislation (Charvet-Almeida & Faria, 2008; MMA, 2014), there is no specific programme to avoid incidental captures and eventual trade. To promote the protection of these species, it is imperative that birth and nursery areas are protected from fishing activity, as there is virtually no fishing gear that can avoid the incidental capture of sawfishes (McDavitt & Charvet-Almeida, 2004). In addition, artisanal landings should be closely monitored to evaluate the impact of this fishery segment on the sawfish population.

The authors would like to thank M. I. Oetinger for providing references.

References

- Almeida, Z. S. (1999). Levantamento e ocorrência de elasmobrânquios capturados pela pesca artesanal no litoral do Maranhão. *Boletim da Sociedade Brasileira para o Estudo de Elasmobrânquios* **4**, 10.
- Almeida, Z. S., Nunes, J. L. S. & Paz, A. C. (2006). Elasmobrânquios no Maranhão. In *Projeto e ações em biologia e química* (Silva, A. C. & Bringel, J. M. M., eds), pp. 35–57. São Luís: EDUEMA.
- Bigelow, H. B. & Schroeder, W. C. (1953). Sawfishes, guitarfishes, skates and rays. *Fishes of the Western North Atlantic, Memoirs of Sears Foundation for Marine Research* **1**, 1–514.
- Carlson, J. K., Gulak, S. J. B., Simpfendorfer, C. A., Grubbs, R. D., Romine, J. G. & Burgess, G. H. (2013a). Movement patterns and habitat use of smalltooth sawfish, *Pristis pectinata*, determined using pop-up satellite archival tags. *Aquatic Conservation: Marine and Freshwater Ecosystems* **24**, 104–117. doi: 10.1002/aqc.2382
- Charvet-Almeida, P. (2002). Sawfish trade in the north of Brazil. *Shark News* **14**, 9.
- Charvet-Almeida, P. & Faria, V. V. (2008). *Pristis perotteti*. In *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* (Machado, A. B. M., Drummond, G. M. & Paglia, A. P., eds), pp. 33–35. Belo Horizonte: Fundação Biodiversitas II.
- Compagno, L. J. V. (2005). Checklist of living Chondrichthyes. In *Reproductive Biology and Phylogeny of Chondrichthyes - Sharks, Batoids and Chimaeras* (Hamlett, W. C., ed), pp. 503–548. Enfield, NH: Science Publications Inc.
- Compagno, L. J. V. & Cook, S. F. (1995). The exploitation and conservation of freshwater elasmobranchs: status of taxa and prospects for the future. *Journal of Aquaculture and Aquatic Sciences* **7**, 62–90.

- Deynat, P. P. (2005). New data on the systematics and interrelationships of sawfishes (Elasmobranchii, Batoidea, Pristiformes). *Journal of Fish Biology* **66**, 1447–1458.
- Dulvy, N. K., Davidson, L. N., Kyne, P. M., Simpfendorfer, C. A., Harrison, L. R., Carlson, J. K. & Fordham, S. V. (2014). Ghosts of the coast: global extinction risk and conservation of sawfishes. *Aquatic Conservation: Marine and Freshwater Ecosystems* **26**, 134–153. doi: 10.1002/aqc.2525
- Faria, V. V. (2007). Taxonomic review, phylogeny, and geographic population structure of the sawfishes (Chondrichthyes, Pristiformes). PhD Dissertation, Iowa State University, Ames, IA, USA.
- Faria, V. V., McDavitt, M. T., Charvet, P., Wiley, T. R., Simpfendorfer, C. A. & Naylor, G. J. P. (2013). Species delineation and global population structure of Critically Endangered sawfishes (Pristidae). *Zoological Journal of the Linnean Society* **167**, 136–164.
- Figueiredo, J. L. (1977). Cações, raias e quimeras. In *Manual de peixes marinhos do sudeste do Brasil* (Figueiredo, J. L. & Menezes, N. A., eds). São Paulo: Museu de Zoologia da Universidade de São Paulo.
- Gadig, O. B. F. (1998). Peixes Cartilaginosos da costa do Estado de São Paulo. *Revista Ceciliansa* **9**, 41–52.
- Last, P. R. & Stevens, J. D. (2009). *Sharks and Rays of Australia*. Collingwood: CSIRO Publishing.
- Lessa, R. (1986). Levantamento faunístico dos elasmobrânquios (Peixe, Chondrichthyes do litoral do Estado do Maranhão, Brasil). *Boletim Laboratório Hidrobiologia* **7**, 27–41.
- Lessa, R. (1997). Sinopse dos estudos sobre elasmobrânquios da costa do Maranhão. *Boletim Laboratório Hidrobiologia* **10**, 19–36.
- Lessa, R., Santana, F. M., Rincón, G., Gadig, O. B. F. & El-Deir, A. C. A. (1999a). *Biodiversidade de elasmobrânquios do Brasil*. Recife: Necton-Elasmobrânquios.
- Lessa, R., Batista, V. & Almeida, Z. (1999b). Occurrence and biology of the daggernose shark: *Isogomphodon oxyrhynchus* (Chondrichthyes: Carcharhinidae) off the Maranhão Coast (Brazil). *Bulletin of Marine Science* **64**, 115–128.
- McDavitt, M. T. & Charvet-Almeida, P. (2004). Quantifying trade in sawfish rostra: two examples. *Shark News* **16**, 10–11.
- McEachran, J. D. & Carvalho, M. R. (2002). Pristidae. In *The Living Marine Resources of the Western Central Atlantic*, Vol. 1 (Carpenter, K. E., ed), pp. 578–585. Rome: Food and Agriculture Organization of the United Nations.
- Menni, R. C. & Lessa, R. (1998). The chondrichthyan community off Maranhão (northeastern Brazil) II. Biology of species. *Acta Zoológica lilloana* **44**, 69–89.
- Menni, R. C. & Stehmann, M. F. W. (2000). Distribution, environment and biology of batoid fishes off Argentina, Uruguay and Brazil: a review. *Revista del Museo Argentino de Ciencias Naturales* **2**, 69–109.
- MMA (2014). *Lista nacional das espécies de invertebrados aquáticos e peixes ameaçadas de extinção. Portaria nº 445 do Ministério do Meio Ambiente, 17 de dezembro de 2014. Diário Oficial da União*. Brasília: Ministério do Meio Ambiente.
- Monte-Luna, P., Castro-Aguirre, J. L., Brook, B. W., Cruz-Aguero, J. & Cruz-Escalona, V. H. (2009). Putative extinction of two sawfish species in Mexico and the United States. *Neotropical Ichthyology* **7**, 509–512.
- Morgan, D. L., Whitty, J. M., Phillips, N. M., Thorburn, D. C., Chaplin, J. A. & McAuley, R. (2011). North-western Australia as a hotspot for endangered elasmobranchs with particular reference to sawfishes and the Northern River Shark. *Journal of the Royal Society of Western Australia* **94**, 345–358.
- NMFS (2009). Listing endangered and threatened species and designating critical habitat: notice of finding on a petition to list the largetooth sawfish (*Pristis perotteti*) as an endangered or threatened species under the Endangered Species Act. *Federal Register* **74**, 37671–37674.
- Norton, S. L., Wiley, T. R., Carlson, J. K., Frick, A. L., Poulakis, G. R. & Simpfendorfer, C. A. (2012). Designating critical habitat for juvenile endangered smalltooth sawfish in the United States. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* **4**, 473–480. doi: 10.1080/19425120.2012.676606

- Peverell, S. C. (2005). Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on sawfish ecology. *Environmental Biology of Fishes* **73**, 391–402.
- Pogonoski, J. J., Pollard, D. A. & Paxton, J. R. (2002). *Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes*. Canberra: Environment Australia.
- Robillard, M. & Séret, B. (2006). Cultural importance and decline of sawfish (Pristidae) populations in West Africa. *Cybiurn* **30**, 23–30.
- Seitz, J. C. & Poulakis, G. R. (2006). Anthropogenic effects on the smalltooth sawfish (*Pristis pectinata*) in the United States. *Marine Pollution Bulletin* **52**, 1533–1540.
- Simpfendorfer, C. A. (2000). Predicting population recovery rates for endangered western Atlantic sawfishes using demographic analysis. *Environmental Biology of Fishes* **58**, 371–377.
- Simpfendorfer, C. A., Poulakis, G. R., O'Donnell, P. M. & Wiley, T. R. (2008). Growth rates of juvenile smalltooth sawfish *Pristis pectinata* Latham in the western Atlantic. *Journal of Fish Biology* **72**, 711–723.
- Simpfendorfer, C. A., Yeiser, B. G., Wiley, T. R., Poulakis, G. R., Stevens, P. W. & Heupel, M. R. (2011). Environmental influences on the spatial ecology of juvenile smalltooth sawfish (*Pristis pectinata*): results from acoustic monitoring. *PLoS One* **6**, e16918. doi: 10.1371/journal.pone.0016918
- Soares, E. C. (2005). *Peixes do Mearim*. São Luís: Instituto Geia.
- Thompson, W. L. (2004). *Sampling Rare or Elusive Species*. Washington, DC: Island Press.
- Thorburn, D. C., Morgan, D. L., Rowland, A. J. & Gill, H. S. (2007). Freshwater sawfish *Pristis microdon* Latham, 1794 (Chondrichthyes: Pristidae) in the Kimberley region of Western Australia. *Zootaxa* **1471**, 27–41.
- Thorson, T. B. (1973). Sexual dimorphism in number of rostral teeth of the sawfish, *Pristis perotteti* Müller and Henle 1841. *Transactions of the American Fisheries Society* **102**, 612–614.
- Thorson, T. B. (1974). Occurrence of the sawfish, *Pristis perotteti*, in the Amazon River, with notes on *P. pectinata*. *Copeia* **1974**, 560–564.
- Thorson, T. B. (1976). Observations on the reproduction of the sawfish, *Pristis perotteti*, in Lake Nicaragua, with recommendations for its conservation. In *Investigations of the Ichthyofauna of Nicaraguan Lakes* (Thorson, T. B., ed), pp. 641–650. Lincoln, NE: University of Nebraska.
- Whitty, J. M., Phillips, N. M., Thorburn, D. C., Simpfendorfer, C. A., Field, I., Peverell, S. C. & Morgan, D. L. (2014). Utility of rostra in the identification of Australian sawfishes (Chondrichthyes: Pristidae). *Aquatic Conservation: Marine and Freshwater Ecosystems* **2**, 791–804. doi: 10.1002/aqc.2398

Electronic References

- Adams, W. F., Fowler, S. L., Charvet-Almeida, P., Faria, V., Soto, J. & Furtado, M. (2006). *Pristis pectinata*. In *IUCN Red List of Threatened Species*. Available at www.iucnredlist.org (last accessed 9 June 2015).
- Carlson, J. K., Wiley, T. & Smith, K. (2013b). *Pristis pectinata* (smalltooth sawfish). In *IUCN Red List of Threatened Species. Version 2013.2*. Available at <http://www.iucnredlist.org/details/18175/0/> (last accessed 9 June 2015).
- Charvet-Almeida, P., Faria, V. V., Furtado, M., Cook, S. F., Compagno, L. J. V. & Oetinger, M. I. (2011). *Pristis perotteti*. In *IUCN Red List of Threatened Species Version 2011.2*. Available at www.iucnredlist.org (last accessed 6 June 2015).
- Kyne, P. M., Rigby, C. & Simpfendorfer, C. A. (2013a). *Pristis clavata* (dwarf sawfish). In *IUCN Red List of Threatened Species. Version 2013.2*. Available at <http://www.iucnredlist.org/details/39390/0/> (last accessed 9 June 2015).
- Kyne, P. M., Carlson, J. K. & Smith, K. (2013b). *Pristis pristis* (largetooth sawfish). In *IUCN Red List of Threatened Species. Version 2013.2*. Available at <http://www.iucnredlist.org/details/39389/0/> (last accessed 9 June 2015).

- NMFS (2000). *Status Review of Smalltooth Sawfish* (*Pristis pectinata*). Available at sero.nmfs.noaa.gov/pr/SmalltoothSawfish.htm (last accessed 10 June 2015).
- Simpfendorfer, C. A. (2013). *Pristis zijsron* (green sawfish). In *IUCN Red List of Threatened Species. Version 2013.2*. Available at <http://www.iucnredlist.org/details/39393/0/> (last accessed 9 June 2015).