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New record of *Carcharhinus leucas* (Valenciennes, 1839) in an equatorial river system

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Abstract

Bull sharks are a cosmopolitan shark species frequently found in shallow shelf ocean waters and, occasionally, in several tropical river systems around the world. Due to bull shark's capability to enter riverine systems, the documentation of its occurrence is essential for future fisheries inspections and studies. In this way, this study aims to report the presence of a medium sized specimen of *C. leucas* in an equatorial river system. The specimen was caught by fishermen at Mearim River, located in Northern Brazil and well known for the occurrence of tidal bores during the highest spring tides of the dry season. The event coincided with the occurrence of one of the strongest spring tides of 2015. The captured female specimen measured approximately 1300 mm and weighted 35 kg. The occurrence of this species was not known in this river basin until now. We recommend and support future ichthyologic studies in the Mearim River basin in order to provide data for the delimitation of the territory used by *C. leucas* in Maranhão State, specially looking into its age, growth, diet, spatial, and temporal movement patterns in this area.

Keywords: Euryhaline shark, Elasmobranch, North Brazil

Introduction

Bull sharks are a coastal cosmopolitan species frequently found in shallow shelf waters, present in all of the world's oceans, occasionally entering warm river systems (Cervigón & Alcalá, 1999; Compagno et al., 2005). It has been known to occur in several other rivers in all continents (Ballantyne & Fraser, 2013). Its presence is known in the Amazon basin since the early 1900s (Thorson, 1972), where specimens were caught about 4200 km into the river (Carvalho and McEachran 2003). This species has also been registered 1200 km into the Mississippi River (Moss, 1984); in Matawan Creek, New Jersey (Klimley, 2013); 175 km into the San Juan River, as well as in other rivers and lakes of Mexico (Helfman et al., 2009); in the Iquitos and Ucayali rivers, both in Peru, among other freshwater systems (Carvalho and McEachran 2003).

Furthermore, it is also known to give birth in estuaries and rivers and to move towards coastal ecosystems when reaches a larger size (Compagno et al., 2005). This behavior is displayed by several other coastal shark species, and is believed to be related to a lower predation risk for the young in these areas (Grubbs, 2010).

This study aims to report the presence of a medium sized specimen of *C. leucas* in the Mearim River basin, Maranhão State, Brazil, extending the number of elasmobranchs listed for this area.

Materials and methods

Mearim River is located in central Maranhão State, geographically considered as Northern Brazil by Programa Revizee (2006) (Fig. 1). It extends for 930 km until its mouth located in the meridional edge of *Ilha dos Caranguejos* (Soares, 2005). Its final portion is known for slow currents, leading to turbid waters and concentration of nutrients and muddy sediments. Perhaps its most unique feature is the occurrence of tidal bores, locally known as *pororoca*, during the highest spring tides of the dry season (August to December). The effect of the high tide can be seen until 256 km into the river basin (Soares, 2005) and causes a mixture between the salty and freshwaters, as well as fine

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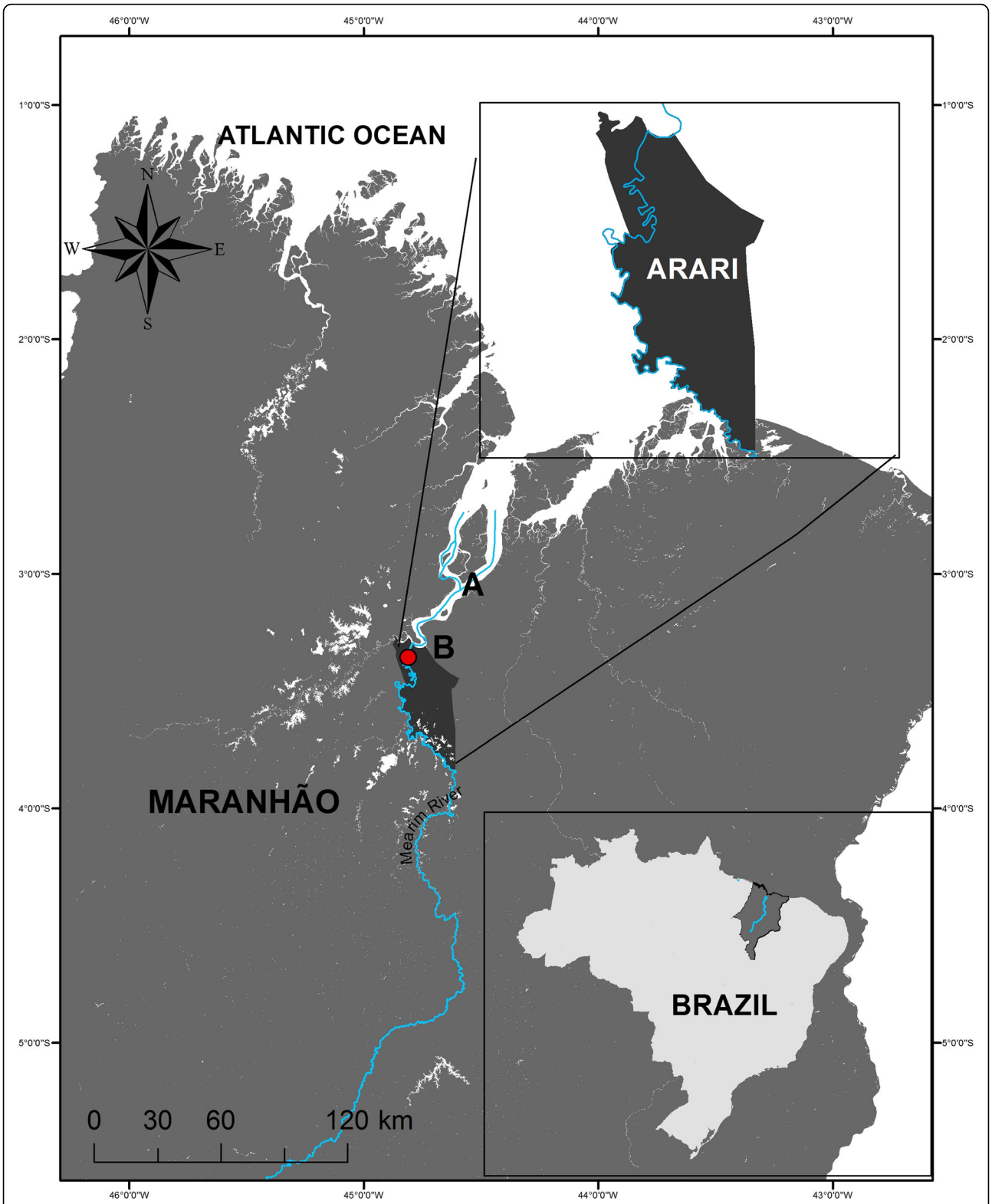

Fig. 1 Middle and lower portions of the Mearim River basin, with the river's mouth (**a**) and the location where the specimen of *C. leucas* was captured (**b**)

Fig. 2 Different views of the juvenile *C. leucas* specimen captured and processed by fishermen in Arari city

sediments (Chanson, 2005). According to Kjerfve & Ferreira (1993), the Mearim River tidal bore, whose effects gradually decrease upstream, causes an increase in salinity up to 18 % and a small decrease in water temperature, reaching its furthest extent in Arari city.

On 3 September of 2015 a juvenile female *Carcharhinus leucas* was caught by local fishermen in the municipality of Arari (3°23′14″S and 44°49′55″W), Maranhão State, on the margin of the Mearim River, located approximately 80 km far from the river's mouth. According to the fishermen, the shark tried to attack a dog on the margin and got stranded due to the low depth. The event coincided with the occurrence of one of the strongest spring tides of the year in the Maranhão State, which has one of the largest tidal variations in Brazil, reaching up to 7 m.

Results

One female specimen of *Carcharhinus leucas* measuring approximately 1300 mm in total length (TL) and weighing 35 kg was caught by local fishermen (Fig. 2). Its identification was carried out following Compagno et al. (2005). It was not possible to analyze the specimen before the fishermen processed it. However, based on studies of Compagno et al. (2005) and Cruz-Martinez et al. (2005) female individuals mature between 1800 mm and 2300 mm TL. Taking this into account, the approximate TL or this specimen suggests that it was not yet mature.

Discussion

Only 5 % of all elasmobranchs can tolerate some sort of salinity range during their lifetime (Helfman et al., 1997). The tolerance level varies according to the age class and specific features of habitat use by each individuals and/or species (Cervigón & Alcalá, 1999; Compagno et al., 2005; Ballantyne & Fraser, 2013). In Maranhão State, several marine species of elasmobranchs have been captured in estuarine areas, such as *Isogomphodon oxyrhynchus*, *Carcharhinus porosus*, *Sphyrna tiburo*, *Rhizoprionodon porosus* (Lessa, 1997; Almeida & Vieira, 2000) and a juvenile specimen of *Pristis pristis* [see Faria et al. (2013) for updated taxonomic nomenclature] measuring weighing 20 kg was incidentally caught in the same area in 1999 (Soares, 2005).

The ability that *C. leucas* has to enter riverine systems further than any other shark species is related to its osmotic acclimation to salinity gradients (Klimley, 2013; Pillans & Franklin, 2004). It is believed to be related to the rectal gland activity plasticity (Pillans et al., 2005), urea and trimethylamine oxide (TMAO) reabsorption by the kidney (Pillans et al., 2008), and ion uptake by the gills (Ballantyne & Robinson, 2010), which is enhanced when in freshwater. With all this put together, according to these authors, *C. leucas* can maintain its body hyperosmotic in freshwater environments, but loses much more water and ions due to large amounts of urine produced.

This record is important to direct future more thorough ichthyologic studies in the Mearim River basin that look into the spatial and temporal scales in which these animals can be found, their size range in the river, diet, age, growth, spatial, and temporal movements to provide useful ecological and biological data for the assessment of distribution of bull shark individuals in the Mearim River.

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Authors' contributions
JLSN and LMF gathered the data presented in this study. LMF, APBM and JLSN participated in the conception and elaboration of the manuscript. All of them have read and approved the final version of this paper and agree to be accountable for all aspects of the work.

Competing interests
The authors declare that they have no competing interests.

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