Aquatic Mammals 2017, *43*(5), 530-536, DOI 10.1578/AM.43.5.2017.530

Short Note

Occurrence of Boto-do-Araguaia (*Inia araguaiaensis*) in a Region of the Araguaia River, Brazil, Documented for an Environmental Impact Study for a Hydroelectric Dam

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River dolphins of the genus *Inia* are widely distributed throughout the Amazon, Orinoco, and Araguaia-Tocantins watersheds, and in the lakes and rivers of Brazil, Bolivia, Colombia, Ecuador, Peru, and Venezuela (Best & da Silva, 1989, 1993; Martin & da Silva, 2004; da Silva & Martin, 2010). Unfortunately, little is known about the species in the Araguaia-Tocantins basin. The boto-do-Araguaia (*Inia araguaiaensis*) is a small cetacean found in the Araguaia River, possibly also in the Tocantins River and potentially in the whole Araguaia-Tocantins river basin. It was distinguished from other members of the genus *Inia* by DNA data as well as via differences in skull morphology (Hrbek et al., 2014). Still, the species' taxonomy has not yet been adopted by the Society of Marine Mammalogy (Committee on Taxonomy, 2016).

The construction of the Tucuruí hydroelectric dam in 1984, in the confluence of the Araguaia and Tocantins Rivers, promoted isolation of the *I. araguaiaensis* populations of the Araguaia River from Amazonian groups (da Silva & Martin, 2010; Araújo & Wang, 2012). Unfortunately, little is known about the species in the Araguaia-Tocantins basin.

Currently, the main threats to the Amazon river dolphins of the genus *Inia* are overfishing, which depletes their food supply; construction of hydroelectric dams, which causes habitat loss and fragmentation and also affects their prey; accidental killing (fishing gear); and intentional killing (fishermen use the animal as bait to capture piracatinga [*Calophysus macropterus*]) (da Silva & Martin, 2010; Araújo & Wang, 2012, 2014; Araújo & da Silva, 2014). Similar threats occur in Chinese rivers and, in addition to pollution, led to the extinction of the baiji (*Lipotes vexillifer*) (Smith et al., 2008).

The construction of dams in the Amazon region grows every year. According to Ecologia e Ação (ECOA) et al. (2017), there are now 13 dams operating in river dolphin distribution areas: six in the Amazonian basin, three in the Orinoco basin, and four in the Araguaia-Tocantins basin. About 150 dams are planned to be built in these three basins by 2030, 55 of them overlapping with the *Inia*'s distribution. The main effects on the species caused by dam construction include fragmentation of populations, isolation and extirpations, reproductive isolation, loss of river connectivity, changes in the river's hydrological cycles, increase in water temperature, water acidification, changes in the water velocity and flow, and change in fish diversity (Paschoalini et al., 2016). More information about *Inia* distribution in some Amazon River regions, especially the Araguaia-Tocantins basin, is required to understand the potential impacts of the planned dams.

This study was part of an environmental impact study carried out in 2009 and is related to a proposed hydroelectric dam to be built in the Araguaia River, Tocantins, west-central Brazil. There was verified presence of *I. araguaiaensis* and its estimated preference in the use of habitats in the dam's area of influence. With this information, it was possible to present how the dam might impact the population of botos present in the dam's influence area and also identify mitigating measures to minimize the impacts predicted in case the dam gained a construction license, which would be granted by the Brasilian Environment Agency (IBAMA).

The study area included 155 km of the Araguaia River between the cities of Ananás (22M 0794802 S/9336220 W) and Araguanã (22M 0735330 S/9253796 W) in the Tocantins State (Figure 1). This 155-km stretch of the Araguaia River was divided into five sections (Figure 1), each ~31 km long (Table 1).

Field data collection occurred over a period of 20 nonconsecutive days in 2009 during four

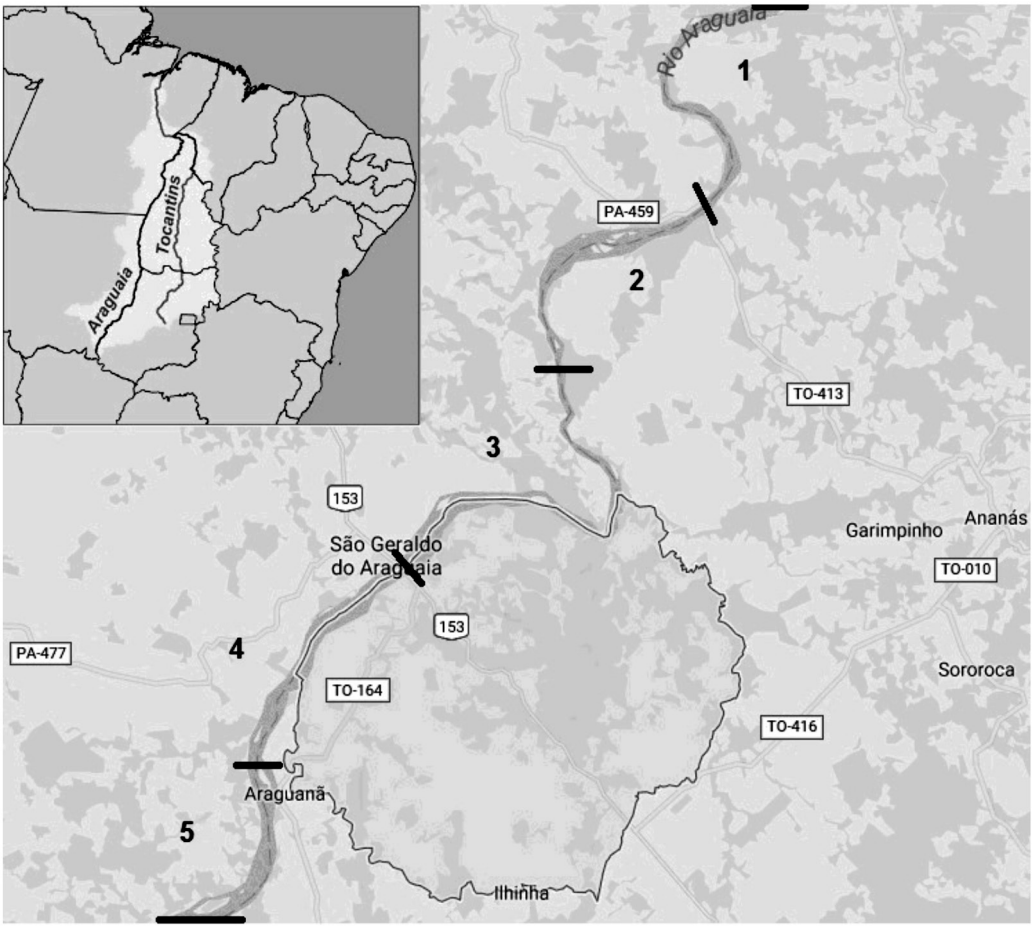

Figure 1. The study area in the Araguaia-Tocantins basin. The study covered a section of the Araguaia River between the cities of Ananás and Araguanã, Tocantins, and was divided into five sections.

Table 1. Characterization of each sampled section (round trip) of the Araguaia River

River section	Geographic coordinates limit	Length (km)	Limits description	Section description
1	22M 0798386/9322476 – 0794802/9336220	60	Rapids to the downstream limit	Preserved area
2	22M 0798386/9322476 – 0786224/9302680	38	Rapids to the sand beach	Preserved area with farms
3	22M 0786224/9302680 – 0771721/9292704	70	Sand beach to Xambioá City	Preserved area; backwaters in the confluence of Araguaia and Corda Rivers
4	22M 0771721/9292704 – 07583340/9262428	87	Xambioá City to Murici River confluence	Most anthropized area; confluence with Lontra's River
5	22M 07583340 / 9262428 – 0735330 / 9253796	55	Murici River confluence to upstream limit	Preserved area with farms

hydrological seasons: (1) rising (16 to 24 March; sampling effort: 51 h), (2) high (23 to 30 April; sampling effort: 40.9 h), (3) falling (2 to 8 July; sampling effort: 41.2 h), and (4) low (5 to 11 September; sampling effort: 50 h). Botos were found by active search and visual census technique (Fuller & Mosher, 1981; Fundación Omacha et al., 2008). A 5-m aluminum boat with a 15- or 30-hp motor, driven at speeds between 5 and 10 km/h, was used for all surveys. Linear transects running parallel to both river margins (main shores) were made (modified from Gomez-Salazar et al., 2012b). A section of the river was traversed each day, going along one margin and returning closer to the other side. During the low season, low depth prevented access to several areas, and surveys were conducted in the waterway of the river. Two observers searched for boto groups at the bow using binoculars. Each covered a 90° field of view with a range of about 200 m each.

The boat stopped when boto groups were sighted, and the following data were collected: date, time, position (Garmin Etrex Legend, UTM, SAD69), group size, ages (e.g., adult, juvenile, and calf), behavioral activities (e.g., foraging/feeding, socialization, resting, and traveling), and type of habitat (e.g., igapó, waterway, or beach) (Table 2) (modified from Martin et al., 2004; Gomez-Salazar et al., 2011).

Statistical analyses were conducted using *Bioestat 5.0*. Groups of botos were analyzed according to descriptive statistics for quantitative data (total number [*N*], range, median, and standard deviation [SD]). Kruskal-Wallis (at the significance level of 0.05) was used to compare number of groups and number of individuals in different hydrological seasons, sections of the river, and habitats (e.g., igapó, middle of the river, and beach). Relative density for each section (sightings/km of section; $N_{individuals}$/km of section) was calculated as well, and a Kruskal-Wallis test was used to determine if boto density was uniform in all sections of the river.

In total, 119 individuals (42 groups) were spotted in the 155 km of the Araguaia River during 183 h of field effort along 1,360 km navigated during the four hydrological seasons (Figure 2). Some individuals might have been counted more than once (mean = 2.53, SD = 2.28).

Group sizes varied from two to ten individuals. Single animals were observed most frequently (36%). During the rising and high seasons, 30 boto groups (N = 90, range = 1 to 10, mean = 3.0, SD = 2.33) were reported; while in the falling and low seasons, only 12 groups (N = 29, range = 1 to 8, mean = 2.42, SD = 1.98) were observed (Figure 3). The greatest number of individuals was reported in the rising season (44% distributed in 16 groups) followed by the high season with 32% of individuals distributed in 14 groups. The low season showed a few individuals (3%) distributed only in one group (Figure 3). There was a significant difference between rising and low seasons in number of groups sighted (Kruskal-Wallis H = 9,027, p = 0.029) and in the number of individuals (H = 8,756, p = 0.033).

The river section with the highest incidence of group sightings was number 3 with 13 groups (N = 33, range = 1 to 7, mean = 2.54, SD = 1.81). This section showed also the highest incidence of groups/km (0.19). Section 1 showed the highest incidence of number of individuals (N = 34), and section 2 showed the highest incidence of number of individuals/km (0.89). Density of number of groups (N_{groups}/km) and number of individuals ($N_{individuals}$/km) are presented in Tables 3 and 4. No significant differences between the river sections for number of groups (Kruskal-Wallis H = 3,241, p = 0.518), number of individuals (H = 1,975, p p = 0.740), density of groups/km (H = 2,834, p = 0.586), and density of individuals/km (H = 4,488, p = 0.344) were found.

Groups of botos mostly associated in the igapó (55%), followed by the waterway (38%), and then the beach area (7%). The rate of animals associated with the igapó and the middle of the river changed according to the hydrological season of the river. The middle of the river was preferred in high season (57%, N = 8), the igapó was preferred in the rising season (81%, N = 13), and the beach area was used only in the falling season (27%, N = 3; Figure 4). The number of the groups sighted between the center of the river and the beach area were significantly different (Kruskal-Wallis H = 1,341, p = 0.0012).

Table 2. Definitions of habitat types

Habitat type	Definition
Igapó	Forest and shrubs swamped during the rising/high water season at the edge of the river
Middle of the river	Waterway – The channel/middle of the river; between margins
Beach	Sand area formed on the main shore during falling/low water seasons

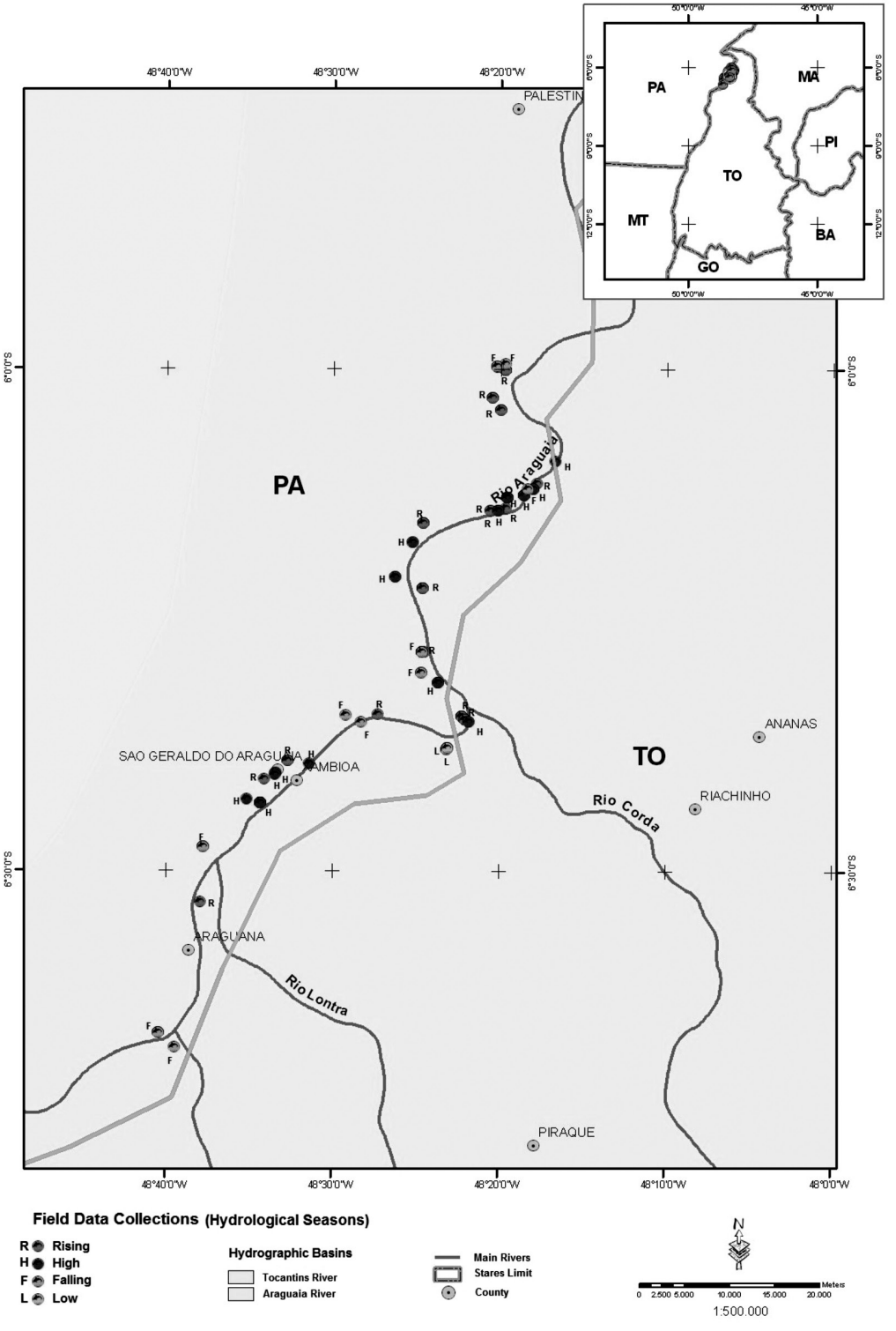

Figure 2. Spatial distribution of *Inia araguaiaensis* groups observed during the four hydrological seasons; scale: 1:300,000.

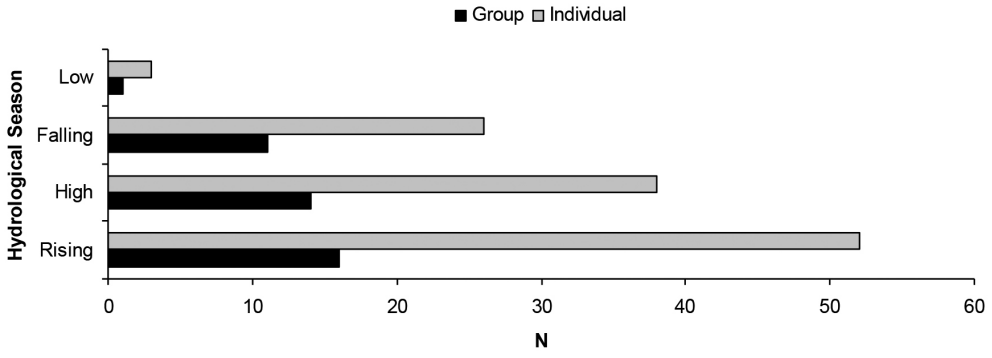

Figure 3. Group and individuals' distributions during the four hydrological seasons

Table 3. Number of groups and density of botos (*Inia araguaiaensis*) (N_{groups}/km) in the five sections of the Araguaia River

Section	Section size (km)	Total		Rising		High		Falling		Low	
		Group (*N*)	Density	Group (*N*)	Density	Group (*N*)	Density	Group (*N*)	Density	Group (*N*)	Density
1	60	10	0.17	5	0.08	4	0.07	1	0.02	0	0.00
2	38	7	0.18	5	0.13	0	0.00	2	0.05	0	0.00
3	70	13	0.19	3	0.04	5	0.07	4	0.06	1	0.01
4	87	4	0.05	1	0.01	2	0.02	1	0.01	0	0.00
5	55	8	0.15	2	0.04	3	0.05	3	0.05	0	0.00
Total	310	42		16		14		11		1	

Table 4. Number of individuals and density of botos ($N_{individuals}$/km) in the five sections of the Araguaia River

Section	Section size (km)	Total		Rising		High		Falling		Low	
		Ind. (*N*)	Density	Ind. (*N*)	Density	Ind. (*N*)	Density	Ind. (*N*)	Density	Ind. (*N*)	Density
1	60	35	0.58	20	0.33	11	0.18	4	0.07	0	0.00
2	38	34	0.89	22	0.58	4	0.11	8	0.21	0	0.00
3	70	23	0.33	7	0.10	6	0.09	7	0.10	3	0.04
4	87	16	0.18	1	0.01	12	0.14	3	0.03	0	0.00
5	55	8	0.15	4	0.07	0	0.00	4	0.07	0	0.00
Total	310	116		54		33		26		3	

I. araguaiaensis is a species recently described by Hrbek et al. (2014). Its population is known to be isolated to the basins of the Tocantins and Araguaia Rivers and is threatened by habitat loss due to intense human occupation (Hrbek et al., 2014). The limited amount of literature on boto-do-araguaia and the small sampling effort are not enough to make conclusions about areas of feeding and reproduction for this species along the studied area of the Araguaia River. It is possible that the reduced number of observations in the low season is associated with some peculiar characteristics of this period such as low water depth, greater boat traffic, and crowding of tourists on the beaches. This kind of tourism generates noise and intense fishing as well as nautical tourism in the water and along the beaches of the Araguaia River, mostly between the cities of Xambioá and Araguanã.

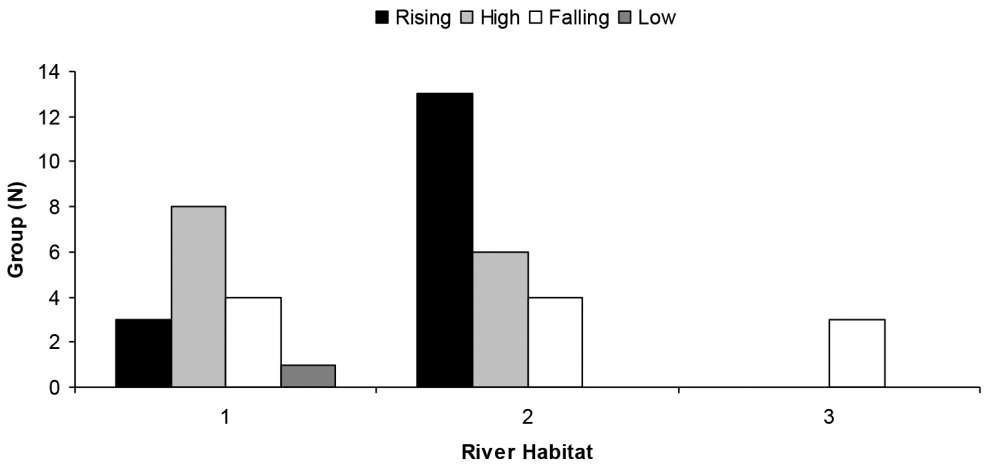

Figure 4. Group presence in each hydrological season associated with habitat type

Most of the boto groups were found in more preserved areas of the river, far from cities, such as in sections 1, 2, 3, and 5. Section 3 was the area with the highest concentration of sightings, although this is not statistically significant. If sampling effort had been higher, the boto density in section 3 might have been significant. There is a backwater in the confluence of the Araguaia and Corda Rivers, and it is likely that the food resources there are more available and abundant (Magnusson et al., 1980; Meade & Koehnken, 1991; Leatherwood et al., 2000). These results corroborate the observations of Araújo & da Silva (2010) who reported the highest density of Araguaia pink river dolphin (*I. araguaiaensis*) in a confluence area of the Araguaia River. Other studies conducted with *Inia geoffrensis* in the Amazon and Orinoco basins showed high concentrations of botos in river confluence areas, probably due to the great availability of prey as in similar observations (Vidal et al., 1997; Martin et al., 2004; Gomez-Salazar et al., 2012a, 2012b).

In the Amazon rivers (Best & da Silva, 1993; Martin & da Silva, 2004; Martin et al., 2004), botos mainly use the igapó during the rising and high seasons. During the falling and low seasons, they are found in the center of the river (Martin et al., 2004) and deeper backwater regions. According to Best & da Silva (1993), reproduction of the *I. geoffrensis* occurs in the high and falling seasons, taking place mainly between May and July.

Our study proves the existence of a vulnerable species in an area where biodiversity is very rich and the existence of a hydroelectric dam is not so relevant. In Brazil, any construction project is required to conduct an impact study on fauna, flora, and the local community. These studies are evaluated by the environmental inspection agency (IBAMA), and the project is approved (if it is low impact) or not. It is important that more studies are done with this cetacean species in the Araguaia-Tocantins basin, a region threatened by the construction of dams, waterways, increasing deforestation, intense nautical and fishing tourism, and intentional and accidental catch.

Acknowledgments

We would like to thank the geographer, Marcos Antônio de Melo, for the maps, and our boat driver, "Seu" Juca. This work was funded and permitted by Consórcio GESAI and supported by Fauna Pro Consultoria Ambiental Ltda. and Ecótonus Meio Ambiente e Arquitetura Ltda.

Literature Cited

Araújo, C. C., & da Silva, V. M. F. (2014). Spatial distribution of river dolphins, *Inia geoffrensis* (Iniidae), in the Araguaia River (central Brazil). *Mammalia*, *78*(4), 481-486. https://doi.org/10.1515/mammalia-2013-0112

Araújo, C. C., & Wang, J. Y. (2012). Botos (*Inia geoffrensis*) in the upper reaches of the Tocantins River (central Brazil) with observations of unusual behavior, including object carrying. *Aquatic Mammals*, *38*(4), 435-440. https://doi.org/10.1578/AM.38.4.2012.435

Araújo, C. C., & Wang, J. Y. (2014). The dammed river dolphins of Brazil: Impacts and conservation. *Oryx*, *49*(1), 17-24. https://doi.org/10.1017/S0030605314000362

Best, R. C., & da Silva, V. M. F. (1989). Amazon river dolphin, boto *Inia geoffrensis* (de Blainville, 1817). In S. H.

Ridgway & R. J. Harrison (Eds.), *Handbook of marine mammals* (Vol. 4, pp. 1-23). London: Academic Press.

Best, R. C., & da Silva, V. M. F. (1993). *Inia geoffrensis*. *Mammalian Species*, *426*, 1-8.

Committee on Taxonomy. (2016). *List of marine mammal species and subspecies*. Lawrence, KS: Society for Marine Mammalogy. Retrieved from www.marine mammalscience.org

da Silva, V. M. F., & Martin, A. R. (2010). Status, threats, conservation initiatives and possible solutions for *Inia geoffrensis* and *Sotalia fluviatilis* in Brazil. In F. Trujillo, E. Crespo, P. A. Van Damme, & J. S. Usma (Eds.), *The action plan for South America river dolphins 2010-2020* (pp. 123-143). Bogotá, DC, Colombia: World Wildlife Fund (WWF), Fundación Omacha, Wildlife Conservation Society, Whale and Dolphin Conservation Society (WDCS), Solamac.

Ecologia e Ação (ECOA), International Rivers, & Fundación Proteger. (2017). *Dams in Amazonia*. Retrieved from www.dams-info.org

Fuller, M. R., & Mosher, J. A. (1981). Methods of detecting and counting raptors: A review. *Studies in Avian Biology*, *6*, 235-246.

Fundación Omacha, World Wildlife Fund (WWF), Wild Conservation Society, & Whale and Dolphin Conservation Society (WDCS). (2008). *First evaluation of abundance of the three river dolphin species (*Inia geoffrensis, I. boliviensis, *and* Sotalia fluviatilis*) in the Orinoco and Amazon river basins, South America*. Retrieved from http://mobil.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Report_River_Dolphins.pdf

Gomez-Salazar, C., Trujillo, F., & Whitehead, H. (2012a). Ecological factors influencing group sizes of river dolphins (*Inia geoffrensis* and *Sotalia fluviatilis*). *Marine Mammal Science*, *28*(2), E124-E142. https://doi.org/10.1111/j.1748-7692.2011.00496.x

Gomez-Salazar, C., Trujillo, F., Portocarrero-Aya, M., & Whitehead, H. (2012b). Population, density estimates, and conservation of river dolphins (*Inia* and *Sotalia*) in the Amazon and Orinoco river basins. *Marine Mammal Science*, *28*, 124-153. https://doi.org/10.1111/j.1748-7692.2011.00468.x

Hrbek, T., da Silva, V. M. F., Dutra, N., Gravena, W., Martin, A. R., & Farias, I. P. (2014). A new species of river dolphin from Brazil or how little do we know our biodiversity. *PLOS ONE*, *9*(1), e83623. https://doi.org/10.1371/journal.pone.0083623

Leatherwood, S., Reeves, R. R., Würsig, B., & Shearn, D. (2000). Habitat preferences of river dolphins in the Peruvian Amazon. In R. R. Reeves, B. D. Smith, & T. Kasuya (Eds.), *Biology and conservation of freshwater cetaceans in Asia* (pp. 131-144). Gland, Switzerland: International Union for Conservation of Nature.

Magnusson, W. E., Best, R. C., & da Silva, V. M. F. (1980). Numbers and behaviour of Amazonian dolphins, *Inia geoffrensis* and *Sotalia fluviatilis*, in the Rio Solimões. *Aquatic Mammals*, *8*(1), 27-32.

Martin, A. R., & da Silva, V. M. F. (2004). River dolphins and flooded forest: Seasonal habitat use and sexual segregation of botos (*Inia geoffrensis*) in an extreme cetacean environment. *Journal of Zoology*, *263*, 295-305. https://doi.org/10.1017/S095283690400528X

Martin, A. R., da Silva, V. M. F., & Salmon, D. L. (2004). Riverine habitat preferences of botos (*Inia geoffrensis*) and tucuxis (*Sotalia fluviatilis*) in the central Amazon. *Marine Mammal Science*, *20*(2), 189-200. https://doi.org/10.1111/j.1748-7692.2004.tb01150.x

Meade, R. H., & Koehnken, L. (1991). Distribution of the river dolphin, tonina *Inia geoffrensis*, in the Orinoco river basin of Venezuela and Colombia. *Interciencia*, *16*, 300-312.

Paschoalini, F. M., Dutra, A. P. G., Trujillo, F., Andriolo, F., & Zerbini, A. (2016, November). *Endangered South America river dolphins: The impact of dams construction*. XI Congreso de la Sociedad Latinoamericana de Especialistas en Mamiferos Acuaticos, Valparaiso, Chile.

Smith, B. D., Zhou, K., Wang, D., Reeves, R. R., Barlow, J., Taylor, B. L., & Pitman, R. (2008). *Lipotes vexillifer*. In International Union for Conservation of Nature (IUCN) (Ed.), *The IUCN red list of threatened species 2008*. Retrieved from www.iucnredlist.org

Vidal, O. J., Barlow, J., Hurtado, L. A., Torre, J., Cendón, P., & Ojeda, K. (1997). Distribution and abundance of the Amazon river dolphin (*Inia geoffrensis*) and the tucuxi (*Sotalia fluviatilis*) in the upper Amazon River. *Marine Mammal Science*, *13*, 427-445. https://doi.org/10.1111/j.1748-7692.1997.tb00650