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Source: Tropical Conservation Science, 10(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/1940082917728375>


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Tropical Conservation Science
Volume 10: 1–9
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DOI: 10.1177/1940082917728375
journals.sagepub.com/home/trc


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Abstract

Alive Antillean manatee stranding is one of the main challenges for the conservation of the species in Brazil. In the present study, data on Antillean manatee stranding recorded by the CMA/ICMBio's Wild Animals Rehabilitation Center from 1987 to 2015 were analyzed. The CMA and the REMANE's (Northeastern Aquatic Mammal Stranding Network's) institutions have rescued on average five Antillean manatees per year. Approximately 56% of the animals were alive when rescued, and 43.7% were found dead. The states of Ceará and Rio Grande do Norte have the highest records of stranding, rescue, and assistance of alive calves. Stranding of alive specimens is more frequent during the austral summer, especially in January, February, and March. In the North region, the main threat to the Antillean manatee population seems to be interaction with fishing activities. Studies on the causes of dependent calf stranding in northeast Brazil are urgently needed to promote the development of public policies for the conservation of the species. Brazil's manatee rehabilitation centers must undergo improvements to better assist stranded calves, which need special care to survive.

Keywords

newborn calves, anthropogenic threats, manatee, mortality, Brazil

Introduction

Stranding of marine mammals occurs throughout the world and, although there is a lack of global statistical records, some countries have well-established programs and databases in response to these events (Aragones et al., 2010). The development of a database contributes to more refined studies of the species, yielding a greater success in preserving marine mammals (Moraes & Barreto, 2004). The institutions within the Northeastern Aquatic Mammal Stranding Network (REMANE, acronym in Portuguese) are the ones in charge of rescuing Antillean manatees (*Trichechus manatus manatus*) in Brazil. This network was developed by the government, research organizations, and academic institutions in the year 2000 to rescue marine mammals stranded in northeast Brazil. The National Center of Research and Conservation of Aquatic Mammals of the Chico Mendes Institute for Biodiversity Conservation (CMA/ICMBio,

acronym in Portuguese) is the government representative and network coordinator.

Antillean manatees inhabit warm coastal waters of the Caribbean Sea, Gulf of Mexico, and the western Atlantic Ocean (Lefebvre, Marmontel, Reid, Rathbun, & Domning, 2001). In Brazil, this subspecies occurs discontinuously along the coast from the state of Amapá to Alagoas. However, historically, the Antillean manatees

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Received 26 May 2017; Revised 13 July 2017; Accepted 31 July 2017

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have inhabited areas further south, down to the state of Espírito Santo (Lima, Paludo, Soavinski, Silva, & Oliveira, 2011; Luna, Lima, Araújo, & Passavante, 2008). Currently, the Antillean manatee population is severely reduced in Brazil, being estimated at approximately 1,000 specimens, and is considered an endangered subspecies (Alves et al., 2015; Luna, Lima, et al., 2008; Self-Sullivan & Mignucci-Giannoni, 2008). The main threats to the Brazilian population of Antillean manatees are low genetic variability, change and loss of habitats, interaction with fisheries, stranding of calves in the northeast region, and hunting in the North region (Lima et al., 2011; Luna, Araújo, et al., 2008; Luna et al., 2012; Meireles, 2008).

Antillean manatee strandings have been recorded in Brazil since the 1980s (Meireles, 2008; Parente, Vergara-Parente, & Lima, 2004). The REMANE institution closest to the stranding site rescues the stranded animals, which, after a stabilization period, are allocated to the CMA/ICMBio. After receiving proper rehabilitation treatment at the CMA/ICMBio, the animals are released back to their natural habitat. In instances when a dead manatee is stranded, the institution rescuing it can keep the carcass. In the present study, we only evaluated the carcasses sent to the CMA/ICMBio. This study summarizes the CMA/ICMBio's records for Antillean manatee stranding and describes the spatial and temporal distribution of those strandings and differences in sex and length of manatees rescued more than 29 years.

Methods

The CMA/ICMBio is a center specialized in Antillean manatee conservation and, until July 2013, it was the only institution in Brazil that kept this subspecies in captivity. The present analysis considered stranded manatees that were assisted or received by the CMA/ICMBio's Wild Animals Rehabilitation Center from 1987 to 2015. Calves born in captivity were not included in the analysis.

The area of assisted strandings extends from the state of Amapá (North Brazil) through the states of Maranhão, Ceará, Rio Grande do Norte, Paraíba, and Pernambuco to Alagoas (northeast Brazil). In the state of Amapá, the rainy and dry seasons occur from January to June and from July to December, respectively. The average annual rainfall is 2,500 mm, and the temperatures range from 27°C to 32°C (Ab'Saber, 1977). In the northeast region, due to its coastal configuration, the rainfall is irregular and varies spatially and temporally. In the eastern coast of the northeast region, the rainy season is between January and June, and the dry season occurs from July to December (Hastenrath, 2012). The average annual rainfall is 1,800 mm (da Silva, 2004) and, according to the National Weather Institute (*Instituto Nacional de Meteorologia*); the average annual temperature ranges from 20.7°C to 27.4°C. On the other hand, the northern

coast has a semiarid climate with average annual temperatures from 23°C to 33°C. The rainy season is short, concentrated between February and May, while the dry season occurs from April to January, and the annual average rainfall is 537.5 mm (*Instituto de Desenvolvimento Sustentável e Meio Ambiente*, 1999).

The manatees were rescued, rehabilitated, or necropsied following the REMANE protocol (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*, 2005). The specimens were rescued within the shortest period possible after stranding notifications issued by the network of collaborators in coastal communities. Depending on the animals' clinical condition and the environmental conditions of the stranding site, which includes the presence of other manatees in the area, the priority was to attempt immediate reintroduction, especially for calves, as described in the protocol. In cases of failure, the rescued animals were transported to the nearest REMANE institution and received initial care and stabilization. They were then transferred to the CMA/ICMBio and received the necessary veterinary care. Animals deemed suitable for reintroduction were transferred to natural captivity for later release (Normande et al., 2015). Dead animals were necropsied, depending on the stage of carcass decomposition (Geraci & Lounsbury, 2005).

To verify the spatial distribution and seasonality of strandings, georeferenced records of manatee stranding from 1987 to 2015 were reviewed and organized by Brazilian state and date (month). The sex (male, female, and unknown) of stranded manatees (alive or dead) was checked as well as their length (cm), measured as a straight line from the tip of the nostril to the tip of the tail, which was compared using the Mann–Whitney test.

Results

One hundred and forty-two Antillean manatees were translocated to the CMA throughout the 29 years of rescues (five manatees per year, on average). Of these, on average per year, three were stranded alive (56.3%) and two were found dead (43.7%). The male or female ratio was 1:1; however, it was not possible to determine the sex of 8% of the dead animals due to advanced decomposition of the carcasses (Code 4; Geraci & Lounsbury, 2005), making them impossible to necropsy.

The states of Rio Grande do Norte ($n=40$; 28%), Ceará ($n=39$; 27%), and Paraíba ($n=29$; 20%) had the highest number of strandings, followed by the states of Maranhão ($n=18$; 13%), Alagoas ($n=9$; 6%), Pernambuco ($n=6$; 4%), and Amapá ($n=1$; 1%). The highest number of strandings of alive Antillean manatees was recorded in eastern Ceará ($n=34$; 24%) and the northern coast of Rio Grande do Norte ($n=26$; 18%; Figure 1).

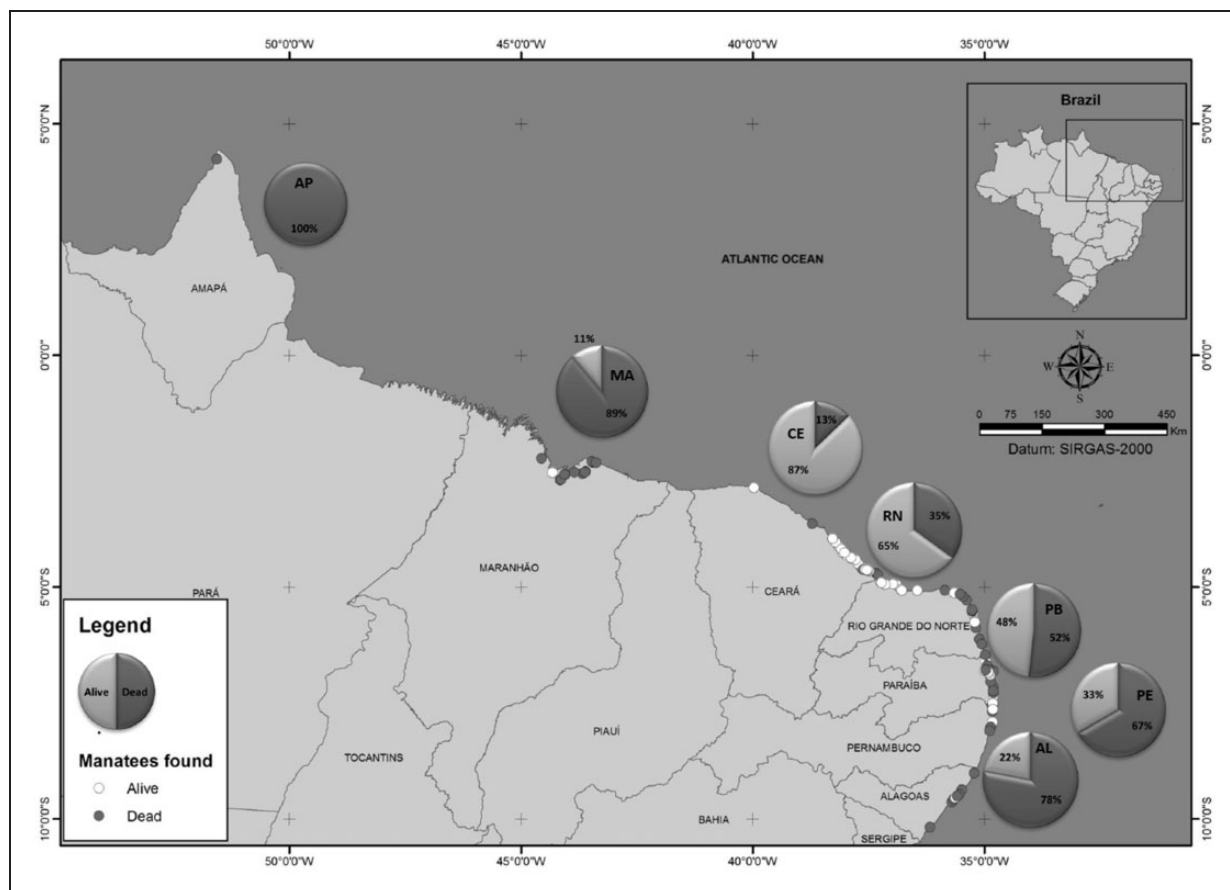


Figure 1. Antillean manatee stranding records and location by Brazilian state from 1987 to 2015.

The highest number of rescues was registered in 2004 and 2008 ($n=11$ manatees) with the same number of alive ($n=4$) and dead animals ($n=7$) recorded in both years. In 2008, four of the dead animals were found in a mangrove area of the state of Maranhão. The highest record of alive strandings during the studied period was in 2010 ($n=9$; Figure 2). Strandings of alive calves occurred in all months of the year but were more common during the austral summer, especially in January, February, and March. There were no records of stranding of dead calves during the winter. Strandings of dead adults were also registered in every month of the year with a higher incidence in February (Figure 3).

Of the 129 Antillean manatees measured, 75% were less than 220 cm long. The smallest specimen, at 67 cm long, was found dead in a mangrove area in the state of Maranhão in December 2009. Specimens rescued alive ($n=77$) were significantly smaller than those found dead (Mann-Whitney = 503, $df=1$, $p < .001$; Table 1; Figure 4). Only two manatees rescued alive were not newborns according to the classification of Borges et al. (2012), their sizes being consistent with those of specimens older than 2 years old.

Calves rescued alive showed no signs of congenital diseases (hydrocephalus, eye and facial deformities, cardiac anomalies verified by auscultation) or other diseases diagnosed by clinical and laboratory tests. However, recently, one specimen is showing abnormal development likely related to congenital diseases, but some tests are needed to confirm the suspicion (F. Attademo, personal communication, September 2015). Commonly, the calves were found with remnants of the umbilical cord and folded tail, which are neonate characteristics. After being rescued, the animals underwent a health assessment, including complete blood count and serum chemistry. Their body condition score and body size were compared with those of healthy animals of the same age, and their body condition was always compatible with healthy neonates estimated with an average age of 0 to 3 days (database CMA/ICMBio).

Discussion

Alive Manatees

Strandings are invaluable sources of information on the biology and ecology of marine mammals and provide

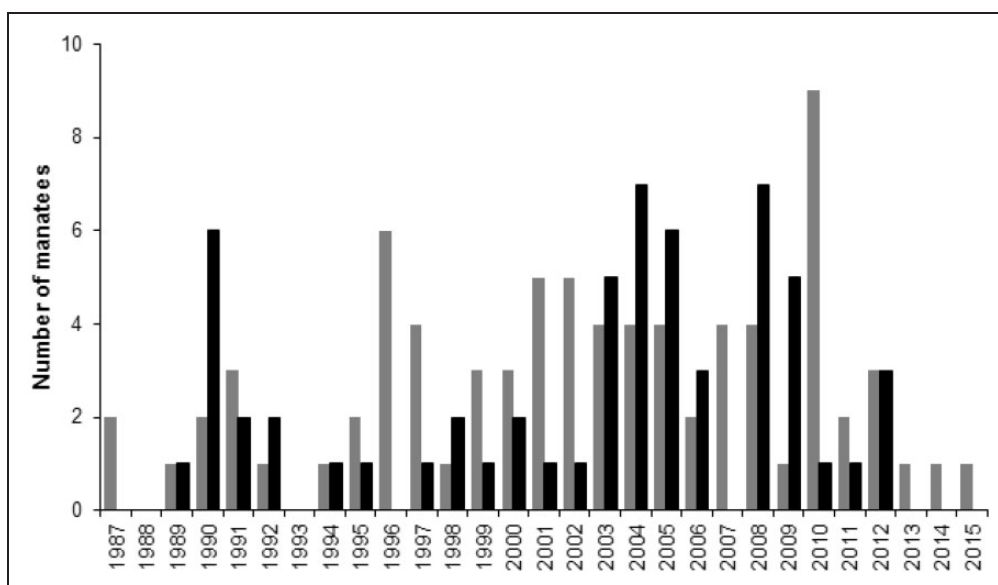


Figure 2. Number of stranded Antillean manatees allocated to the CMA more than 29 years. Black bars = dead manatees; Gray bars = alive manatees.

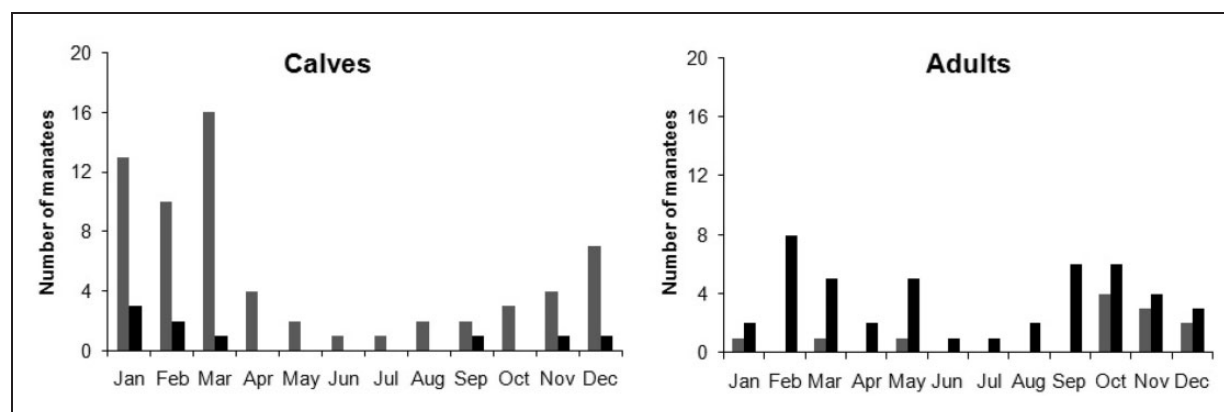


Figure 3. Temporal distribution of records of manatee calves and adults stranded in Brazil. Black bars = dead manatees; Gray bars = alive manatees.

Table 1. Length of Stranded Antillean Manatees Allocated to the CMA From 1987 to 2015. Number of Manatees = 129.

	Alive		Dead		
	Female	Male	Female	Male	Unknown
Number	39	38	22	23	7
Minimum length (cm)	108	93	120	83	67
Maximum length (cm)	335	169	340	315	300
Mean length (cm) \pm SD	136 \pm 40	125 \pm 12	249 \pm 78	230 \pm 68	207 \pm 80

important information about the animals' health (Borsa, 2006; Bossart, 2011). The stranding patterns of a particular species may be related to its distribution, migration, and reproduction (Perrin & Geracy, 2002). The data analyzed in the present study show that strandings are more common among calves; and stranding of alive manatees occurs in the northeast coast of Brazil, mainly in the states of Ceará and Rio Grande do Norte.

Studies have been cautioning about the stranding of newborn and immature calves in Brazil, indicating that this situation has been persistent over the years (Meireles, 2008; Parente et al., 2004). The eastern coast of the state of Ceará and the northern coast of the state of

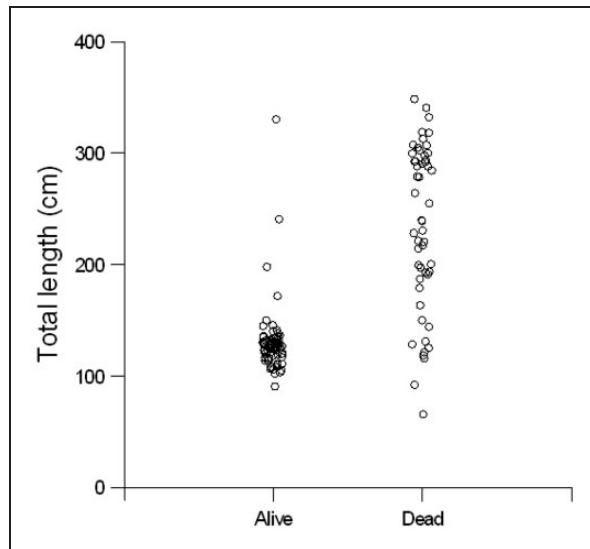


Figure 4. Size of Antillean manatees rescued alive and dead in Brazil from 1987 to 2015.

Rio Grande do Norte have the highest rates of alive Antillean manatee stranding and rescue and are considered the most critical areas. Stranded calves are sent to rehabilitation centers and most are reintroduced into their natural habitat (76% success rate; Normande, Attademo, & Luna, 2016; Normande et al., 2015). However, when in captivity, calves miss a critical learning period and fail to learn how to find food, freshwater, and shelter on their own (Reep & Bonde, 2006), which may compromise their survival in the natural habitat after release.

Studies on the causes for calf stranding in Brazil are rare, but a significant anthropogenic impact has been verified in areas where stranding occurs, including the establishment of shrimp farms and lobster fishing in the northern coast of the Potiguar Basin, between the states of Rio Grande do Norte and Ceará (de Almeida, 2010). Some studies have also indicated that calf stranding is associated with the silting of rivers and degradation of coastal ecosystems, especially in relation to the estuarine complex and its recesses in the states of Ceará and Rio Grande do Norte (Lima et al., 2011; Parente et al., 2004). These anthropogenic disturbances limit the access of female manatees to inshore birthing sites; consequently, calves born in offshore waters may become separated from their mothers and strand along the beaches (Lima et al., 2011; Meireles, 2008). Adult manatees are able to free themselves from other environmental barriers, such as ocean currents and tidal changes (Hartman, 1979; Paludo & Langguth, 2002). For calves, however, the tidal fluctuations can cause stranding, since they lack the adults' agility and strength. For example, during low tide, a dependent calf was stranded alive in a silted area of the state of Paraíba. After 24 h searching for the

presence of others manatees in the surroundings, an adult female was found vocalizing close to the silted area. The calf was placed near the female and both vocalized substantially. Then, the female approached the calf and demonstrated parental care. This episode was considered a successful immediate reintroduction.

Adult Antillean manatees are able to move in shallow waters (1.2 m deep, on average) or along sandbanks and have been found resting in extremely shallow waters (0.4 m deep, on average; Paludo & Langguth, 2002). Therefore, it seems that adults are not disturbed by silting areas. As a matter of fact, in Brazil, between the beaches of Baía Formosa (state of Rio Grande do Norte) and Barra do Rio Camaratuba (state of Paraíba), adults were observed in shallow waters near the beach with their dorsum partially exposed.

Strandings of alive manatees were recorded through all the months of the studied years (1987–2015); however, the highest frequency was observed during the austral summer, which corresponds to the manatee reproductive season in northeast Brazil (Silva, Paludo, Oliveira, Lima, & Soavinski, 2011). The smallest manatee recorded in the present survey, which had been probably aborted (Ackerman, Wright, Bonde, Odell, & Banowetz, 1995; Mignucci-Giannoni et al., 2000) was found dead in a mangrove area in the state of Maranhão during the summer. Calf stranding was recorded in two occasions during or after the stranding of an adult specimen was recorded. However, it was not possible to verify if the calf stranding had its cause in the stranding of its mother. In some cases, the cause for the stranding was related to natural factors, such as diseases, congenital disorders or others, and, several times, to environmental factors. In the northern coast of the Potiguar Basin (state of Rio Grande do Norte), 12- to 15-knot winds can have an influence on strandings in the month of August to November (UERN, data not published). The seasonality of stranding records during the reproductive season demonstrates the need for maintaining rescue actions and for endeavoring to accomplish preventive actions. In many occasions, parturient females are also believed to remain at the stranding site in the days following the event. Therefore, an effort to locate these females for an average period of 72 h can be effective for the immediate reintroduction of the calf, when it is healthy. By bringing mother and offspring together again, the calf would be spared from remaining in captivity offsite.

In Brazil, there is no data showing the effects of stranding of alive calves on the size of the manatee population. In the last national conservation status assessment, *T. manatus* status downgraded from critically endangered to endangered. However, no study has proved that the population increased, since the existing surveys used different sampling methods (Alves et al., 2015; Luna, Lima, et al., 2008). The REMANE's

successful performance in the rescue of stranded calves has greatly contributed to the conservation of Antillean manatees in Brazil, considering that 76% of manatees were rehabilitated and reintroduced into their natural environment (Normande et al., 2015, 2016).

Dead Manatees

The death of aquatic mammals due to entanglement in fishing nets has been frequently reported (Goldstein et al., 1999; Machado, Oliveira, & Montealegre-Quijano, 2015; Morizur, Berrow, Tregenza, Couperus, & Pouvreau, 1999; Ott et al., 2002; Read, 2008; Vidal, Waerebeek, & Findley, 1994; Yousuf et al., 2009). In northeast Brazil, these records have become priority in the last two decades, with the strengthening of the REMANE (Batista, Schiavetti, Santos, & Reis, 2012; Meirelles et al., 2009; Meirelles, Ribeiro, Siva, & Soares Filho 2010; Monteiro-Neto et al., 2000). Some small cetacean and sirenian species are incidentally captured in fishing nets because of their coastal habits (Adulyanukosol, Prasittipornkul, Man-Anansap, & Boukaew, 2009; Borgonia, Moreira, & Barreto, 2002; Cremer et al., 2013; Danilewicz et al., 2009; Dawson, 2006; Rodas-Trejo, Romero-Berny, & Estrada, 2008; Rojas-Bracho, Reeves, & Jaramillo-Legorreta, 2006; Rosas, Monteiro-Filho, & Oliveira, 2002). For the Antillean manatee, interaction with fisheries is also a cause of stranding and death of young and adult specimens in Brazil and in other countries (Castelblanco-Martinez et al., 2009; de Thoisy et al., 2003; Marsh & Lefebvre, 1994; Mignucci-Giannoni et al., 2000). Most of the specimens found dead in the states of Amapá and Maranhão were adults in advanced state of decomposition making it difficult to determine the cause of death at necropsy. However, cuts, bruises in the head, and tail injuries consistent with fishing nets were observed in three of those specimens. External post-mortem examination indicated that the injuries were recent and interactions with fisheries may have led to death of animals by drowning. Gill nets (called *malha-deira* or *malhão*) are set perpendicularly to estuary channels in the state of Maranhão, obstructing the passage of manatees, which get entangled in the nets (Alvite, 2008). In the state of Ceará, manatees occur in coastal fishing areas (Alves et al., 2013), and the stranding and death of adults have been associated with the shrimp trawl activities (Meireles, 2008; Silva, Choi, & Carvalho, 2006). Collisions with motorboats may also cause edemas in the frontal part of the body and multiple cuts all over the body, as previously registered on the northeast coast of Brazil by Borges, Vergara-Parente, Alvite, Marcondes, and Lima (2007).

The present study did not aim to determine the cause of death of the reintroduced manatees (these specimens were considered in the group of calves stranded alive).

However, death caused by anthropogenic activities, such as debris ingestion (Attademo et al., 2015) and injuries by firearms and sharp piercing objects (data not published because it is part of a criminal investigation) have already been described.

Cold stress syndrome is one of the causes of manatee (*T. m. latirostris*) and dugong (*Dugon dugong*) stranding in Florida and Queensland, respectively (Ackerman et al., 1995; Fertl et al., 2005; Owen, Flint, Limpus, Palmieri, & Mills, 2013). There are no records of manatee stranding due to this syndrome anywhere where *T. m. manatus* is distributed, since the average temperature in the area of species distribution is around 24°C throughout the year, which is not a stress factor for the population.

The number of dead Antillean manatees analyzed here may be underestimated because the CMA/ICMBio has not conducted a systematic monitoring during the studied years. Furthermore, manatees found dead in the states of Ceará and Rio Grande do Norte have not been sent to the Rehabilitation center since 2006; and in the states of Pará and Amapá, dead animals are sent to other institutions and local universities. Brazil has a Monitoring System of Marine Mammals (SIMMAM, in Portuguese), in which the records of strandings and sightings are registered. It is our belief that a greater commitment toward keeping that database updated would allow for more realistic estimates of strandings, which in turn would help in the conservation of the species.

Implications for Conservation

Sirenians are K-strategists, have long lifespans, physically develop and reach sexual maturity slowly, produce small litters (often one offspring at a time), and provide long parental care for their few offspring (Reynolds & Marshall, 2012). The current scenario, associated with the species biological characteristics, raises the concern about the future of Antillean manatees in Brazil. Our hope is that the present study will stimulate researches into the causes of stranding of alive calves in the northeast region. It is also necessary to implement protection campaigns in fishing communities more often to prevent the death of manatees in the North and northeast regions. Finally, it is our hope that public policies for the conservation of the Antillean manatee continue for many years and include the conservation of their habitats as well, especially mangrove areas.

Acknowledgments

The authors thank L. N. Domingues for translating the manuscript and Ursula Migon for the revision and are grateful to anonymous reviewers, who provided valuable editorial comments on the manuscript. The authors also thank REMANE institutions, for their support and collaboration during the rescue of Antillean manatees.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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