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Mortality of the Antillean manatee, *Trichechus manatus manatus*, in Ceará State, north-eastern Brazil

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Manatee mortality in Ceará State (north-eastern Brazil) is analysed from twenty-five strandings between 1987 and 2002. The majority of the causes were related to the 'dependent calf' category (83.3%). Direct human-related causes were attributed to incidental catches in fishing gear (shrimp trawling and gill-nets) (12.5%) and direct capture (4.2%). Spatial distribution was not uniform, with the highest number of strandings on the east coast. The number of strandings has increased since 1999, and the seasonal distribution showed peaks in February, March and January, in that order. The stranding of manatee calves in Ceará State seems to be indirectly related to human activities that impact coastal nursing habitats.

Keywords: *Trichechus manatus manatus*; Antillean manatee; north-eastern Brazil; mortality.

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INTRODUCTION

The Antillean manatee, *Trichechus manatus manatus* Linnaeus 1758, is the most endangered aquatic mammal in Brazil (Oliveira *et al.*, 1990). The species has been protected since 1967 by federal laws and has been classified as 'critically endangered' since 1989 (IBAMA, 1989).

In Brazil, the species' original distribution extended from Espírito Santo (20°23′S) to Amapá States (04°25′N) (Whitehead, 1978), but now it is considered extinct from Espírito Santo, Bahia and Sergipe States (Albuquerque & Marcovaldi, 1982). Interviews with manatee hunters in north-eastern Brazil indicated that harpoons are not used anymore, and that dynamite was once used in Rio Grande do Norte State (Lima *et al.*, 1992). Nowadays, the incidental catch of manatees in gill-nets and shrimp trawling nets represent the majority of mortality cases in the area.

The first manatee mortality study in the region was conducted by Paludo (1998), who verified 33 events from 1981 to 1996, with 24 deaths (56% incidental catch in fishing gear). There was a high number of strandings of dependent calves (36.4%). Lima (1999) suggested that this occurs because the pregnant females are not gaining access to calm waters of estuarine areas to give birth. Parente *et al.* (2004) studied the manatee stranding records in north-eastern Brazil from 1981 to 2002, verifying 74 events, with 31 deaths (20 directly human-related) and 43 animals rescued alive and nurtured to rehabilitation.

In this paper, I document manatee mortality in Ceará State, north-eastern Brazil, analysing the causes and consequences of these events for the species in the area.

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MATERIALS AND METHODS

The study area comprises the coastal zone of the State of Ceará (02°30′S 41°15W–04°30′S 36°45′W), north-eastern Brazil. According to the National Coastal Zone Management Plan (Brazil, 1997), this region is divided into four zones: Far Western, Western, Fortaleza Metropolitan Region and Eastern (Figure 1).

The strandings documented in this study were recorded by Centro Mamíferos Aquáticos (CMA/IBAMA) and Associação de Pesquisa e Preservação de Mamíferos Marinhos—AQUASIS. From July 1996 to 1999, about one field trip per month was conducted along the coast. During these surveys, educational campaigns were also conducted in the coastal communities to build a collaborative network aimed at improving manatee stranding reports. The data from the other years included in this work were obtained from non-systematic surveys and reports from fishermen, government officials and tourists. Live animals were rescued by AQUASIS and transported to its Marine Mammal Rehabilitation Centre, where they received a special milk formula and clinical treatment. As soon as the animals recovered from the stranding stress, they were transported by aeroplane or car to the larger facilities of CMA/IBAMA (~800 km away). When animals stranded dead, carcasses were buried on the spot or transported to the laboratory for necropsy procedures, depending on the logistics and the condition of the carcass. All osteological materials were deposited in the AQUASIS Collection. In both cases, external examinations were conducted looking for scars and wounds.

The following variables associated with mortality events were analysed (Ackerman *et al.*, 1995; Mignucci-Giannoni *et al.*, 2000): cause of death; spatial distribution; temporal and seasonal distribution (spring: 23 September to 21 December; summer: 22 December to 20 March; autumn: 21 March to 20 June; and winter: 21 June to 22 September); condition

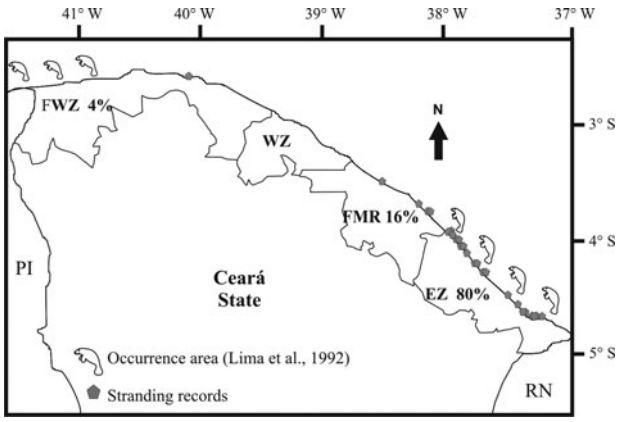

Fig. 1. Map of the study area in Ceará State (north-eastern Brazil) showing the division of the coast into four zones: (FWZ, Far Western Zone; WZ, Western Zone; FMR, Fortaleza Metropolitan Region; EZ, Eastern Zone), manatee stranding records, and the former range proposed by Lima *et al.* (1992).

of specimen; sex; and age-class (as there is no published information for *T. m. manatus*, age-class categories were based on data for *T. m. latirostris* (Marmontel, 1993)).

RESULTS

Twenty-five stranding events were reported in Ceará State from 1987 to 2002 (Table 1).

Cause of death

It was possible to determine the predominant cause of stranding in 24 out of 25 events (96%). The majority of these cases were due to natural causes (83.3%), all assigned to the 'dependent calf' category. 'Direct human-related' causes were due to incidental catch in fishing gear (12.5%) and direct capture (4.2%).

The fishing gear involved in the incidental catches were shrimp trawling nets, which killed a 2.72 m adult female and a 2.69 m adult male; and gill-nets, that captured a male calf (1.40 m total body length). 'Direct capture' was recorded when a fisherman took a newborn calf (1.12 m total body length) with his hands out of the water, driving off the mother.

Spatial distribution

The majority of events (80%) occurred on the eastern coast of Ceará State, and only one (4%) took place in the Far Western Zone, where a 1.32 m male stranded alive, but in poor health (Figure 1).

Temporal and seasonal distribution

The first case was recorded in January 1987, and the last event included in this study occurred in November 2002. There has been an increase in the number of cases reported since 1999, with 52% of the events occurring between 1999 and 2002 (Figure 2). The χ^2-test indicated a significant difference in the number of events reported along four-year blocks ($\chi^2 = 22.25$; $P < 0.01$). The events assigned to the 'dependent calf' category occurred in all four-year blocks, and the 'direct human-related' causes were recorded only after 2000.

The distribution of events along the seasons was not uniform ($\chi^2 = 14.84$; $P < 0.01$) with the highest number in summer (56%), followed by spring (24%), autumn (16%) and winter months (4%). The monthly temporal distribution was significantly different ($\chi^2 = 25.40$; $P < 0.01$) and showed

Table 1. Manatee mortality reported in Ceará State from 1987 to 2002.

Date	Size	Gender	Location (Beach/Zone)	Cause of death
January 1987	<1.75 m[a]	F	Barra de Sucatinga/EZ	Dependent calf
December 1990	1.29 m[b]	F	Barro Preto/FMR	Dependent calf
February 1991	1.20 m[b]	F	Morro Branco/EZ	Dependent calf
April 1991	1.35 m[b]	M	Fontainhas/EZ	Dependent calf
March 1992	<1.75 m[a]	M	Icaraí/FMR	Dependent calf
February 1993	1.35 m[b]	F	Morro Branco/EZ	Dependent calf
January 1995	~2.0 m	I	Parajuru/EZ	Undetermined
February 1996	1.14 m[b]	M	Quixaba/EZ	Dependent calf
March 1996	1.16 m[b]	F	Parajuru/EZ	Dependent calf
December 1996	1.28 m[b]	M	Retiro Grande/EZ	Dependent calf
February 1997	1.18 m[b]	M	Aracati/EZ	Dependent calf
October 1997	1.27 m[b]	F	Praia do Diogo/EZ	Dependent calf
February 1999	1.32 m	M	Praia da Volta do Rio/EZ	Dependent calf
February 1999	1.54 m	M	Porto das Dunas/FMR	Dependent calf
February 2000	1.39 m	M	Retiro Grande/EZ	Dependent calf
July 2000	2.69 m	M	Quixaba/EZ	Entanglement
November 2000	1.35 m	M	Lagoa de Dentro/EZ	Dependent calf
January 2001	1.37 m	F	Balbino/EZ	Dependent calf
January 2001	2.72 m	F	Fontainhas/EZ	Entanglement
March 2001	1.23 m	M	Prainha do Canto Verde/EZ	Dependent calf
March 2001	1.28 m	F	Canoa Quebrada/EZ	Dependent calf
March 2001	1.40 m	M	Retiro Grande/EZ	Entanglement
May 2002	1.12 m	M	Redonda/EZ	Intencional capture
October 2002	1.41 m	M	Barro Preto/FMR	Dependent calf
November 2002	1.30 m	F	Prainha do Canto Verde/EZ	Dependent calf

[a] Not available in Centro Mamíferos Aquáticos/IBAMA database. [b] Data provided by Centro Mamíferos Aquáticos/IBAMA.

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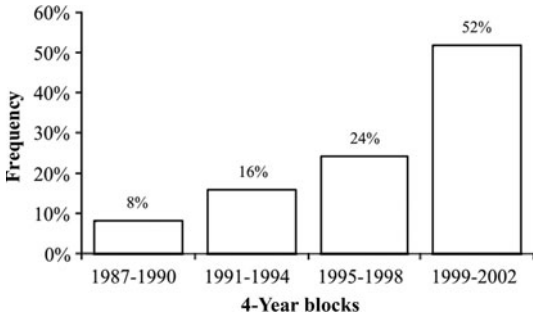

Fig. 2. Frequency distribution of manatee mortality records in Ceará State, showing the increase in the number of cases along the four-year blocks.

peaks in February (28%), March (20%) and January (16%) (Figure 3).

Condition of specimens

The majority of the animals stranded alive (80%), while some died recently (12%) and a smaller percentage was found in an advanced state of decomposition (8%).

Sex

Sex was determined in 96% of the cases. Of these, males constituted 58.33% (N = 14) and females 41.67% (N = 10). The χ^2-test indicated no significant difference between the sex ratio ($\chi^2 = 0.6667$; $P > 0.05$).

Age-class

Age-class was determined for all cases. The majority were calves (88%), followed by adults (8%) and subadults (4%). The smallest animal recorded was a 1.12 m-long male with umbilical remains, which stranded on Redonda Beach, in the Eastern Zone, after being intentionally captured by a fisherman. The largest animal was a 2.72 m female accidentally captured by a shrimp bottom trawler.

DISCUSSION

Cause of death

Manatee mortality in Ceará State differs when compared with data from Florida (Ackerman *et al.*, 1995), where 32.5% of the events were due to direct human interaction and 35% were due to natural causes (20.9% dependent calves); and Puerto Rico (Mignucci-Giannoni *et al.*, 2000), where the majority of cases were due to direct human interaction (49.3%) and 24.1% were due to natural causes (21.5% dependent calves).

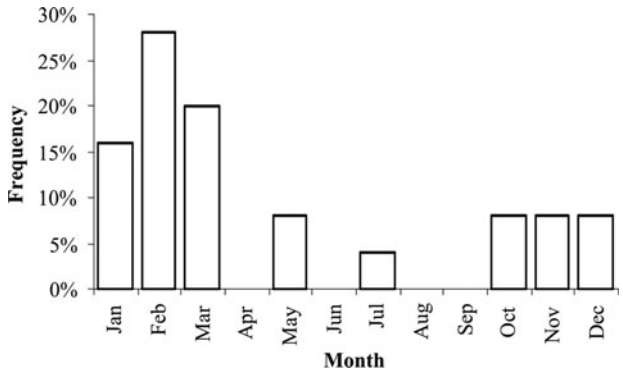

Fig. 3. Monthly frequency distribution of manatee deaths in Ceará State.

According to Bonde *et al.* (1983), calf strandings are considered a natural cause because perinatal manatees can suffer from malnutrition, umbilical infection, diarrhoea or bacterial infection. However, in Ceará State the majority of stranded calves showed no evidence of disease, except for signs of dehydration.

According to Bossart (1999), the high dependent-calf mortality observed in the United States can be related to two different factors, operating independently or combined: first, the adult females may be killed, leaving dependent calves behind. These animals die from malnutrition or/and opportunistic disease; second, experienced females, that had already given birth several times, may be killed at such a high rate that inexperienced females, that had never given birth, are recruited into the breeding population. These females may abandon their calves, which die from the mentioned causes. 'Dependent calf' deaths, therefore, may represent indirect human-related mortality.

Hartman (1979) reported that the Florida manatee looks for calm waters in canals, creeks, lagoons and rivers, which provide habitat for feeding, resting, cavorting, mating and calving. Lima *et al.* (1992) suggested that in Rio Grande do Norte and Ceará States, the pregnant females were not gaining access to these sheltered places to give birth, and the calves were born in areas with strong winds and coastal currents, resulting in strandings.

On the eastern coast of Ceará State, where the majority of events were recorded, the coastline is very linear, and there are no embayments, lagoons or other sheltered coastal areas, except for a few river mouths and estuaries. Although there are no recent records of manatees inside the estuaries, ethnobiological records in the Jaguaribe River indicate that the animal was present when the river was deeper, a few decades ago. Nowadays, especially in this estuary, there is a great deal of boating activity. According to the US Fish and Wildlife Service (1999), this activity can cause stresses in manatees, leading to disruption of normal breeding behaviour, disruption of cow–calf bonding, interference with migration routes and patterns, and the loss of feeding areas. Thus, boating activity in the Jaguaribe River could be driving the manatees away from the estuary, and driving them to other sheltered areas, as suggested by Alves (2003).

A major issue in the Jaguaribe River estuary is the silting process caused by marginal and mangrove deforestation, especially to build shrimp grow-out ponds. In Ceará State, the fast growth of marine shrimp culture has been destroying mangrove areas along the coast (Campos *et al.*, 2003), and according to Gesteira *et al.* (2001), the estuarine region of the Jaguaribe River concentrates the highest number of farms in the State, probably over its carrying capacity. Besides reducing available sheltered areas by mangrove deforestation and landfilling, shrimp farms also promote reduction in water quality by the discharge of chemicals and hypersaline waters, and increase the silting process that makes the river shallower, which will also limit manatee access into the estuary. Thus, the stranding of dependent calves on the eastern coast of Ceará State seems to be indirectly human-related, caused by the degradation of a critical habitat for the species.

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In the Far Western Zone of Ceará State, where only one of the manatee strandings occurred, Lima (1999) recorded the presence of manatees in Bitupitá municipality, where four rivers meet in the border of Ceará and Piauí States to form a large estuarine area. This estuary is still little impacted by human activities, and manatees are sighted frequently. Differently from the Jaguaribe River, the manatees that inhabit this estuary have more undisturbed sheltered areas available for feeding and calving. According to Parente *et al.* (2004) there are no manatee stranding records in the area, which corroborates this hypothesis.

The 'direct human-related' causes recorded in this study are different from those observed in Florida (Ackerman *et al.*, 1995), where 77.6% of manatee mortalities were caused by watercraft collisions and 13.2% were due to injuries in flood control structures. In Ceará State these events were not observed, mainly because the majority of vessels are sailing boats used in the coastal artisanal fisheries, while in Florida according to the Marine Mammal Commission (1992) there are a great number of fast motor boats of recreational use.

Incidental and intentional catches were the only human-related causes recorded in Ceará State, representing 16.7% of all identifiable causes. Paludo (1998) conducted a study in north-eastern Brazil and verified that 54% of all manatee deaths were related to fishing activities. In Florida these events are ranked as 'other human related' (together with 'vandalism', 'debris ingestion', and others) and were observed only in 3% of the events (Ackerman *et al.*, 1995). However, in Puerto Rico 31.6% of the cases were due to fishing activities, and the majority was related to intentional catches (Mignucci-Giannoni *et al.*, 2000). In this study, the incidental capture in fishing gear was responsible for the death of three animals (12.5%). In Ceará State, fishing activities have great social and economic importance, supporting the livelihood of most coastal communities. Gill-nets, shrimp trawling nets—which captured manatees in the study area—hand lines, long lines, bottom drift-nets, and lobster traps are responsible for the majority of the states' fisheries production (AQUASIS, 2003).

The shrimp trawls that captured the two adult manatees recorded in this study were first used in Ceará State in the 1970s. Before this, shrimp catches were restricted to the beach area and performed manually, but with motorized boats the fisheries extended to a vast portion of the shallow waters used by the manatees. Besides being a threat to the manatees, this type of fishing gear captures a great amount of by-catch, which is discarded (Isaac & Braga, 1999), degrades the benthic environment, and destroys the algae and sea grass beds (Green & Short, 2003).

In 1967, a federal decree (No. 221) prohibited the use of shrimp trawling nets in north-eastern Brazil in less than three nautical miles from the coast. However, in 1986 another legal instrument allowed the use of this type of fishing gear between the mouth of Choró River (38°23′W) and Ponta Grossa (37°30′W), eastern Ceará, in waters deeper than 5 m. The two adult manatees recorded here were captured inside this area by trawlers from Quixaba community, in Aracati municipality. The adult male captured by a Quixaba boat was butchered on the beach by the community for local consumption.

Spatial distribution

According to Lima *et al.* (1992) in Ceará State there is a discontinuity in manatee distribution between Iguape Beach, in the Eastern Zone, and Jericoacoara Beach, in the Far Western Zone (Figure 3). Some of the events recorded in this work took place in the Fortaleza Metropolitan Region, inside the proposed gap mentioned above. These strandings could be explained by the action of the strong coastal current that runs westward along the coast of Ceará. Thus, dead animals or lost calves from the east coast could be carried by this current to the central metropolitan coast.

The only case reported in the Far Western Zone was also out of the range proposed earlier (Figure 3). The absence of coastal communities in some areas with poor road access could limit the number of reports from those areas.

Temporal and seasonal distribution

The increase in the number of events reported in the study area through the years is not necessarily related to an increase in the death rate of manatees, but may be a response from the coastal communities to the educational campaigns developed by AQUASIS in the state, informing the public about the need to protect the endangered manatees, and how to report strandings.

Since 88% of the events in Ceará State were related to dependent calves, and most of these occurred in the summer months (from January to March), this may represent the period when most manatee calves are born. Alves (2003, 2007) conducted land-based monitoring of manatees on the eastern coast of Ceará from 2002 to 2005, observing breeding behaviour only once (in February), and a peak in the sightings of females with calves from October to March, supporting the summer breeding hypothesis. This indirect evidence is the first record for South America of seasonal calving in Antillean manatees. Rathbun *et al.* (1995) reported seasonal calving in Florida manatees, with a peak in mating and parturition in boreal spring (March–May), possibly related to water temperature.

Age-class

The age-class ratio inequalities seem to be related to the different manatee mortality causes. According to Ackerman *et al.* (1995), age-classes have different vulnerability, and this difference can be inferred from the ratio observed.

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REFERENCES

Ackerman B.B., Wright S.D., Bonde R.K., Odell D.K. and Banowetz D.J. (1995) Trends and patterns in mortality of Manatee in Florida, 1974–1992. In T.J. O'Shea *et al.* (eds) *Population biology of the Florida manatee*. Washington, DC: National Biological Service

https://doi.org/10.1017/S0025315408000817 Published online by Cambridge University Press

Information and Technology Report 1, US Department of the Interior, pp. 223–258.

Albuquerque C. and Marcovaldi G.M. (1982) Ocorrência e distribuição do peixe-boi marinho no litoral brasileiro (SIRENIA, Trichechidae, *Trichechus manatus*, Linnaeus, 1758). In *Proceedings of the First Simpósio Internacional sobre a utilização de Ecossistemas Costeiros: Planejamento, Poluição e Produtividade* 27.

Alves M.D.O. (2003) *Monitoramento de peixe-boi marinho,* Trichechus manatus manatus *Linnaeus 1758, por meio de ponto fixo, no município de Icapuí, litoral leste do Ceará*. BA Monograph, Universidade Federal do Ceará, Fortaleza, Brazil.

Alves M.D.O. (2007) *Peixe-boi marinho,* Trichechus manatus manatus: *ecologia e conhecimento tradicional no Ceará e Rio Grande do Norte, Brasil*. MSc thesis, Universidade Federal de Pernambuco, Brazil.

Bonde R.K., O'Shea T.J. and Beck C.A.A. (1983) *A manual of procedures for the salvage and necropsy of carcasses of the West Indian Manatee* (Trichechus manatus latirostris). National Technical Information Service, Springfield, Va. Document PB 83-255273, 175 p.

Bossart G.D. (1999) The Florida manatee: on the verge of extinction? *Journal of the American Veterinary Medical Association* 214, 1178–1183.

Campos A.A., Monteiro A.Q., Monteiro-Neto C. and Pollete M. (2003) *A Zona Costeira do Ceará: diagnóstico para a Gestão Integrada*. AQUASIS, Fortaleza, Brazil, 248 p.

Gesteira T.C.V., Nunes A.J.P. and Miranda P.T.C. (2001) Expansão da carcinicultura marinha no estado do Ceará. In *Proceedings of the Twelfth Congresso Brasileiro de Engenharia de Pesca, Foz do Iguaçu, Brazil*.

Green E.P. and Short F.T. (2003) *World atlas of seagrasses: present status and future conservation*. Berkeley, USA: University of California Press.

Hartman D.S. (1979) Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. *American Society of Mammalogists Special Publication* 5, 1–53.

IBAMA (1989) *Lista Oficial das espécies da fauna brasileira ameaçada de Extinção*. Portaria no. 1522, 19/12/1989.

Isaac V.J. and Braga T.M.P. (1999) Rejeição de pescado nas pescarias da região norte do Brasil. *Arquivo de Ciências do Mar* 32, 39–54.

Lima R.P. (1999) Peixe-boi marinho (*Trichechus manatus*): distribuição, status de conservação e aspectos tradicionais ao longo do litoral nordeste do Brasil. *Série Meio ambiente em debate* 30, IBAMA, 73 p.

Lima R.P., Paludo D., Soavinski R.J., Silva K.G. and Oliveira E.M.A. (1992) Levantamento da distribuição, ocorrência e status de conservação do peixe-boi marinho (*Trichechus manatus*, Linnaeus, 1758) no litoral nordeste do Brasil. Peixe-boi. *Coletânea de Trabalhos de Conservação e Pesquisa de Sirênios no Brasil*. MMA/IBAMA 1, 47–72.

Marine Mammal Commission (MMC) (1992) *Annual Report to Congress*, 1991. Tallahassee, Florida: Marine Mammal Commission.

Marmontel M. (1993) *Age determination and population biology of the Florida manatee*, Trichechus manatus latirostris. PhD thesis, University of Florida, Gainsville, USA.

Mignucci-Giannoni A., Montoya-Ospina R.A., Jiménez-Marrero N.M., Rodríguez-López M.A. Jr, Williams E.H. and Bonde R.K. (2000) Manatee mortality in Puerto Rico. *Environmental Management* 25, 189–198.

Oliveira E.M.A., Langguth A., Silva K.G., Soavinski R.J. and Lima R.P. (1990) Mortalidade de peixe-boi marinho (*Trichechus manatus*) na costa nordeste do Brasil. In *Proceedings of the Fourth Reunião de Trabalho de Especialistas em Mamíferos Aquáticos da América do Sul, Valdívia, Chile*, pp. 191–196.

Paludo D. (1998) Estudos sobre a ecologia e conservação do peixe-boi marinho *Trichechus manatus manatus* no nordeste do Brasil. *Série Meio ambiente em debate* 22, IBAMA, 70 p.

Parente C.L., Vergara-Parente J.E. and Lima R.P. (2004) Strandings of Antillean manatees, *Trichechus manatus manatus*, in northeastern Brazil. *Latin American Journal of Aquatic Mammals* 3, 69–75.

Rathbun G.B., Reid J.P., Bonde R.K. and Powell J.A. (1995) Reproduction in free-ranging Florida Manatees. In O'Shea T.J. *et al.* (eds) *Population biology of the Florida manatee*. Washington, DC: National Biological Service Information and Technology Report 1, US Department of the Interior, pp. 135–156.

US Fish and Wildlife Service, (1999) *South Florida multi-species recovery plan*. Atlanta, Georgia, 2172 p.

and

Whitehead P.J.P. (1978) Registros antigos da presença do peixe-boi do Caribe (*Trichechus manatus*) no Brasil. *Acta Amazônica* 8, 497–506.

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