

## STRANDINGS OF ANTILLEAN MANATEES, *TRICHECHUS MANATUS MANATUS*, IN NORTHEASTERN BRAZIL

Cristiano Leite Parente <sup>1,\*</sup>, Jociery Einhardt Vergara-Parente <sup>2</sup> and Régis Pinto de Lima <sup>3</sup>

**Abstract** – The Antillean manatee (*Trichechus manatus manatus*) is considered to be one of the most endangered aquatic mammals in Brazil. From 1981 through 2002 an extensive research was performed to collect information about stranding of manatees on the northeast coast of Brazil. Data were separated in two distinct periods (1981-1990 and 1991-2002) and analyzed according to specific categories: stranded dead (captured by nets, captured by harpoons and undefined cause) and stranded alive (dead in captivity and captive population). There were 74 events of stranding manatees in the period surveyed. Thirty-one events of dead manatees and 43 events of specimens that survived until December 2002 were recorded. In the last years of the study there were more strandings of alive animals than dead. The main reason for the strandings of manatee calves in northeastern Brazil is the separation from their mothers. The largest numbers of stranded manatees occurred in Ceará and Rio Grande do Norte states.

**Resumo** – O peixe-boi marinho (*Trichechus manatus manatus*) é considerado um dos mamíferos aquáticos mais ameaçados do Brasil. Entre 1981 e 2002 foi realizado um extenso levantamento de informações sobre os encalhes de peixes-boi marinho na costa nordeste do Brasil. Os dados foram dispostos em dois períodos distintos (1981-1990 e 1991-2002) e analisados conforme categorias: encalhados mortos (capturado por rede, capturado por arpão e causa indeterminada) e encalhados vivos (morto no cativeiro e população em cativeiro). Ocorreram 74 encalhes de peixes-bois no Brasil durante o período estudado dos quais 31 casos de mortes e 43 casos de animais que permaneceram vivos até dezembro de 2002. O principal motivo de encalhes no nordeste do Brasil está relacionado à separação dos filhotes de peixes-boi marinhos de suas mães. Os estados onde ocorreram maiores registros de encalhes de peixe-boi marinho foram o Ceará e o Rio Grande do Norte.

**Keywords:** Northeastern Brazil, Antillean manatee, Stranding, Rescue.

### Introduction

The West Indian manatee (*Trichechus manatus*), a species of sirenian of the Trichechidae family, is subdivided into two subspecies: *T. m. latirostris*, also known as Florida manatee and *T. m. manatus*, known as the Caribbean or Antillean manatee (Hatt, 1934). The first subspecies is found primarily in peninsular Florida. The Antillean manatee ranges from Central America to northeastern Brazil (Domning and Hayek, 1986; Lima, 1997; Manatee Population Status Working Group, 2000). Both subspecies are classified as “vulnerable” by The World Conservation Union (IUCN) due to the estimated reduction of individuals of the species and degradation of their habitat in areas where they are found (Hilton-Taylor, 2000). In Brazil the manatee is considered to be one of the most endangered aquatic mammals (IBAMA, 2001). This classification is based on results of surveys that have been conducted since the 1980s (Albuquerque and Marcovaldi, 1982<sup>4</sup>; Best and Teixeira 1982; Borobia and Lodi 1992; Lima, 1997).

The historical distribution of the Antillean manatee in Brazil ranged from Espírito Santo state to Amapá state (Whitehead, 1978). Surveys conducted along the northeast and north regions of Brazil by governmental agencies have shown that the present distribution of the Antillean manatee has been reduced to coastal areas between Alagoas and Amapá states (Albuquerque and Marcovaldi, 1982; Lima, 1997).

In the early nineties Oliveira *et al.* (1994) presented a study conducted between 1981 and 1991 which identified and quantified causes of manatee mortality. This study expands the analyses of stranding records of Antillean manatees in northeastern Brazil up to December 2002. With the creation of a center for rescue and rehabilitation of Antillean manatees in northeastern Brazil in 1991, there was interest in examining potential differences between the number of stranding records that occurred before and after 1991. This study focused on four main questions: (1) Do more manatees strand alive or dead? (2) Why are there live manatee strandings? (3) Which states in northeastern Brazil have higher number of strandings? (4) Is there a time of the year when manatees strand more often?

### Material and Methods

Information about stranding events of Antillean manatees was obtained through the Aquatic Mammal Rescue Program at the National Center for Research, Conservation and Handling of Aquatic Mammals (“CMA” in Portuguese). Such information consists of reports given by the community.

The CMA, together with Aquatic Mammal Foundation (“FMA” in Portuguese) and other institutions, conducts yearly campaigns to educate the communities in the northeastern coast about the importance of conservation of the Antillean manatee and other species of aquatic mammals.

<sup>1</sup>Rua João Sales de Menezes, 419-502-B, Recife, PE 50670-390 Brazil.

\* Corresponding author, e-mail: crparente@pop.com.br

<sup>2</sup>Fundação Mamíferos Aquáticos. Caixa Postal 01, Ilha de Itamaracá, PE 53900-000 Brazil.

<sup>3</sup>Centro Mamíferos Aquáticos/IBAMA. Caixa Postal 01, Ilha de Itamaracá, PE 53900-000 Brazil.

<sup>4</sup>Albuquerque, C and Marcovaldi, G.M. (1982) *Ocorrência e distribuição das populações do peixe-boi marinho no litoral brasileiro* (SIRENIA, Trichechidae, *Trichechus manatus*, Linnaeus, 1758). Page 27 in Abstracts, Symposium of Utilization of Coastal Ecosystem: Planning, Pollution and Productivity, November 22-25, Rio Grande, RS Brasil.

However, these campaigns have not been conducted on a regular basis throughout all these years. In the campaigns, posters were handed out, lectures were given and a toll-free telephone line was made available to the communities so that any (dead or alive) stranding event could be reported. In cases of live strandings, either of calf or of adult manatees, the CMA was asked to conduct an immediate release in case the specimen was healthy and certain criteria were met (*e.g.*, presence of conspecifics in the area, and favourable environmental conditions) or to rescue the animal and transport it to the rehabilitation pools in Itamaracá, Pernambuco state. Both types of rescues were performed by CMA, through one of its field stations and by other institutions participating in the Northeastern Aquatic Mammal Stranding Network ("REMANE" in Portuguese), depending on the location where the event occurred. At distances of up to 500 km from the CMA, the animal was transported by car; otherwise, it was transferred by plane. The study covered an area that ranged from the Gurupí river ( $3^{\circ} 39'S, 46^{\circ} 41'W$ ) to the mouth of the Real river ( $11^{\circ} 24.7'S, 37^{\circ} 26.1'W$ ) in northeastern Brazil (Figure 1).

In Itamaracá, the animal was placed in a quarantine pool when rescued alive. A medical test was subsequently performed to define the food, monitoring and treatment to be recommended. According to Miller (1996), quarantine is a basic component of preventive medicine programs in zoos and parks. It is a fundamental step towards the prevention of dissemination of diseases among the specimens in the area.

Dead specimens were taken to the Aquatic Mammal Laboratory in the CMA, where necropsies were carried out and biological material was collected for histological

analysis whenever viable samples were available. Finally, all the information was stored in the Biological Material Collection (BMC) of the Aquatic Mammal Center's computerized databank.

The analyses were separated in two groups. The first analysis included events occurring between 1981-1990, presented by Oliveira *et al.* (1994) when there was neither a rehabilitation center nor periodic campaigns. The second included events that took place between 1991-2002, when there was a rehabilitation center and periodic campaigns. The BMC information of stranded specimens was processed and classified in two categories (dead and alive) and five events as below:

1) Stranded dead - those animals founded dead due to the following events:

- a) *Captured by nets*: when the animal died due to be entangled in any kind of fishing net;
- b) *Captured by harpoon*: when there were indications that the manatee was killed with harpoon use;
- c) *Undefined dead*: cases in which the animal was found dead and the cause of death was impossible to be determined, usually due to the advanced state of decomposition.

2) Stranded alive - those manatees found alive and transferred to captive facilities according to the following events:

- a) *Dead in captivity*: when specimen was found stranded alive and taken to captivity where it was kept until they died.
- b) *Captive population*: stranded animal was rescued and taken to captivity.

Comparative analyses were conducted using the annual average of strandings and considering categories in relation to years and months. Statistics tests were done with software BioEstat 3.0 (Ayres *et al.*, 2003).

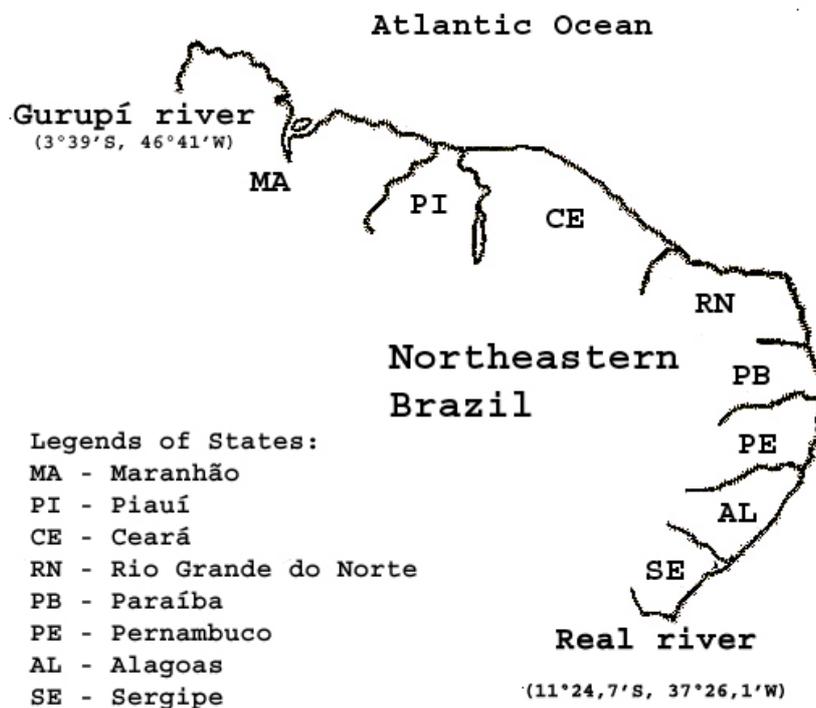


Figure 1. Map of the surveyed area of Antillean manatees stranded between 1981 and 2002.

## Results and Discussion

### General Analysis

In the period between 1981 and 2002, 74 stranding Antilleans manatees (dead or alive) were reported on the northeastern coast of Brazil (Table 1) with an average of three stranded manatees per year. An annual mean of 2.7 (SD  $\pm$  3.3) and 5.0 (SD  $\pm$  1.6) stranded manatees was reported from 1981 to 1990 and from 1991 to 2002, respectively. High inter-annual variation in the number of stranded manatees was observed (Figure 2). The *Chi-square* test with *Yates correction* showed significant differences between the stranding in the two periods ( $\chi^2 = 13.692$ ,  $p = 0.0002$ ; *Yates* = 11.778,  $p = 0.0006$ ). These differences might be a consequence of the differing effort in the two study periods. This happened due to the increase in the monitoring effort after the establishment of a specialized center and the beginning of co-administration of the Manatee Project with FMA that provided periodic educational campaigns in coastal communities.

The number of events may appear small when compared to stranded number of Florida manatees (*Trichechus manatus latirostris*) in North America, where more than 4,000 specimens have been killed since 1974 (Bonde *et al.*, 1983; O'Shea *et al.*, 1985; Van-Meter, 2001; Ackerman *et al.* in O'Shea *et al.*, 1992). Mignucci-Giannoni *et al.* (2000) recorded 90 cases of manatee strandings in Puerto Rico from 1990 through 1995. Whereas those studies included adult animals, all the live stranded Antillean manatees (*Trichechus manatus manatus*) in northeastern Brazil were of dependent calves (mean TL = 155.7cm; range: 109-245cm).

### Analysis of Categories and Events

The characteristics of stranding records of manatees along

the Brazilian northeastern coast showed significant change during the period of study. A *Kruskal-Wallis* test showed no significant differences between the events in the first ( $H = 2.1$ ;  $p = 0.7173$ ) and significant difference in the second ( $H = 11.4$ ;  $p = 0.0229$ ) periods. The 'captured by nets' and 'captured by harpoon' categories together amounted to 57.9% of cases, accounting for the main causes of manatee strandings in the first period. These events represented 16.4% of all cases recorded in the second period (Figure 3). The number of manatees rescued and transferred to facilities (dead in captivity and captive population) in the period 1991-2002 was higher than total records in the period 1981-1990. This supports the findings of Lima *et al.* (1992) that strandings of orphan calves might be the main recent threat to the species in northeastern Brazil.

There were 43 reported cases of alive (58.1%) and 31 of dead (41.9%) manatees in the studied period. During the period 1981-1990 there were difference between occurrence of alive and dead manatees (*Poisson* = 2.59,  $p = 0.0097$ ) with a dominance of dead records. The differences also occurred in the second period (1991-2002) suggesting a large number of records of alive manatees (*Poisson* = -3.15,  $p = 0.0016$ ). The trends suggest that hunting pressure on the animals in their habitat may have declined through the years. In addition, more recently the communities have been actively participating in the rescue of stranded manatees, thus contributing for the conservation of the species in this area. The highest number of the "captured by harpoons" events happened in 1990. This year marks the beginning of the expeditions conducted by Manatee Project to estimate the distribution and status of conservation of the Antillean manatee along the north and northeastern coasts of Brazil (Lima *et al.*, 1992). Since 1990 cases of live strandings have become more common (Figure 2). This highlights the importance of educational campaigns and the systematic monitoring of beaches for stranded animals.

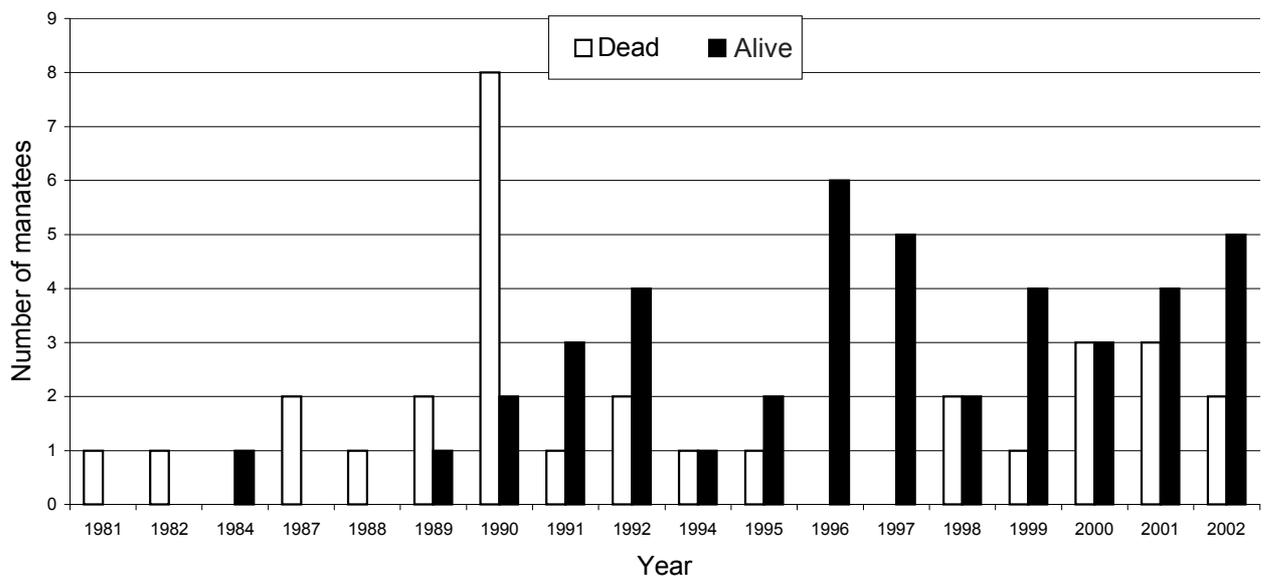


Figure 2. Distribution of Antillean manatee stranding records between 1981 and 2002 in northeastern Brazil.

**Table 1.** Stranding records of Antillean manatees in the northeastern Brazil according to location, date and category.

SOURCE OR CMA # CODE	SEX	TOTAL LENGTH (cm)	STATE	LOCATION	DATE	CATEGORY	EVENT
Oliveira <i>et al.</i> (1994)		120	PB	Tambaú	4/5/1981	Dead	Captured by nets
Oliveira <i>et al.</i> (1994)		190	PB	Bessa	18/3/1982	Dead	Captured by nets
Oliveira <i>et al.</i> (1994)		?	PE	Pau Amarelo	mar/84	Live	Dead in captivity
Oliveira <i>et al.</i> (1994)		?	PB	Barra de Mamanguape	21/1/1987	Dead	Captured by harpoons
Oliveira <i>et al.</i> (1994)		?	AL	Pajuçara	7/5/1987	Dead	Captured by harpoons
Oliveira <i>et al.</i> (1994)		?	RN	Natal	19/7/1988	Dead	Undefined cause
Oliveira <i>et al.</i> (1994)		268	PB	Lucena	5/1/1989	Dead	Captured by harpoons
Oliveira <i>et al.</i> (1994)		120	PB	Praia da Penha	23/3/1989	Dead	Captured by nets
S0112/1	♀	138	PE	Pau Amarelo	8/4/1989	Live	Dead in captivity
S0111/55	♂	135	PB	Jacumã	16/1/1990	Dead	Undefined cause
S0110/54	U	?	CE	Canoa Quebrada	1/2/1990	Live	Dead in captivity
S0112/81	♀	298	PB	Lucena	22/2/1990	Dead	Captured by nets
Oliveira <i>et al.</i> (1994)		130	RN	Barreta	11/3/1990	Dead	Captured by harpoons
Oliveira <i>et al.</i> (1994)		?	PB	Rio Abiaí	5/4/1990	Dead	Captured by harpoons
Oliveira <i>et al.</i> (1994)		210	RN	Maxaranguape	28/6/1990	Dead	Captured by harpoons
S0112/60	♀	310	AL	Barreiras	20/9/1990	Dead	Captured by harpoons
S0110/52	U	198	RN	Sagi	24/10/1990	Dead	Undefined cause
Oliveira <i>et al.</i> (1994)		320	AL	Maceió	28/10/1990	Dead	Undefined cause
S0112/2	♀	142	CE	Barro Preto	8/12/1990	Live	Captive population
S0111/3	♂	137,5	RN	Sagi	13/1/1991	Live	Captive population
S0112/4	♀	175	CE	Morro Branco	26/2/1991	Live	Captive population
S0111/5	♂	162,5	CE	Fontainha	24/4/1991	Live	Captive population
#	U	?	PB	Barra do Rio Gramame	8/7/1991	Dead	Captured by harpoons
S0112/6	♀	173	CE	Morro Branco	5/3/1992	Live	Captive population
S0112/7	♀	?	CE	Caucaia	18/3/1992	Live	Dead in captivity
#	U	?	PB	Baía da Traição	19/5/1992	Dead	Captured by harpoons
#	U	?	RN	Diogo Lopes	23/10/1992	Dead	Captured by nets
S0111/9	♂	264	CE	Muriú	18/12/1992	Live	Captive population
S0112/8	♀	266	CE	Morro Branco	18/12/1992	Live	Captive population
#	U	?	PE	Olinda	12/4/1994	Dead	Captured by nets
S0112/11	♀	259	RN	Pipa	21/5/1994	Live	Captive population
S0112/12	♀	108	AL	Jacarecica	28/7/1995	Live	Dead in captivity
S0111/13	♂	203	PB	Coqueirinho	8/12/1995	Live	Captive population
#	U	?	PB	Porto de Pedreira	16/12/1995	Dead	Captured by harpoons
S0111/14	♂	199	RN	Sagi	7/2/1996	Live	Captive population
S0111/15	♂	180	CE	Quixaba	23/2/1996	Live	Captive population
S0111/16	♂	185	MA	São Luís	2/3/1996	Live	Captive population
S0112/17	♂	109	CE	Parajuru	2/3/1996	Live	Dead in captivity
S0112/19	♀	204	RN	Pipa	5/11/1996	Live	Dead in captivity
S0112/20	♀	128	CE	Aracati	17/12/1996	Live	Dead in captivity
S0112/22	♀	93	PB	Barra de Mamanguape	27/1/1997	Live	Dead in captivity
S0111/23	♂	193,5	CE	Aracati	7/2/1997	Live	Captive population
S0110/56	U	170	RN	Baía Formosa	13/2/1997	Live	Dead in captivity
S0111/26	♂	169	RN	Tibau do Norte	13/10/1997	Live	Dead in captivity
S0112/27	♂	126	CE	Beberibe	14/10/1997	Live	Dead in captivity
S0112/31	♀	132	PB	Pitimbu	20/3/1998	Live	Dead in captivity
S0112/28	♀	245	PB	Barra de Mamanguape	30/3/1998	Live	Dead in captivity
S0111/24	♂	295	RN	Praia Zumbi	3/10/1998	Dead	Undefined cause
S0111/40	♂	~300	PB	Barra do Rio Miriri	30/10/1998	Dead	Captured by harpoons
S0111/33	♂	?	CE	Praíinha	16/2/1999	Dead	Undefined cause
S0111/34	♂	83	RN	Barra do Cunhaú	20/2/1999	Live	Dead in captivity
S0111/29	♂	138	CE	Acaraú	24/2/1999	Live	Dead in captivity
S0112/30	♀	130,5	PB	Barra de Camaratuba	26/3/1999	Live	Dead in captivity
S0120/93	U	145	RN	Areia Branca	5/11/1999	Live	Dead in captivity
S0111/94	♂	142	CE	Retiro Grande	26/2/2000	Live	Captive population
S0111/95	♂	137	RN	Redinha	5/6/2000	Live	Dead in captivity
AQUASIS	♂	?	CE	Ponta Grossa	6/7/2000	Dead	Captured by nets
S0111/96	♂	?	PB	Pitimbu	16/9/2000	Dead	Undefined cause
S0111/97	♂	?	PB	Baía da Traição	22/11/2000	Dead	Undefined cause
S0111/98	♂	135,5	CE	Lagoa de Dentro	22/11/2000	Live	Dead in captivity
S0112/99	♀	137	CE	Balbina	11/1/2001	Live	Captive population
S0112/100	♀	335	RN	Redinha	17/1/2001	Dead	Undefined cause
AQUASIS	U	?	CE	Fontainha	28/1/2001	Dead	Captured by nets
S0111/113	♂	123	CE	Canto Verde	20/3/2001	Live	Captive population
S0112/114	♀	128	CE	Canoa Quebrada	31/3/2001	Live	Dead in captivity
S0112/115	♀	?	PB	Not specified	21/4/2001	Dead	Undefined cause
S0112/116	♀	125	RN	Pipa	30/11/2001	Live	Captive population
S0111/117	♂	123	RN	Praia do Sal	11/4/2002	Live	Captive population
S0110/125	U	~300	MA	São José de Ribamar	21/4/2002	Dead	Captured by nets
S0112/126	♀	291	MA	São José de Ribamar	12/5/2002	Dead	Undefined cause
S0111/118	♂	112	CE	Redonda	31/5/2002	Live	Captive population
S0111/119	♂	141	CE	Barro Preto	22/10/2002	Live	Captive population
S0111/122	♂	140	RN	Areia Branca	1/11/2002	Live	Captive population
S0112/124	♀	126	CE	Canto Verde	15/11/2002	Live	Captive population

(#) report in Aquatic Mammals Center/IBAMA with no record number, (U) undetermined.

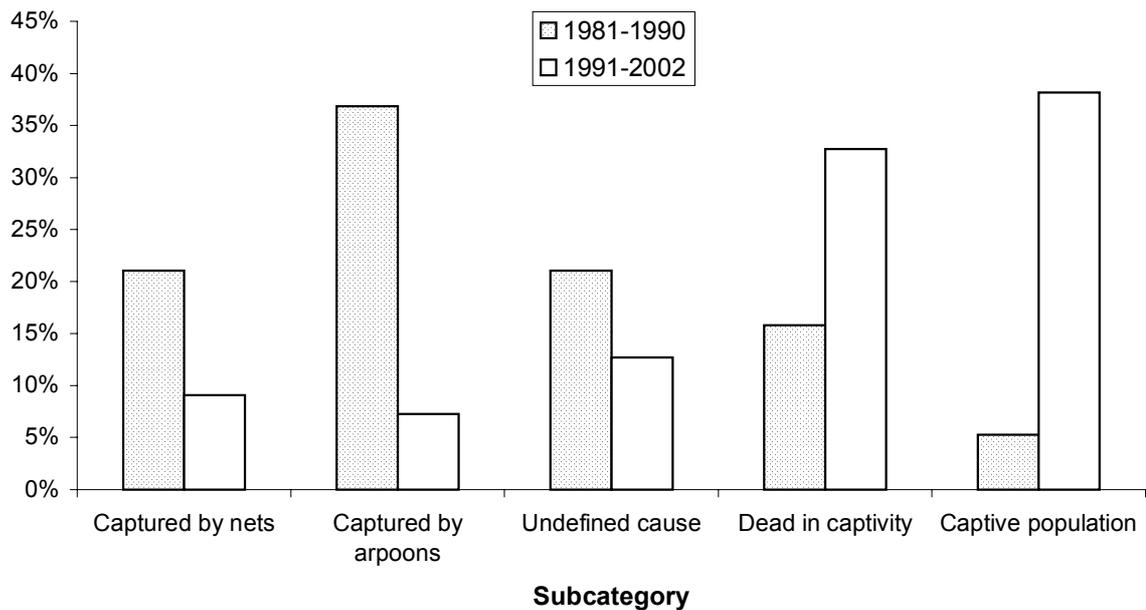


Figure 3: Stranding events of Antillean manatees recorded in northeastern Brazil during the study period.

All deaths of captive animals ("dead in captivity") occurred within a two-year period. Thus, the time limit for handling the species in captivity is shorter than two years and has to be determined.

Studies comparing bacteria in the upper respiratory tract of the manatees with those found in the water of the facilities revealed the possibility of infection of the specimens (Vergara-Parente *et al.*, 2003a). A fatal case of generalized infection caused by *Salmonella panama* was found in a calf with only 25 days of captivity (Vergara-Parente *et al.*, 2003b). Cultures with nasal secretion of the manatees revealed the presence of the bacteria *Klebsiella* sp., *Enterobacter* sp. and *Escherichia coli*. These bacteria, among other types, were cited as pathogenic agents in aquatic mammals maintained in captivity (Boness, 1997). Some analysis revealed the presence of the bacterium *Pseudomonas aeruginosa* in tissues of specimens with respiratory infections. Wallach and Boever (1983) stated that the bacterium *Pseudomonas aeruginosa* is responsible for bronchopneumonia, dermatitis, osteomyelitis and septicemia in bottlenose dolphins (*Tursiops truncatus*).

#### Stranding analysis by month

Considering just the category (dead or alive), strandings of live manatees occurred especially between October and May, with peaks in February and March (Figure 4). A similar analysis done by Mignucci-Giannoni *et al.* (2000) on the frequency of manatee strandings in Puerto Rico showed that those events were more common in March and October, with 30% occurring during summer. Our experience with captive animals indicated that calves were extremely sensitive to alterations in the environment. Lima *et al.* (1992) attributed the stranding of calves to the difficulty of pregnant females during delivery to find access to protected waters of estuaries. As a result, calving would

take place in waters with strong currents and waves, thus increasing the potential for mother-calf separation. No clear pattern of monthly stranding of manatees was observed; they occurred through the year except for month of August.

#### Regional Analysis

Confirming what was presented by Lima (1997), the states with the highest stranding number of live manatees were Ceará and Rio Grande do Norte (Table 2), between the areas of 3°43' - 5°47' S and 35°12' - 38°32' W. The strategy of implanting executive units in Alagoas, Pernambuco, Paraíba, Ceará and Piauí states, as well as the establishment of REMANE, have allowed for constant communication between the Manatee Project and coastal communities, and to immediate reporting of stranding cases. The Environmental Protection Areas of Barra de Mamanguape (Paraíba state), Costa dos Corais (Alagoas and Pernambuco states) and Cajueiro da Praia (Piauí state) were established to facilitate the accessibility of females and their calves to estuaries (recommendations made by Lima, 1997).

**Table 2.** Recorded numbers of Antillean manatees (*Trichechus manatus manatus*) stranded alive and dead in states of northeastern Brazil between 1981 and 2002.

STATES	COORDINATES	DEAD	ALIVE	TOTAL
Maranhão	02°S/044°W	2	1	3
Ceará	03°S/038°W	3	22	25
Rio Grande do Norte	05°S/035°W	7	12	19
Paraíba	07°S/034°W	15	5	20
Pernambuco	08°S/034°W	1	2	3
Alagoas	09°S/035°W	3	1	4
<b>Total</b>		<b>31</b>	<b>43</b>	<b>74</b>

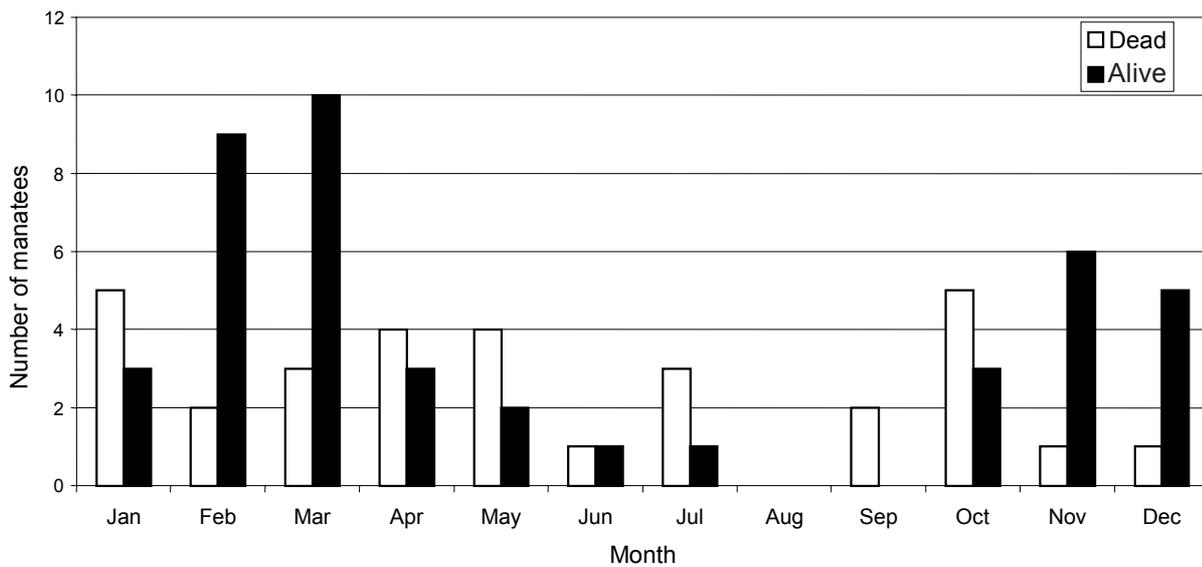


Figure 4: Temporal distribution for stranded Antillean manatees from 1981 to 2002 in northeastern Brazil.

Deaths of manatees “captured by nets” between 1991-2002 were slightly higher when compared to the previous years. These events occurred in the states of Ceará, Maranhão, Pernambuco and Rio Grande do Norte. Between 1981-1990 all cases occurred in Paraíba state (Oliveira *et al.*, 1994). It is important to note that in the first period analysed, the effort to ensure the conservation of the species was concentrated in Paraíba state due to the installation of the first base of the Manatee Project in the estuary of Barra de Mamanguape (Borobia and Lodi, 1992).

The accelerated growth of anthropic activities on the coastal zones such as the uncontrolled tourism and installation of aquaculture farms in estuarine areas, may have contributed to the increase of cases of stranded calves due to the reduction of the available habitats for calving and nursing.

Souza Lima (1999) studied the vocalization of Antillean manatees and inferred about the use of sounds in the communication between adult females and their calves. It is possible that other noise sources generated near calving and resting areas may constitute contributing factors to additional strandings of calves.

## Conclusions

The results of statistical analyses showed differences between the record numbers of live and dead manatees in both periods prevailing live stranded manatees during the last years. The high number of orphaned calves suggests that the main reason of the strandings in northeastern Brazil might be the separation of mothers from their calves.

The states with the largest numbers of stranded manatees were Ceará and Rio Grande do Norte, suggesting the need to establish conservation units in these states and increase of educational campaigns in the local communities. In addition, reports of manatees captured by harpoons and

captured by nets in recent years indicate that educational campaigns should also be extended to the states of Maranhão and Piauí.

Regarding the handling and care of manatees in captivity, we recommend that steps be taken to improve water quality to reduce the incidence of diseases in captive animals, as well as the development of procedures for analysis and control bacteria and other pathogenic agents that can be found in the aquatic environment.

The months with the largest number of stranded manatees were February and March. This period coincides with the period of rains in the states of Rio Grande do Norte and Ceará. Although there were peaks of strandings in those months, the educational campaigns and the monitoring should be accomplished regularly during the entire year. The larger number of dead specimens in the second period may be related to the increase in monitoring effort and educational campaigns along the coast.

## Acknowledgements

We would like to thank all individuals and institutions that contributed to the rescue and maintenance of the stranded manatees. We thank Nélio Barros and two anonymous reviewers for critical comments on the manuscript. Our especial thanks go to fishermen and the inhabitants of several communities who contacted CMA, and to cooperative institutions as well as REMANE management institutions that have contributed with information about strandings in their respective states since 2000.

## References

- Ackerman, B.B., Wright, S.D., Bonde, R.K., Odell D.K. and Banowetz, D.J. (1992) Trends and patterns in manatee mortality in Florida, 1974-1991. Page 22 *in* O’Shea, T.J.,

- Ackerman, B.B. and Percival, H.F. (Eds) *Interim report of the technical workshop on manatee population biology*. Manatee Population Research Report No.10. Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, Florida.
- Ayres, M., Ayres Jr., M., Ayres, D.L. and Santos, A.S. (2003) *BioEstat*. Version 3.0. Sociedade Mamirauá, MCT-CNPq, Belém, Pará, Brazil.
- Best, R.C. and Teixeira, D.M. (1982) Notas sobre a distribuição e status aparentes dos peixes-bois (Mammalia, Sirenia) nas costas amapaenses brasileiras. Rio de Janeiro, Brasil. *Boletim FBCN Rio de Janeiro, Brasil* 17: 41-47.
- Bonde, R.K., O'Shea, T.J. and Beck, C.A. (1983) *Manual of procedures for the salvage and necropsy of carcasses of the West Indian Manatee (Trichechus manatus)*. Sirenia Project, U.S. Fish and Wildlife Service, Gainesville, Florida.
- Boness, D.J. (1997) Water quality management in aquatic mammal exhibits. Pages 231-240 in Kleiman, D.G., Alen, M.E. and Thompson, K.V. *Wild mammals in captivity: principles and techniques*, University of Chicago Press. Chicago.
- Borobia, M and Lodi, L. (1992) Recent observations and records of the West Indian manatee *Trichechus manatus* in northeastern Brazil. *Conservation Biology* 59: 37-43.
- Hartman, D.S. (1979) Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. *American Society of Mammalogists* (special publication n. 5).
- Hilton-Taylor, C (Compiler) (2000) *2000 IUCN Red List of Threatened Species*. IUCN, Gland, Swizerland and Cambridge, UK. 61pp+ xviii. Downloaded on 08 March 2002.
- IBAMA (2001) *Mamíferos aquáticos do Brasil: plano de ação, Versão II*, Edições IBAMA, Brasília, Brasil.
- Lima, R.P. (1997) Peixe-boi marinho (*Trichechus manatus*): distribuição, status de conservação e aspectos tradicionais ao longo do litoral nordeste do Brasil. *MSc. Thesis*, Universidade Federal de Pernambuco, Recife, Brazil.
- Lima, R.P., Paludo, D., Silva, K.G., Soavinski, R.J. and Oliveira, E.M.A. (1992) Distribuição, ocorrência e status de conservação do peixe-boi marinho *Trichechus manatus* ao longo do litoral nordeste do Brasil. *Peixe-Boi - Coletânea de Trabalhos de Conservação e Pesquisas de Sirênios, Brasil* 1(1): 47-72.
- Luna, F.O. (2001) Distribuição, status de conservação e aspectos tradicionais do peixe-boi marinho (*Trichechus manatus manatus*) no litoral norte do Brasil. *MSc. Thesis*, Universidade Federal de Pernambuco, Recife, Brazil.
- Miller, R.E. (1996) Quarantine protocols and preventive medicine procedures for reptiles, birds and mammals in zoos. *Revue Scientifique et Technique de L'Office International des Epizooties* 15(1): 183-189.
- Manatee Population Status Working Group (2000) *Manatee Status Statement*. Annual report prepared by the Interagency Working Group: U.S. Fish and Wildlife Service, U.S. Geological Survey, Florida Fish and Wildlife Conservation Commission, Mote Marine Laboratory.
- Mignucci-Giannoni, A.A., Montoya-Ospina, R.A., Jiménez-Marrero, N.M., Rodríguez-López, M.A., Williams Jr., E.H. and Bonde, R.K. (2000) Manatee mortality in Puerto Rico. *Environmental Management* 25(2): 189-198.
- Oliveira, E., Langguth, A., Gurgel da Silva, K., Soavinsky, R.J. and Lima, R.P. (1994) Mortalidade do peixe-boi marinho (*Trichechus manatus* Linn.) na costa nordeste do Brasil. *4ª Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur*. 191-196.
- O'Shea, T.J., Beck, C.A., Bonde, R.K., Kochman, H.I. and Odell, D.K. (1985) An analysis of manatee mortality patterns in Florida, 1976-1981. *Journal of Wildlife Management*, 49: 1-11.
- Souza-Lima, R.S. (1999) Comunidade acústica em peixe-boi (Sirenia: Trichechidae): repertório, discriminação vocal e aplicações no manejo e conservação das espécies no Brasil. *MSc. Thesis*, Universidade Federal de Minas Gerais. Belo Horizonte, Brazil.
- Van-Meter, V.B. (2001) *The Florida manatee*. Florida Power & Light Company, Miami, Florida.
- Vergara-Parente, J.E., Sidrim, J.J.C., Pessoa, A.B.G.P., Parente, C.L., Marcondes, M.C.C., Teixeira, M.F.S. and Rocha, M.F.G. (2003a) Bacterial flora of upper respiratory tract of captive Antillean manatee. *Aquatic Mammals* 29(1):124-130.
- Vergara-Parente, J.E., Sidrim, J.J.C., Teixeira, M.F.S., Marcondes, M.C.C. and Rocha, M.F.G. (2003b) Salmonellosis in an Antillean manatee (*Trichechus manatus manatus*) calf: a fatal case. *Aquatic Mammals* 29(1): 131-136.
- Wallach, J.D. and Boever, W.J. (1983) Cetaceans and sirenians. Pages 686-725 in Wallach, J.D. and Boever, W.J. (Eds) *Diseases of exotic specimens: medical and surgical management*. W. B. Saunders Company, Philadelphia.

Received 22 October 2003. Accepted 20 April 2004.