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Distribution and Conservation of the Antillean Manatee (*Trichechus manatus manatus*) in NE Brazil

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FINAL REPORT

Execution

Sponsors

Institutional Partnerships

Summary

FINAL REPORT

This report presents the findings and discussions of the project "Distribution and Conservation of the Antillean Manatee (*Trichechus manatus manatus*) in NE Brazil", according to its main objectives:

- Determine the distribution of the Antillean Manatee in the east coast of the state of Ceará and west coast of the state of Rio Grande do Norte;
- Identify and describe the most important feeding and reproductive areas;
- Identify the major threats;
- Determine priority areas for the conservation of the Antillean Manatee in the region;
- Identify priority actions for the Antillean Manatee in the region

1. Introduction

The Antillean manatee, *Trichechus manatus manatus*, is the most endangered marine mammal in Brazil, with an estimated population of less than 200 individuals in the entire Brazilian coast (IUCN, 2009). In NE Brazil, the bordering area between the states of Ceará and Rio Grande do Norte corresponds to the most critical area for manatee conservation, since it holds the national record of strandings of neonates, representing the most significant population loss in the country. Twelve years ago, Lima (1997) indicated the east coast of Ceará State and the west coast of neighbouring Rio Grande do Norte as the main areas of neonate strandings. A more recent work (Parente et al., 2004) reviewed stranding data on Antillean manatee in Brazil, and concluded that neonate strandings in the same area are the main threats to the conservation of the species. In this sense, the project "Distribution and Conservation of the Antillean Manatee (*Trichechus manatus*) in NE Brazil" conducted field research and interviews in fishing communities in the study area. An extensive assessment was performed between January and December 2009 in order to determine manatee distribution, identify and describe the most important feeding and reproductive areas, identify major threats as well as determine priority areas and actions for manatee conservation.

2. Distribution of the Antillean manatee (*Trichechus manatus manatus*) on the east coast of Ceará state and west coast of Rio Grande do Norte state, northeastern Brazil

2.1. Data collection

The distribution of the Antillean Manatee, *Trichechus manatus manatus*, between Beberibe city, in the state of Ceará, and Touros city, in the state of Rio Grande do Norte, was determinate by the Traditional Ecological Knowledge (TEK) of fishermen in the region, obtained from semi-structured interviews with 10% of the 5.573 active fishermen from all fishing communities of the study area (Figure 01).

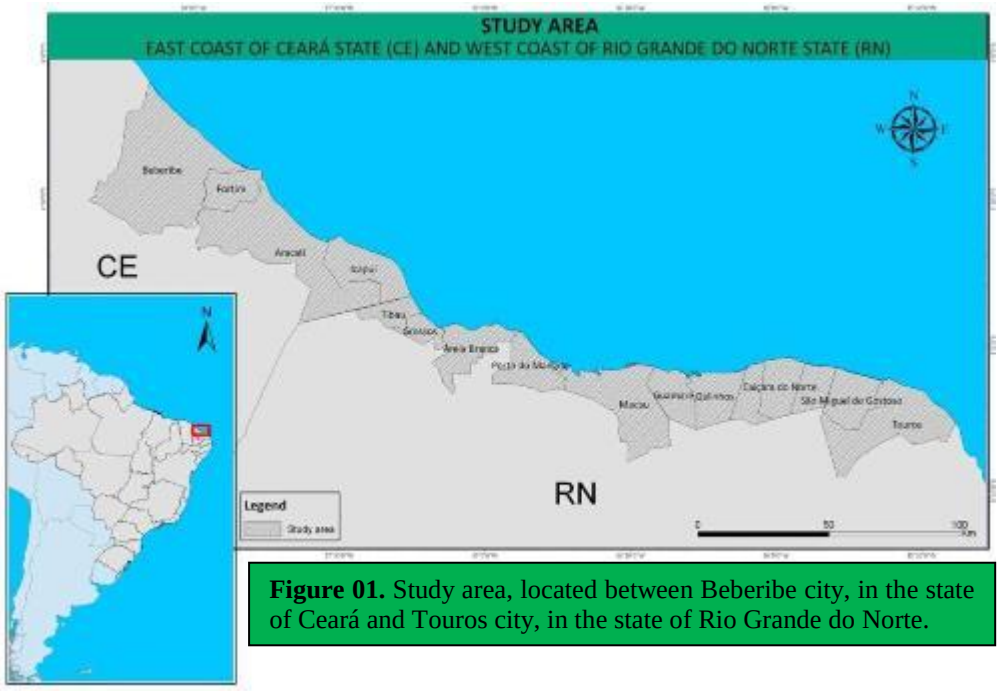


Figure 01. Study area, located between Beberibe city, in the state of Ceará and Touros city, in the state of Rio Grande do Norte.

2.1.1. Traditional Ecological Knowledge (TEK) as a tool for the study of Antillean manatee distribution

Ethno-biology studies the environmental knowledge of the local traditional communities, and contributes to conservation efforts, aiding in the understanding of organisms and their interactions (Begossi et al., 2002). Albuquerque (2002) states that to ensure biodiversity conservation, it is necessary to include local population knowledge, since many studies show that these populations have a refined knowledge about the environment where they live.

Interview is the most widely used method to study traditional population's knowledge. According to Viertler (2002), there is a balanced interface communication between the emic view (the interviewed) and the ethical vision (the researcher) during the interviews. The kind of interview most widely used is the "partially structured or semi-structured", in which some topics are predetermined and others are defined along the interview process, in order to guide the dialogue to the issues to be investigated (Mello, 1996; Chizzotti, 2000).

The study of the knowledge and concepts developed by human populations about the biology of marine mammals has been increasingly applied in Brazil and it is considered an important cost-effectiveness tool for research and conservation of endangered species like the Franciscana dolphin, *Pontoporia blainvillei* (Souza, 2005), the Bottlenose dolphin, *Tursiops truncatus* (Peterson et al., 2005), the Guiana dolphin, *Sotalia guianensis* (Souza & Begossi, 2006), the Amazonian manatee, *Trichechus inunguis* (Calvimontes & Marmontel, 2004) and the Antillean manatee, *Trichechus manatus manatus* (Lima, 1999; Luna, 2001, Alves, 2007).

Some ethno-biological studies have been developed by Antillean manatee researchers, especially on identifying the species distribution and main areas of occurrence. In order to determine Antillean Manatee distribution in Brazil, Lima (1997), Luna (2001) and Alves (2007) conducted surveys through semi-structured interviews.

Alves (2007) points out that traditional knowledge was very important in manatee data acquisition, because of similarities with the scientific knowledge acquired, enabling coastal communities as potential partners in the implementation of conservation strategies.

Paludo (1998) indicated that it is necessary to know the Antillean manatee distribution along the Brazilian coast to support conservation work, recording the species occurrence from the information of fishermen. Fishermen live in close relationship with natural environment and depend on its resources, becoming a source of numerous studies of traditional knowledge. According to Oliveira et al. (2008), the fishing communities' knowledge has fundamental importance in scientific studies involving coastal ecosystems and marine organisms.

2.1.2. Semi-structured Interviews

Semi-structured interviews were conducted in all 77 fishing communities of the study area (Figure 02). The number of fishermen was obtained from Fishermen Office of the municipalities or from the communities themselves. According to Matheus Marcos Rotundo - researcher at the Laboratory for Biological Research (Lapebio / Santa Cecília University - UNISANTA) - (personal communication), only 40% of fishermen registered in the Fishermen Associations are usually in activity. Therefore, to calculate a 10% sample of this universe the forty percent were used as the total number.

In communities where the number of fishermen was very small, efforts were made to interview, at least, five fishermen. However, some communities were relatively small, enabling the researches to achieve this sampling. Table 01 shows the number of interviews in each community, corresponding to 10% of the active fishermen in each one (Table 2, in attachment, shows the math).

The key question used to determine manatee distribution was "When was the last time you saw a manatee in the region?" On occasions where it was necessary to confirm the consistency and validity of the answers, we used the same method applied by Mourão & Nord (2003): the appeal to the repetition of questions, creating diachronic situations (same question, repeated to the same person in different times). A visual guide with marine animals' pictures (dolphins, whales, manatees and turtles) was also used to ensure that the interviewee was really talking about manatee, similarly as used by Serrano et al. (2007).

Figure 02. Semi-structured interviews with fishermen in coastal communities of the east coast of Ceará and the west coast of Rio Grande do Norte.

Table 01. Number of interviews conducted with fishermen of fishing communities.

City	Community	Number of interviews
Touros	Perobas	10
	Carnaubinha	20
	Touros	40
	Lagoa do Sal	20
	São José	15
	Cajueiro	28
	Monte Alegre	5
São Miguel do Gostoso	S. Miguel do Gostoso	14
	Morro dos Martins	9
	Morro dos Paulos	2
	Cauã	3
	Praia do Marco	4
	Enxu Queimado	8
Caiçara do Norte	Caiçara do Norte	36
Galinhos	Galos	7
	Galinhos	12
Guamaré	Guamaré	16
Macau	Sertãozinho	4
	Diogo Lopes	11
	Barreiras	11
	Macau	18
Porto do Mangue	Porto do Mangue	16
	Rosado	3
	Pedra Grande	6
Areia Branca	Ponta do Mel	6
	Cristóvão	7
	Redonda	6
	Morro Pintado	5
	Baixa Grande	4
	Upanema	6
	Areia Branca	8
Grossos	Barra	2
	Grossos	8
	Pernambuquinho	13
	Alagamar	3
	Valença	2
	Areias Alvas	8
Tibau	Gado Bravo	6
	Praia das Emanuelas	5
	Praia Ceará	6

Icapuí	Praia do Manibu	5
	Peixe-Gordo	5
	Praia de Melancias	5
	Tremembé	6
	Quitérias	11
	Requenguela	12
	Barrinha	7
	Barreiras de Baixo	6
	Barreiras de Cima	10
	Picos	5
	Peroba	5
	Redonda	14
	Ponta Grossa	5
	Retiro Grande	5
Aracati	Retirinho	7
	Fontainhas	7
	São Chico	5
	Lagoa do Mato	7
	Quixaba	10
	Majorlândia	10
	Canoa Quebrada	6
	Pedra Redonda	5
	Cumbe	4
	Volta	5
Fortim	Barra	8
	Pontal do Maceió	9
	Fortim	8
	Viçosa	6
	Jardim	5
Beberibe	Morro Branco	6
	Praia das Fontes	6
	Diogo	4
	Uruau	9
	Barra da Sucatinga	6
	Lagoa de Dentro	9
	Prainha do Canto Verde	9
	Parajuru	13
Sum		678

2.2. Data analysis

Data analysis was strictly qualitative, and it was done through the interpretation of the interviewees' narrative.

The responses to the main inquiry "When was the last time you saw a manatee in the region?" were divided into four categories, according to the most recent record of manatee observation in the area: affirmative answers of manatee observation less than two years were considered indicative of **Current Occurrence** of the species on the local; those communities

where the most recent sightings of manatees occurred between two and five years ago were considered **Recent Occurrence**; areas where sightings are no early than five years were considered areas of **Historical Occurrence** of the manatee; where there were no reports of the animal sighting were not considered part of the species distribution (Table 03).

Table 03. Categories of occurrence, according to sighting reports of manatees in the study area

Sighting Report of Antillean Manate	Occurrence category
From 0 to 2 years	Current Occurrence
From 2 to 5 years	Recent Occurrence
More than 5 years	Historical Occurrence
Have never seen	No record

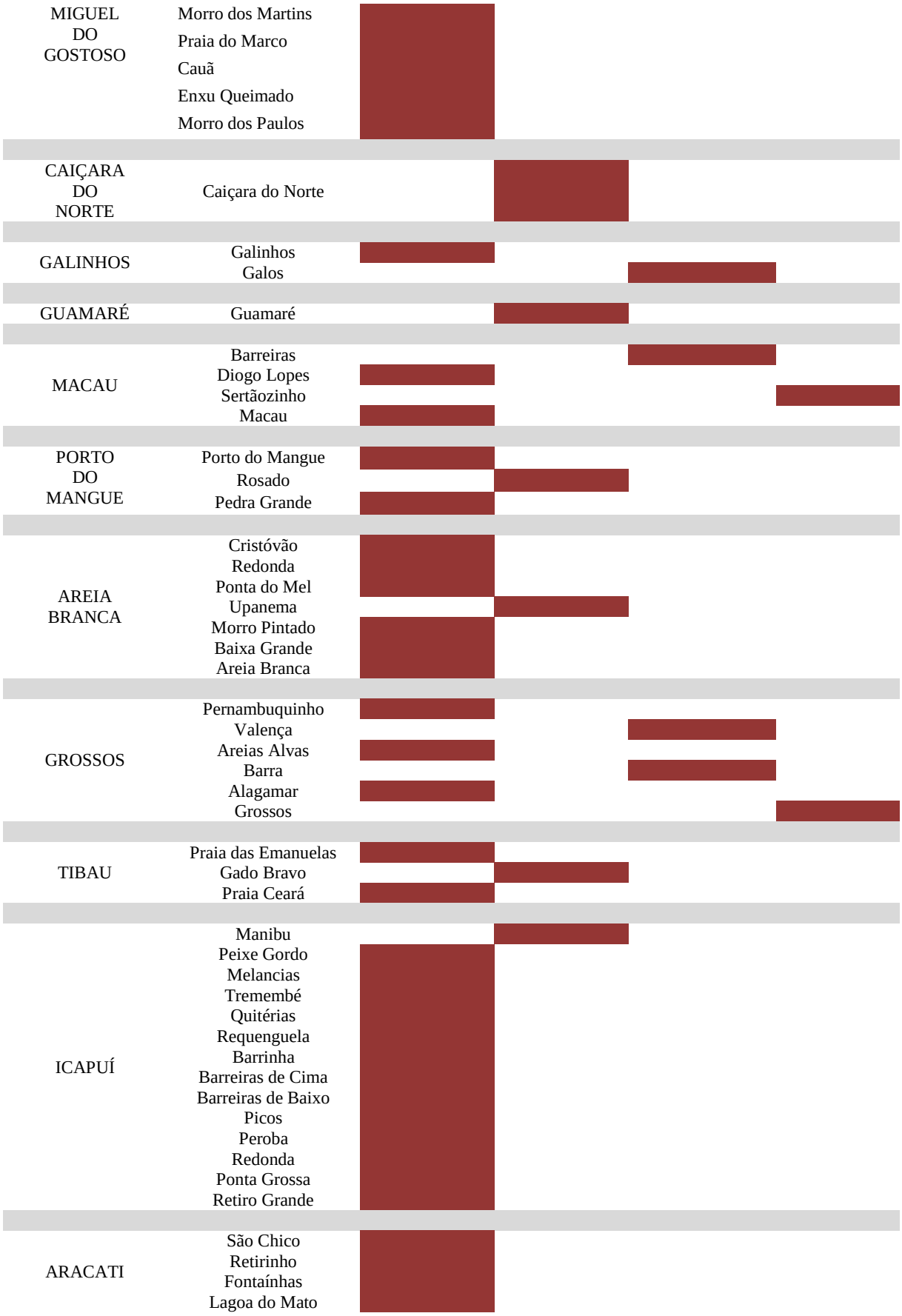
Since the methodology used to produce a map of the occurrence areas and the distribution of the species was primarily based on interviews, we analyzed the data according to ethno-biological principles, which consider the experiences of populations, and it is used and accepted in several studies (Posey, 1987; Begossi, 1993, Marques, 1995; Diegues, 1999, Adams, 2000; Begossi et al., 2002). We started based on the principle that all answers are reliable and shall be considered on the data analysis. Thus, even if only one interviewee reported manatees' observations in the location of the interview, his answer was considered enough to determine the species occurrence on the local. So, for the definition of manatee occurrence in the study area, it was always considered the answers of most recent sightings of animals on the local, even though they were not quantitatively representative within the universe of sampling in that community.

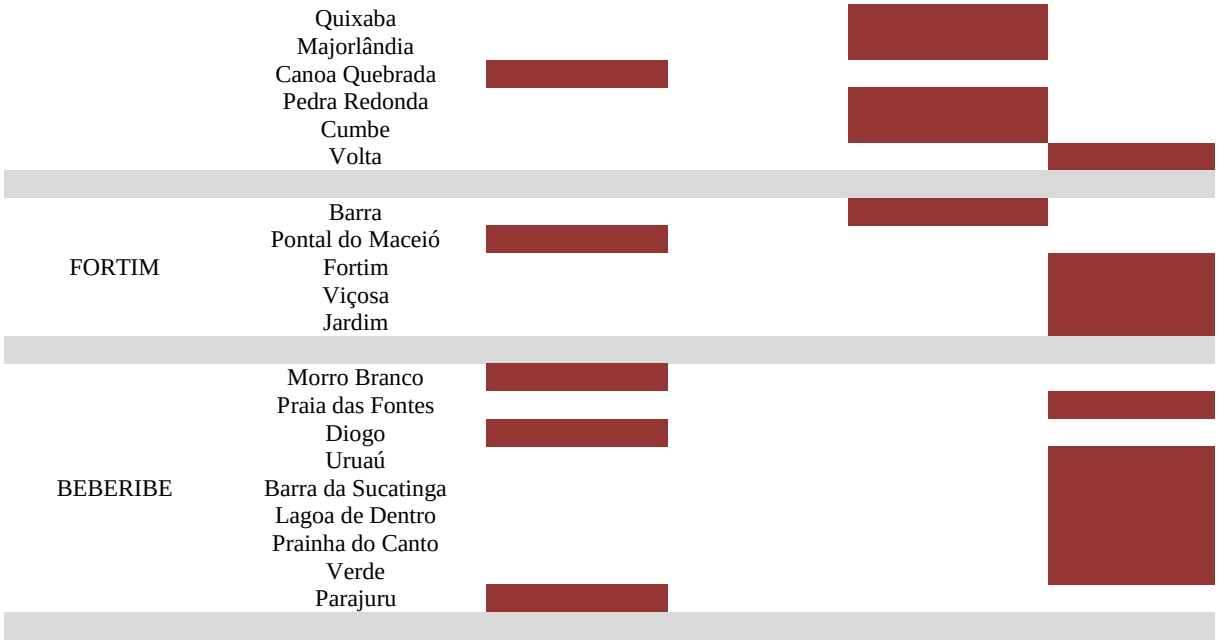
This method of data analysis was also used for another reason. The different responses to the inquiry of manatee sighting do not represent opposite information. If a fisherman claimed to have seen an animal in the local a year ago, it necessarily means that the manatee was in the region a year ago. However, if another fisherman said that the last manatee was sighted by him seven years ago, it does not mean that the manatee was not on that local for the last seven years, but only that the fisherman did not see any animal in this period.

The categories' information crossed with communities produced a table with the manatee occurrences in each community (Table 04).

Table 04. Manatee Occurrence in the coastal communities between the east coast of Ceará and west coast of Rio Grande do Norte (Current Occurrence; Recent Occurrence; Historical Occurrence and; Does Not Occur).

City	Coastal Community	OCCURRENCE CURRENT	RECENT	HISTORICAL	DOES NOT OCCUR
TOUROS	Perobas				
	Carnaubinha				
	Touros				
	Cajueiro				
	Lagoa do Sal				
	São José				
	Monte Alegre				
SÃO	S.M. do Gostoso				


MIGUEL DO GOSTOSO
Morro dos Martins
Praia do Marco
Cauã
Enxu Queimado
Morro dos Paulos
CAIÇARA DO NORTE
Caiçara do Norte
GALINHOS
Galinhos
Galos
GUAMARÉ
Guamaré
MACAU
Barreiras
Diogo Lopes
Sertãozinho
Macau
PORTO DO MANGUE
Porto do Mangue
Rosado
Pedra Grande
AREIA BRANCA
Cristóvão
Redonda
Ponta do Mel
Upanema
Morro Pintado
Baixa Grande
Areia Branca
GROSSOS
Pernambuquinho
Valença
Areias Alvas
Barra
Alagamar
Grossos
TIBAU
Praia das Emanuelas
Gado Bravo
Praia Ceará
ICAPUÍ
Manibu
Peixe Gordo
Melancias
Tremembé
Quitérias
Requenguela
Barrinha
Barreiras de Cima
Barreiras de Baixo
Picos
Peroba
Redonda
Ponta Grossa
Retiro Grande
ARACATI
São Chico
Retirinho
Fontaínhas
Lagoa do Mato



This study obtained an average of 8.8 interviews per community visited within the study area. This number express a high sampling effort and a high level of empirical knowledge on manatee by the fishermen from the east coast of Ceará and the west of Rio Grande do Norte. The result was possible since the sampling attempted to address individuals who actually had knowledge of the species. This study had a higher sampling effort when compared to previous studies performed with interviews. Lima (1999) conducted 538 interviews in 182 communities in seven north-eastern Brazilian states, with an average of three interviews per location. Luna (2001) obtained an average of 1.81 interviews in 145 locations in the northern coast of Brazil. In the study conducted by Alves (2007) an average of 6.6 interviews were held per location in the eastern coast of the state of Ceará and the furthest west of Rio Grande do Norte.

2.3. Distribution

The following concepts were used to determinate Antillean manatee distribution:

- Occurrence area: manatee specific occurrence locals;
- Distribution: current occurrence areas unified in a unique polygon, in which the distance between these areas may be used as a corridor by the manatees.

As the occurrence of manatees is strongly influenced by water depth (Hartman, 1979, Lefebvre et al. 2001; Olivera-Gomez & Mellinck, 2005), studies show a minimum depth of 0.4 m (Paludo, 1998) and a maximum of 10 m (Nowak, 1999); occurrence and distribution maps of the species were limited to 10 m isobath. In Table 05, we can see the Antillean manatee occurrence, the presence of seagrass meadows, freshwater sources and the sightings of calves per sampled community.

With this information, it was initially prepared a map with the occurrence areas of the Antillean manatee in the study area (Figure 03).

Table 05. Occurrence of the Antillean manatee, the presence of seagrass meadows, freshwater sources and sightings of calves per sampled community (legends about manatee occurrence:

City	Coastal Community				
TOUROS	Perobas				
	Carnaubinha				
	Touros				
	Cajueiro				
	Lagoa do Sal				
	São José				
	Monte Alegre				
SÃO MIGUEL DO GOSTOSO	S.M. do Gostoso				
	Morro dos Martins				
	Praia do Marco				
	Cauã				
	Enxu Queimado				
	Morro dos Paulos				
CAIÇARA DO NORTE	Caiçara do Norte				
GALINHOS	Galinhos				
	Galos				
GUAMARÉ	Guamaré				
MACAU	Barreiras				
	Diogo Lopes				
	Sertãozinho				
	Macau				
PORTO DO MANGUE	Porto do Mangue				
	Rosado				
	Pedra Grande				
AREIA BRANCA	Cristóvão				
	Redonda				
	Ponta do Mel				
	Upanema				
	Morro Pintado				
	Baixa Grande				
	Areia Branca				
GROSSOS	Pernambuquinho				
	Valença				
	Areias Alvas				
	Barra				
	Alagamar				
	Grossos				
TIBAU	Praia das Emanuelas				
	Gado Bravo				
	Praia Ceará				
ICAPUÍ	Manibu				
	Peixe Gordo				

	Melancias				
	Tremembé				
	Quitérias				
	Requenguela				
	Barrinha				
	Barreiras de Cima				
	Barreiras de Baixo				
	Picos				
	Peroba				
	Redonda				
	Ponta Grossa				
	Retiro Grande				
ARACATI	São Chico				
	Retirinho				
	Fontaínhas				
	Lagoa do Mato				
	Quixaba				
	Majorlândia				
	Canoa Quebrada				
	Pedra Redonda				
	Cumbe				
	Volta				
FORTIM	Barra				
	Pontal do Maceió				
	Fortim				
	Viçosa				
	Jardim				
BEBERIBE	Morro Branco				
	Praia das Fontes				
	Diogo				
	Uruaú				
	Barra da Sucatinga				
	Lagoa de Dentro				
	Prainha do Canto				
	Verde				
	Parajuru				

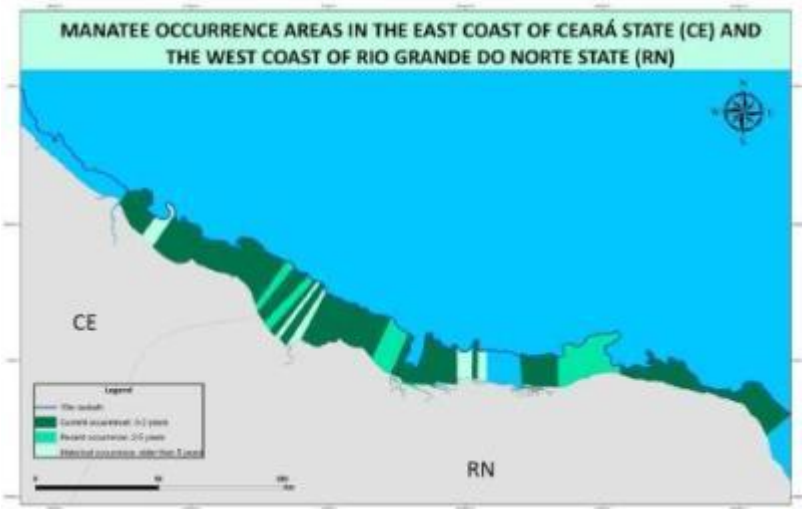


Figure 03. Manatee occurrence areas in the east coast of Ceará (CE) and the west coast of Rio Grande do Norte (RN), according to interviews.

The need of further discussion about this occurrence area must be explained, since three sites have a single isolated record of the species presence: Beberibe, Fortim and Guamaré. In October 2008, an Antillean manatee calf stranded in "Praia das Fontes" beach (Beberibe city), and an adult manatee remained in the area for about four days. In December 2008, a calf was seen with its mother in Fortim. This calf stranded a day after the first sighting and it was reintroduced by the Aquasis rescue team on the same day. In 2009, two adult manatees and one injured calf were sighted in Guamaré. The calf stranded on the coast, but was reintroduced by the community. In these three events, the team took part in the investigation and confirmed that the reports dealt with only those records and that the residents had never observed individuals of Antillean manatee previously. Thus, we chose not to consider these locations as current occurrence areas of the species. The presence of the animals in the region is not well understood, as well as some assumptions must be investigated, for instance: (i) manatee population may be increasing and searching for new areas with favourable ecological conditions; (ii) breeding sites are very degraded and females may be seeking new areas to give birth; (iii) by the reducing of population by hunting history, there may be an early recruitment of females, and due to their inexperience, they do not have the necessary knowledge to choose the most appropriate sites for their early calves.

Based on the map of the occurrence area and on this information, the distribution of the species was established between Canoa Quebrada, in Aracati city/CE, and Perobas in Touros city/RN (Fig. 04).

The distribution of marine mammals is affected by demographic factors (population structure and abundance), evolutionary factors (morphological, physiological and behavioural adaptations), ecological factors (primarily related to presence and abundance of food, predators and competitors), factors related to the habitat (temperature, salinity, bathymetry, etc.) and anthropogenic factors (e.g., anthropogenic sounds, pollutants and bycatches) (Forcada, 2002). Therefore, the distribution of a species is the product of the interaction between all these factors.

Several environmental factors appear to influence the presence of manatees in a particular area: water temperature - especially in subtropical areas (Irvine, 1983, Deutsch et al., 2003, Jiménez, 2005), depth (Hartman, 1979, Lefebvre et al ., 2001; Olivera-Gomez & Mellinck, 2005), salinity (Hartman, 1979; Colmenero-Rolon & Zárate, 1990, Lefebvre et al., 2001; Olivera-Gomez & Mellinck, 2005), marine current (Hartman, 1979; Lefebvre et al., 2001); abundance of aquatic vegetation (Hartman, 1979; Smith, 1993) and freshwater sources (Aquasis, 2006; Olivera-Gomez & Mellink, 2005; Jiménez, 2002, Lima, 1999, Lefebvre et al., 1989; Odell, 1982; Hartman, 1979).

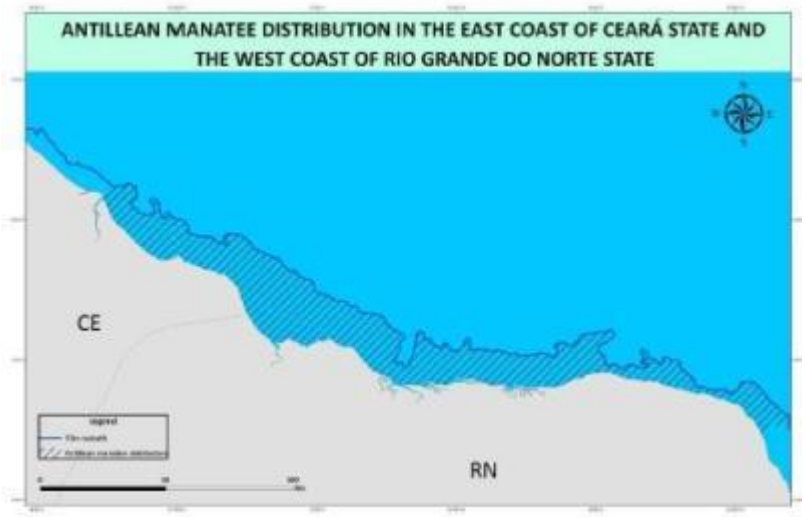


Figure 04. Antillean Manatee distribution on the east coast of Ceará and the west coast of Rio Grande do Norte state, between Aracati city (from the right bank of Jaguaribe River) and Touros city.

The distribution of the Antillean manatee in the study area is in accordance with the habits and preferences of the species. As described above, we observe the occurrence of animals preferably in calm and shallow waters, in which are overlapping areas with aquatic vegetation (Husar, 1978; Jiménez, 2000; FWC, 2005). The water temperature is not a limiting factor due to the equatorial zone location of the study area.

The presence of predators, human activity (motorboats traffic, for example), the absence of appropriate locations for rest and interact with other individuals (reproduction, caring for young animals) are other factors that may limit the presence of manatees in a particular area (Olivera-Gomez & Mellink, 2005). The analysis of the threats in the region can provide valuable information on the absence (or non-occurrence) of the species in certain locations.

Based on the occurrence map (Figure 03) obtained through the interviews, we observe that the distribution of manatees seems to have small geographic gaps, which may due to the species absence in the region, but also because of the low frequency of the area usage. The greatest distance of discontinuity in the map is 25 km (i.e., Caiçara do Norte city), and this distance cannot be considered as geographical discontinuity for a species given that the ability to travel up to 40 Km per day (Bengston, 1981; USGS / BRD, 1993). The area also has no physical barrier. Kinnaird (1983) and Stith et al. (2001) indicated that manatees usually move along the coastline and use deep corridors to access shallow water, feeding and resting areas. According to Bengston (1981), the animals generally travel faster and directly towards a specific destination, with males reaching over longer distances than females.

Distribution studies in Brazil began in the 70s, when Banks (1971 apud Lima, 1999) and Silveira (1975 apud Lima, 1999) described the first scientific information about the species *T. manatus*, showing their occurrence in the states of Pernambuco, Paraiba and Rio Grande do Norte. In 1978, Whitehead reported that the Antillean manatee distribution in Brazil extended from the mouth of the river "Rio Doce" – Vila Velha, Espírito Santo to São Luís in the state of Maranhão, with apparent disruption of the São Francisco River to the state of Paraíba. Over the years, however, it was observed the disappearance of the species in the states of Espírito Santo, Bahia (Albuquerque & Marcovaldi, 1982) and Sergipe (Lima et al.,

1992). The Pontal do Peba in Alagoas, is now the southern boundary of *T. m manatus* distribution in Brazil. Lima et al. (1992) confirmed that in the north-eastern region manatee distribution is discontinuous, with absences along the southern coast of Pernambuco and in part of the coast of Ceará.

There were characterized three areas of occurrence along the Brazilian coast (Paludo, 1998).: from the Oiapoque to Cacimbinhas beach in Guriú, Camocim city, on the west coast of Ceará; from Barro Preto (Iguape city), on east coast of Fortaleza, to Olinda, Pernambuco state; and from Tamandaré, in Pernambuco to the Pontal do Peba, at the mouth of the São Francisco river, on the boundaries of Sergipe and Alagoas states.

Regarding the current distribution in Brazil, recent studies were performed by Lima (1999) and Luna (2001). They report that the current distribution of the Antillean manatee covers the state of Alagoas until Amapá, however with discontinuity areas: the first located between Barra de Camaragibe, in the state of Alagoas, and Recife, in Pernambuco; the second between Iguape and Jericoacoara, in Ceará; the third between the Parnaíba River (Delta do Rio Parnaíba) and the "Lençóis Maranhenses".

Studies conducted by Silva (2003) in Ceará demonstrate two areas of Antillean manatee occurrence in the state: on the west coast, in Barroquinha city (on the border with Piauí) and on the east coast, in the cities of Fortim, Aracati and Icapuí. This last one, on the border with the state of Rio Grande do Norte. And in a more recent paper Choi et al. (2009) indicated that Antillean manatee species do not occur in Barroquinha city.

In this study, we observed that the area of manatee occurrence on the east coast of Ceará seems to be much smaller than the one described by Lima (1999). This difference may be related to different methods of analysis of conducted surveys, since Lima (1999) considered stranding areas as occurrence areas. However, we observed that calves´ strandings also occur west of the occurrence area, mainly due to strong east-west coastal current direction. Thus, the places where there are stranding records, but no reports of manatee's sightings in the interviews, were not considered as occurrence areas.

Comparing the occurrence area described in this study with the one defined by Silva (2003), a reduction was also observed. In the east coast of Ceará, the current limit of distribution seems to be Aracati city, but no longer Fortim city.

On the west coast of Rio Grande do Norte, the previous work performed by Lima (1999) referred the entire state of Rio Grande do Norte as the occurrence of the Antillean manatee. We also observed in this study that manatee occurs in the entire west coast of Rio Grande do Norte.

3. Antillean Manatee feeding and reproductive areas on the east coast of Ceará and west coast of Rio Grande do Norte

According to interviews, manatee feeding habitats were identified due to the presence of seagrass beds. Although Antillean manatees also consume algae, gross examination of fresh stomach contents from carcasses recovered by Aquasis in the study area showed, primarily, seagrass contents. As shoal grass, *Halodule wrightii*, is widespread seagrass species in the area, it was considered the main item of manatees' diet in the region.

Antillean manatee potential use areas (feeding – seagrass meadows, freshwater sources, reproduction and parental care) were identified with the help of traditional knowledge, through semi-structured interviews with fishermen in coastal communities from Beberibe, in Ceará, to Touros, in Rio Grande do Norte. The questions: "Do you observe calves in the area?"; "Are there any seagrass beds?" and "Are there any freshwater sources in

the region?" were related to this issue. For these questions, there were three feasible answers ("yes", "no" and "do not know"), although some fishermen chose not to answer.

The responses were recorded and inserted in an Excel's database in order to produce a map, similar to the potential feeding and reproductive areas, assumed that all answers were reliable and should be considered in the data analysis. If only one interviewed affirmed the existence of seagrass beds, the positive answer would be considered. On the other hand, negative answers do not imply the absence of seagrass beds in the region, but the fact that the interviewed never noticed it. As the majority of fishermen fish with equipments, and do not see the ocean bottom, many denied the presence of seagrass while local divers ensured the occurrence of phanerogam in the region. The same methodology was employed to establish the presence of freshwater sources and calves. Table 05 and Figure 05 summarize an array of localities with manatee occurrence, presence of seagrass, presence of freshwater sources and calves' sightings.

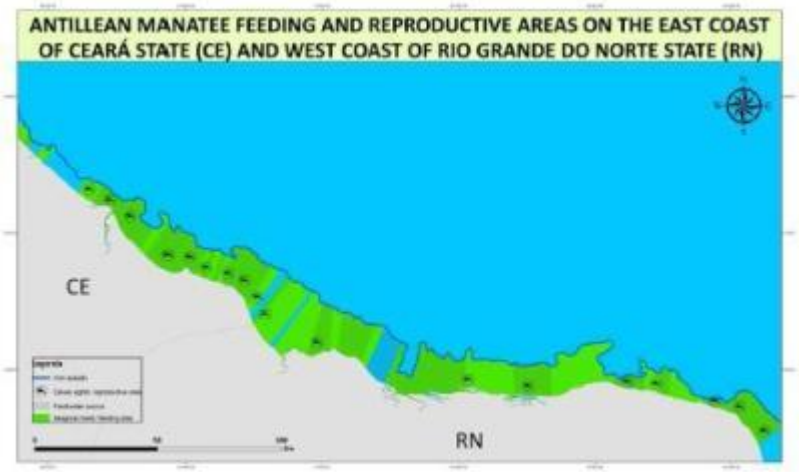


Figure 05. Antillean Manatee feeding and reproductive areas on the east coast of Ceará and the west coast of Rio Grande do Norte, according to interviews.

3.1. Antillean manatee feeding areas

3.1.1. Seagrass beds

All Sirenia are herbivorous, which is a characteristic that limits the distribution and types of habitats (Hartman, 1979). In this work, the potential feeding areas considered the presence of seagrass beds (*Halodule wrightii*), although manatees feed on other plant sources such as algae and mangrove leaves (Best & Teixeira, 1982; Paludo, 1997, Borges et al., 2008). Lima (1997) confirms and reports that *Halodule wrightii* is the main food item of manatees and this same seagrass seems to be the main source of food for animals in the study area (Aquasis, unpublished data).

From the 75 coastal localities, the presence of seagrass beds were recorded in 65, that were considered potential manatee feeding areas, according to the interviews. As shown in Table 04, all places where there were reports of manatee current occurrence, except for Diogo Beach in Beberibe, have seagrass beds. This result confirms Domning (1981 apud Lima, 1999), who states that the distribution of Sirenia occurs in conjunction with the distribution of

submerged shoal grass in tropical and subtropical regions. Also, the result suggests that the occurrence of the animals is restricted to shallow coastal waters, estuaries and rivers, where there aquatic vegetation is abundant between depths ranging from 0.9 to 2.1 m.

In the tropics, seagrass beds are an important component of the coastal zone, and have high productivity and biomass of fish, such as coral reefs and mangroves (Gullström et al., 2002). The seagrass beds suffer seasonal changes in its structure, biomass, height and composition. This seasonality depends on different factors, for instance: costal morphology (exposed or sheltered), type of bottom and wind regime (therefore, current). Sheltered coastal areas possess seagrass beds with higher biomass than exposed ones (Aquasis, 2006).

Since seagrass beds are a very dynamic ecosystem, as well as biologically important, both for manatee and the whole coastal biodiversity, studies on its composition and biomass should be considered as priority in the region in the next years.

3.1.2. Freshwater sources

The location of potential sources of freshwater springs in sub tidal zone (called "olheiros" by local people) was determined according to fishermen knowledge. These freshwater sources are difficult to be located offshore, and many interviewed could not answer the question.

As showed in Table 04, fishermen from 41 of the 75 localities visited reported the presence of freshwater springs. All these locations overlap the current occurrence of manatee, and correspond to 82% of the total area of occurrence. The presence and quantity of water supplied by the sources depend on the volume of ground water that feeds it, and varies with the rainfall season in the region (Aquasis, 2006). Similar results were reported by Odell (1982), Marmontel et al. (1992), Lefebvre et al. (2001) and Oliveira-Gomez & Mellink (2005). According to Fertl et al. (2005), the manatees' displacement patterns are also influenced by access to sources of freshwater. However, this preference is not always well understood, because manatees apparently survive for long periods without freshwater (Ortiz, 1994).

Studies on blood and urine of Antillean manatee suggested that the consumption of freshwater may not be physiologically necessary for the species (Brownell et al., 1978). The ability of manatees to concentrate urine indicates that they could consume sea water to keep the concentration of body fluids (Irvine et al., 1980), and recent studies on the structure of its kidney suggest that this species can survive for long periods without freshwater (Ortiz, 1994). They may also use water from the plants they eat or from the metabolism of fat (Hill & Reynolds, 1989).

However, there is behavioural evidence that manatees need to consume freshwater. Several cases of freshwater consumption in different places have already been observed (Hartman, 1979). Furthermore, physiological studies have shown the same result (Ortiz et al., 1998, 1999). The permanence of manatees near freshwater sources and its frequent consumption has been indicated as extremely beneficial for the animals in order to save energy used for the adjustments mentioned above.

3.1.3. Characterization of seagrass beds and freshwater sources

Due to some difficulties encountered in the proposed methodology, the characterization of seagrass beds and freshwater sources was partially achieved. The work was carried out only in the communities of Touros and Areia Branca. The following limiting factors must be emphasized: fishermen with good knowledge of the sea bottom composition near the coast are hard to find. Besides, the seagrass meadows' spatial location along the year is very dynamic due to the coastal currents, which buried or expose it. Moreover, the study area is very extensive and requires more time and budget to be completed surveyed.

The right location and characterization of the seagrass beds was possible in few areas, and was performed by exploratory snorkelling, collection of substrate and seagrass sample, in order to measure their height. Moreover, in places where these sampling were performed, some parameters were measured (depth, turbidity and salinity) (Figure 06).

Figure 06. Above: Snorkelling survey about the position of seagrass meadows and freshwater springs. Below, on the left: Seagrass sampling. Right: Researchers measuring salinity concentration with the help of an artisanal fishermen.

Touros city

It was possible to perform two boat surveys in Touros, where seagrass beds were located and characterized, from Perobas community to Cajueiro community. The location of the meadows is illustrated in the map below (Figure 07).

Seagrass beds are distributed in patches scattered along the substrate in the marine area sampled. Two large meadows were found as can be observed in Figure 08. In general, seagrass beds were found in association with benthic macroalgae.

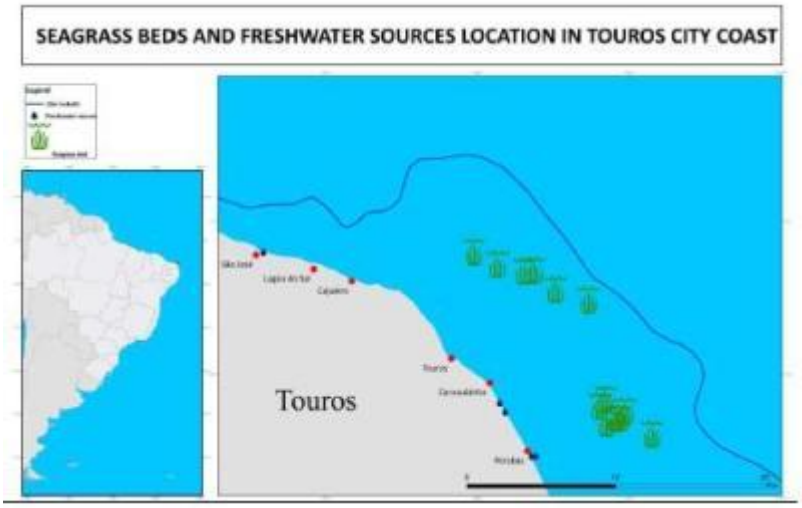


Figure 07. Seagrass beds and sub tidal water springs location in Touros, Rio Grande do Norte.

Water salinity remained almost constant in all sampling sites, ranging between 34 and 37.5. The measured depth was 4.08 meters in Perobas, and 8.8 meters in Touros.

The substrate of the meadows consists primarily of unconsolidated substrate (sand, or sand quartz/gravel). The height of the seagrass leaf samples range between 18 and 36cm. The meadows were relatively dense, with a patchy distribution (Figure 08).

Figure 08. Sub tidal dense seagrass bed in association with brown algae.

It is important to highlight that in front of Touros community, there was a greater difficulty in finding seagrass beds due to the high depth and less knowledge of their location by the fisherman who were leading the research team.

In Perobas community, the area could be easily exploited by the field team through snorkelling, because the water was very clear. On this site, we observed the formation of coral reefs parallel to the coast.

Besides the seagrass beds, five freshwater springs were located in Touros, which consist in potential sources of freshwater for manatees in the region. However, all these springs were buried on the day of sampling, and their location was based on reports of fishermen. Aquasis (2006) found that most of the springs are buried temporarily, during the dry season, because of the decrease in the supply of ground water, or changes in current that may carry sediment and bury it. The substrate in all the springs was sand, in association with rock formations.

Areia Branca city

Another boat survey was possible in Areia Branca city, in Cristóvão community, where the difficulties of the proposed methodology were observed, mainly concerning to the high depths where the meadows were located, as well as low visibility. The map with the location of the seagrass beds can be seen in Figure 09.

Figure 09. Seagrass beds location in Areia Branca, Rio Grande do Norte.

The seagrass bed found in Areia Branca was also distributed in patches scattered in a substrate composed primarily of sand and gravel. The measured depth was 9.46 m, with a visibility of 6.7 m. The salinity was constant at all sampling points, with the value of 35%. The height of the seagrass leaf was significantly smaller than those from Touros, with an average height of 10 cm. The biomass was less abundant. This is probably due to the reduction of the photic zone for photosynthesis with higher depth. According to Zieman & Wetzel (1980), light is foremost among the factors crucial to seagrass production and growth.

3.2. Reproductive areas

Areas of reproduction and parental care were identified applying the question "Do you see calves in the area?" The majority of fishermen did not answer this question, given the difficulty in observing manatee calves. According to Aquasis (2006), the calves sighting can be influenced by factors that decrease the perception of the observer, which are:

- Newborn calves of manatees typically measure between 1.20 and 1.40 meters (Odell, 1982);
- Calves tend to be more discreet, exposing less the body and especially the tail;
- The wind suffers a considerable increase from July (Campos et al., 2003), which greatly increases the amplitude of the waves and water turbidity and, therefore, may reduce the perception of observers.

According to the interviews, from the 82 localities, in 29 the presence of calves have reported and these were considered areas of reproduction or parental care. As cited before (p.12), the isolated records of the presence of manatees' calves in some localities are related to stranding events and, until the present, they consist of single records.

The areas of breeding and parental care in the region are mostly shallow waters and/or sheltered areas in the coastal zone. Hartman (1979) observed that pregnant females seeking for places such as canals, lagoons and rivers to reproduce and give birth. There are reports that female manatee raises and carries the calf in the back and tail for several hours, possibly to help it establish its respiration rate (Reynolds, 1977 cited in Caldwell & Caldwell, 1985).

The continuing loss of suitable habitats (i.e., estuaries and mangrove areas) for breeding and parental care, according to Silva (2003) and Meirelles (2008), can force pregnant females or females with calves to seek new and sometimes non-suitable areas to give birth or raise the calf.

Due to the facts reported above, and the presence of calves in the study area, the location can be considered as an important site for breeding and parental care of the manatee, and it is a priority to the conservation of species in the country.

3.2.1. Characterization of reproductive areas

The municipality of Aracati has rectilinear and exposed beaches with a platform slope more pronounced than in the neighbouring municipality, Icapuí, where there are more records of calves' observation. Almost all portion of this city's coast until Retirinho community, does not have the protection rocks in the sub tidal shore, and theoretically, is inappropriate for a female manatee taking care of its calves. Nevertheless, there are manatee sightings in Fontainhas community, which is adjacent to Retirinho. Sightings were also reported for Canoa Quebrada, in the eastern portion of the community, where there is a bay protected by outcrops colonized by algae, besides there is a barrier parallel to the beach also colonized by algae, which could and probably serve as a refuge for a female with its calf. This is probably the most sheltered area in Aracati (Figure 10).

Retirinho, Retiro Grande and Ponta Grossa beaches, in Icapuí municipality, have very gentle slopes (Figure 11). The area is protected by the projection of the eastern side of Ponta Grossa seaward, reducing coastline current. Moreover, the presence of "beach rocks" and abrasion platforms create natural barriers, allowing the animals to rest sheltered from the wind and current.

Figure 10. Canoa Quebrada Beach, in Aracati municipality.

Figure 11. Retiro Grande Beach, in Icapuí Municipality.

Eastern from Ponta Grossa there are the beaches of Peroba, Picos and Barreiras de Cima (Figure 12). The main characteristics of these beaches are the smooth bathymetry associated with the presence of natural barriers formed by conglomerates and abrasion platforms, which make them suitable for parental care. Although the beach of Barrinha is more exposed than those mentioned above, its waters are calm due to the rather mild slope of the platform.

Figure 12. Peroba Beach, in Icapuí Municipality.

Between Ponta Grossa and Peroba, there is the beach of Redonda which has the largest fleet of motorboats in the municipality, and could be an area of transition between two manatees' breeding areas, explaining the sightings of calves in this place.

The nearby beach, eastern of Barrinha, is Requenguela, where a plain-tidal delta quite extensive (6 km) and shallow, called Cajuais Bank is located. Despite the calm waters, apparently it is not the ideal place for manatees breeding due to large variations in depth during tidal cycle. It's off shore side constitutes an important feeding area, where it is located the biggest seaweed/seagrass beds from the east coast of the state, and should be used as a feeding area and corridor between the adjacent beaches (Figure 13).

Figure 13. Cajuais Bank, in Requenguela, during low tide. Shoal grass meadows can be observed.

The beaches of Quitérias, Peixe-Gordo, Ceará and Emanuela (RN) are exposed to wind and ocean currents, especially in the second half of the year when the winds are

intensified in north-eastern Brazil. Nevertheless, in Quitérias, there is the presence of conglomerates, which contributes to the formation of a site of shallow water for manatee parental care. However, although these areas are believed to be important as feeding habitat, that does not constitute an ideal breeding habitat, particularly for the maintenance of newborn and inexperienced calves (Aquasis, 2006).

The coast of Baixa Grande, Morro Pintado and Redonda beaches, in Areia Branca municipality, state of Rio Grande do Norte, is formed by small bays, where the waters are calm most of the year. This feature, combined with low human impact, makes these beaches an ideal place for parental care of manatee calves.

Diogo Lopes is a community located on the edge of an estuary (Ponta do Tubarão), in which calves were sighted in its most exposed part, where an open beach is formed, subject to waves and currents. Galos beach have a similar conformation, and the records of calves sighting in both locations may be tied to isolated events.

In São Miguel do Gostoso municipality, there are small bays on the coastline, which contributes to a decrease of waves and currents inside them (Figure 14). In Morro dos Paulos community, there is the formation of clusters on the beach, forming a very favourable place for female to give birth and care for its calf. The site has no intense fishing activity, which contributes further to the reproduction of manatees. In Enxu Queimado community, on the other hand, there is a small bay, but the platform slope is not smooth and there is a heavy traffic of fishing boats, which can cause difficulties to the caring of calves.

Figure 14. Beach in São Miguel do Gostoso municipality, where small embayments with calm waters can be found.

In Perobas, Touros municipality, there is the extremity of a large coral reef (it is the eastern extremity of the Coral Reef Marine Protected Area - AMP), where the water is shallow, clean and very calm. In Cajueiro, there is a small bay between the beach rocks, which forms the region of the intertidal and sub tidal habitats, and is also a place of very calm water.

Yet, in Lagoa do Sal, São José and Touros, also in Touros municipality, the beaches are more exposed and boat traffic is more intense.

In general, the places where calves were sighted in the study area are sheltered areas with low human impact, corroborating with the literature, which states that female manatees have a preference for local with calm waters to give birth and care for their calves (Hartman, 1979).

3.3. Estuaries

Estuaries within the study area were also analyzed on depth and salinity. Although there is no evidence of recent occurrence of manatees in these areas, it is important to initiate an investigation on this issue. Antillean manatees in Brazil are known to occur in estuary areas, such as the estuary of the Timonha and Ubatuba rivers, on the boundary of the states of Ceará and Piauí, as well as in Paraíba. In addition, the study area of this project is in the region with the highest record of neonate strandings, and it is recognized nationally as a priority for conservation actions for the species.

The mouth of the rivers Pirangi, Jaguaribe, Barra Grande, Areia Branca/Grossos, Porto do Mangue, Macau, Ponta do Tubarão and Guamaré were investigated to evaluate the possibility of manatees entering the rivers.

The salinity of most estuaries was equal to 0 (zero), due to the fact that the sampling period coincided with the rainy season in the Northeast, when the inflow of freshwater increases considerably. In the estuaries of Barra Grande, Ponta do Tubarão and Guamaré it did not happen, and there were found salinities of 10, 35 and 35, respectively. These systems receive insignificant freshwater flow from continental rivers, and the most significant contribution comes from groundwater, forming inlets.

It was observed that the degradation of estuaries caused by shrimp farms, salt pens installation and urbanization contributed to the siltation of the rivers mouths, which probably prevents the entry of animals in the rivers (Figure 15). In fact, the silting of the rivers mouths interferes also in traffic of fishing boats and barges to transport salt. In Pirangi, Jaguaribe, Barra Grande, Areia Branca, Macau and Ponta do Tubarão, the boats travel only during high tides. All these estuaries are heavily impacted by the use and human occupation, which destroyed much of the remaining mangrove forest, and blocked the use of breeding areas for the manatee.

Figure 15. Salt pen instalation in Barra Grande estuary, Icapui municipality.

Areia Branca and Macau estuaries have already been areas of manatee occurrence when the use and occupancy of these areas were still less prominent, as evidenced in interviews conducted in the region. In Areia Branca, there is even the photograph record of a calf that was captured in the estuary by trawl in 1972 (Fig. 16). Therefore, we can assume a strong relationship between the degradation of these two estuaries and the disappearance of manatees in both, promoting a significant loss of habitat for the species.

Figure 16. Photograph of a manatee calf captured by trawl in 1972, in Areia Branca estuary.

3.4. Considerations

The benthic flora characterization, especially the seagrass beds associated or not with seaweeds, is very important not only for the conservation of manatee feeding areas, but also as an indicator of environmental health of the region studied.

Studies on wealth and distribution of the species along the coast; the morphology and environmental conditions found in seagrass meadows; the reproductive biology and phenology; the productivity, growth, biomass and density of plants; the habitats, flora and associated fauna; the trophic interactions and connectivity with other habitats (reefs, mangroves, estuaries, etc.), the degradation and the impacts suffered by human actions should be prioritized and implemented in partnership with other institutions.

4. Antillean Manatee major threats on the east coast of Ceará and west coast of Rio Grande do Norte

The evaluation of human impacts is very important to settle on conservation goals and to design actions and strategies for the conservation of the Antillean Manatee.

There are many human uses in the study area, with different intensity according to the community. Some key human activities were considered for the evaluation of each community, for instance: vessel traffic, vessel collision, fishery activities, shrimp farms, salt farms, urban development, oil exploration, and pollution.

A setting table of threat level was elaborated relating the most important ecological attributes of manatee to each human activity (Table 06). It was given a score of 0 to 3 to the impact of each activity, according to its threat for each ecological attribute. The key ecological attributes considered in this study were: population size (mortality), reproductive success, diseases, food availability, clean freshwater availability, home range and connectivity between occurrence areas.

The sum of impact scores in each key ecological attribute represents the threat of each human activity ( ). The vulnerability of each key ecological attribute is given by the sum of the impacts in this particular attribute ( ).

In order to elaborate a map with each community level of threat, the sum of the impacts of each human activity ( ) was categorized in "high", "moderate" and "low".

Table 06. Model of a threat level setting table: human activities versus manatee key ecological attributes.

Ecological attribute	**Vessel traffic**	**Vessel collision**	**Fishery activities**	**Shrimp farm**	**Salt farm**	**Urban development**	**Oil exploration**	**Pollution**	**TOTAL**
Population size (mortality)									**Vulnerability of an attribute**
Reproductive success									
Diseases									
Food availability									
Clean freshwater availability									
Home range									
Connectivity between occurrence areas									
Total	**Human activity threat**								**Community level of threat**

The discussion of each human activity impact in the Antillean Manatee and its habitat is detailed below.

4.1. Shrimp and salt farms

The study area represents the Brazilian region where most shrimp and salt farms have been established. These enterprises were built in mangrove areas and river banks, which are "Permanent Protected Areas" according to the Federal Law no4.771, from 1965. The destruction and degradation of mangroves produce damages of short, medium and long terms in coastal and marine environments, and losses of valuable ecosystem services.

Mangrove areas destruction represents a significant loss of reproduction habitats for the Antillean manatee. This is the major problem in the study area, where all estuarine complexes are severally impacted by shrimp and salt farms (Fig. 17).

Figure 17. Satellite images showing shrimp and salt farms of: Areia Branca/Grossos estuary (A), Galinhos/Guamaré estuary (B), Porto do Mangue/Macau cities (C) Pirangi river (D), Jaguaribe estuary (E), Barra Grande estuary (F).

The east of Ceará and west of Rio Grande do Norte comprises the mainly area of manatee calves' stranding records, between 1981 and 2002 (Parente et al., 2004). Since 2002, there have been recorded other 32 calf strandings, performing a total of 58 manatee calves (Aquasis, unpublished data; UERN, unpublished data).

The environmental impacts caused by shrimp farms are related to mangrove deforestation, soil sealing, extinction of salt flats and discharge of untreated residues (Fig. 18). These residues modify the biochemical system and physical properties, and also alter the quality and the quantity of water, as well as contaminate the groundwater. In Ceará, 77% of shrimp farms release untreated residues directly into rivers and estuarine waters (IBAMA, 2005).

Figure 18. Untreated water discharge of a shrimp farm in the coastal zone of Icapuí, Ceará.

Salt farms, besides promoting mangrove deforestation for installation, also impact estuarine environments through the release of a very salted product resulted from salt extraction. According to fishermen of Macau city, where these enterprises installation initiated in the 30´s and 40´s decade, estuarine water salting caused the disappearance of the manatee in the region.

In addition, according to Juma (1997), the impacts from shrimp and salt farms are not only in estuaries, but in whole marine ecosystem. The author says that the lack of nutrient in marine environment promoted by mangrove degradation represent annual losses of 4.7 million tons of fish and 1.5 million tons of shrimps for fishery industry. In addition, there are losses of other resources not calculated yet (oysters, crabs, birds, etc.).

4.2. Fishery activities

In the study area, fishery activities are artisanal and represent an important resource for coastal communities. According to the interviews, many types of equipment are used by fishermen along the coast: gillnets, bottom trawl nets, line, lobster and fish traps, compressor and long line. In figure 19, we observe that gillnets are the most used equipment, followed by line, traps and trawling.

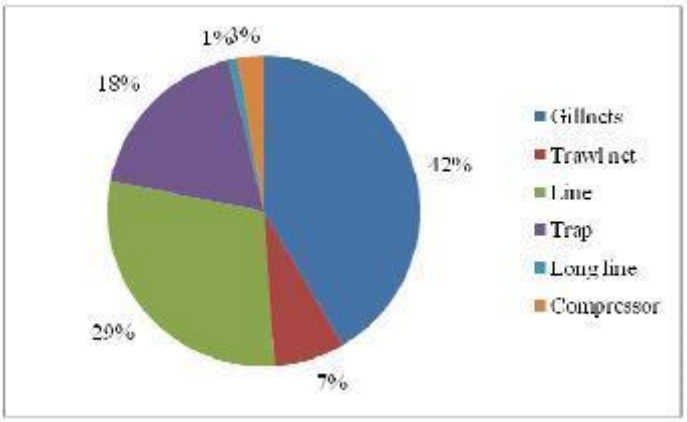


Figure 19. Fishery equipments used in the study area.

Fishery activities configure a threat to manatee because of two different impacts: destruction of feeding areas and accidental capture by fishery equipments. Besides, fishery vessels may also harm manatees, with risk of collision and sound harassment.

4.3. Destruction of feeding areas

Bottom trawling nets used by motorized boats are forbidden in Ceará and Rio Grande do Norte within less than 3 miles from the coast according to the Law nº35/035- N, from June 24th of 2003. However, trawling occurs near the coast all over the year, especially in rainy period (from January to June).

Motorized trawling produces many damages to benthic communities, because it modifies the marine substrate and removes species. Seagrass beds, the most important manatee food item (Lima, 1999; Borges et al., 2008; Reynolds III et al., 1995), are being fragmented by this activity (Green & Short, 2003; Peterson et al., 1987). Aquasis (2006) observed that seagrass beds have low density and are scarcely distributed where trawling occurs. The author suggests that manatee disappearance from Aracati city, in Ceará, could be caused by the decrease of seagrass beds due to motorized trawl fishing, and the harassment of the activity itself.

Besides physical destruction of seagrass beds, fishery activities may also suspend sediments, which contribute to the increase of water turbidity, a critical factor for seagrass that may limit their growth (Smith, 1993).

4.4. Incidental captures

The manatee incidental capture represents a threat to the species. These events were responsible for the death of 43,3% manatees recorded in Colombia from 1980 to 2004 (Castelblanco-Martinéz et al., 2009) and 6,7% animals in Puerto Rico between 1990 and 1995 (Miguinucci-Gianonni et al., 2000), although in Florida bycatches along with other mortality causes were responsible for only 3% of manatee deaths from 1986 to 1992 (Ackerman et al., 1995).

In Nicaragua, incidental capture also appears to be a threat to the species (Jiménez, 2002). In Mexico, Serrano et al. (2007) suggests that manatee disappearance in part of the country is due to the increase of fishery activities, because it might raise the chance of

bycatches. In Brazil, incidental capture is a serious threat to the species. Paludo (1998) verified that 56% of manatee stranding in the north-eastern was related to fishery interactions, from 1981 to 1996. Parente et al. (2004) states that incidental captures were responsible for only 12, 6% of manatee mortality in the same region, between 1981 and 2002. In the state of Ceará, by-catches represented the cause of 12, 6% of manatee deaths from 1987 to 2002 (Meirelles, 2008) and is one of the main threats to the species in the state (Silva, 2003).

In the study area, Aquasis has recorded four events (Aquasis, 2006; Meirelles, 2008). The deaths of two manatees were recorded in bottom trawling nets for shrimp (Fig. 20), and one adult and one calf in gillnet. Besides, during the field work of this study, the team recorded several reports of incidental capture of manatee calves and adults in beach trawl nets.

Figure 20. Adults manatee incidentally captured in motorized trawling, stranded in Fontainhas and Majorlândia communities, Aracati Municipality (photos: Aquasis archive).

4.5. Collision with motorized vessels

There are many fishery ports with significant number of motorized vessels in the study area. Higher concentrations of these fishery vessels are found in Touros coastal community (Touros Municipality), Caiçara do Norte (Fig 21) and Guamaré Municipalities, estuaries of Macau, Areia Branca and Grossos Municipalities, Barra Grande estuary (Icapuí municipality), Pirangi river (Beberibe municipality), and coastal communities Redonda (Icapuí municipality) and Quixaba (Aracati municipality).

Figure 21. Motorized vessels in Caiçara do Norte.

Due to the pre sportation in front of Areia Branca coast; Fig. 22), the traffic of big salt vessels is intense in Areia Branca/Grossos and Macau (Fig. 23) estuaries. In Guamaré estuary big vessels traffic is also intense, due to the Petrobras (Brazilian oil & gas company) port and oil exploration in the region.

Figure 22. Termisa, an offshore port for salt transportation

Figure 23. Vessels for salt transportation in Macau estuary.

The presence of motorized vessels represents two threats to manatee: sound pollution and collision risks.

Manatees use sounds especially to establish and maintain the contact between mother and calf, particularly to locate each other when separated (Hartman, 1979). Besides, sounds are also used as a communication tool between adults in feeding and moving areas, especially in turbid waters (Van Meter, 1989), and evidences of sexual vocal differences suggest that the emission of calls may have function in reproduction (Sousa-Lima et al., 2008). The increase of sound levels may harm the capacity of sound detection, damage the communication between animals and even maternal care, and also may affect immunological functions, reproduction and animal's development (Hildebrand, 2005). Lima et al. (2005), during the monitoring of a female and its calf, observed that after four days from the calf birth there was an increase in the number of motorized vessels in the local they remained, what contributed to their separation, and caused the death of the newborn.

Alves (2007) suggests that trawling in critical habitats may cause the evasion of manatees, and depending on the frequency of the activity, may cause access exclusion to an important area for the species. In Quixaba, Retiro Grande and Ponta Grossa coastal communities, trawling activities for shrimps are very common. Besides, in rainy periods, when rainfall cause the extravasation (or overflow) of shrimp farms, motorized trawling occurs very near the coast and estuaries of the study area.

Miksis-Olds (2006), in a study to verify manatee behaviour alterations in the presence of vessel sounds, verified that 20% of the animals leave the area. This fact shows that sound pollution may deteriorate animals' home range. Serrano et al. (2007) suggest that the increase in the number of fishery vessels in Mexico may have caused the disappearance of manatees in the local, as well as Smith (1993) says that manatees avoid areas with strong vessel traffic, even though the place has great ecological qualities.

Watercraft-related mortality is a serious problem to the species, because it may cause fatal injuries (Borges et al., 2007; Ackerman et al. 1995; Wright et al. 1995; Nowacek et al. 2004). In Florida, manatee collisions with motorized boats are responsible for 25% of animals deaths recorded between 1979 and 2004 (Rommel et al., 2007), and is considered the major threat to the species in the local (Laist & Shaw, 2006). In Puerto Rico, collisions caused 29.8% of the deaths recorded from 1990 and 1995 (Mignucci-Giannoni et al., 2000).

In Brazil, there are six records of collision events between manatees and motorized vessels, involving three animals (one adult and two calves) (Borges et al., 2007). Besides, there is also a record of a female death caused by a collision against a sail vessel in Icapuí city (Meirelles et al., 2009).

It's unknown why collisions occur. The hypotheses are: animals cannot hear motor sound; or animals do hear the sounds, but are relatively slow to escape from the vessel. The literature studies are contradictories.

Ketten et al. (1992) say that manatee hearing is little sensitive, has a limited range and a very weak ability to detect sound source. The authors suggest that the threat of motorized vessels is due to deficiency on manatee ability to detect the own threat. On the other hand, Gerstein (2002) shows that manatee has a great capacity of locating sound source, and this is very important to maintain mother/calf pair, that communicate through vocalizations. However, vessel sounds, in an environment with other natural sounds, is acoustically transparent to the animals. I.e., they do not detect and answer to vessels presence. In contrast, Nowacek et al. (2004) and Miksis-Olds (2006) indicate that manatees detect and answer to

vessels that approach, with a behaviour apparently of fear expressed by submersion to higher depths.

Efforts have being applied to avoid manatee strikes by motor boats. Studies suggest that speed reduction is a good strategy to avoid collisions, because allows the animals to detect the threat and have time to move away (Nowacek et al., 2004; Laist & Shaw, 2006). However, Gerstein (2002) says that manatees are even less capable to detect a vessel when it reduces speed. Traffic restriction in critical areas also contributes to minimize risks of collision, allowing animals safety (Gorzelany 2005; Laist & Shaw 2006).

According to Smith (1993), motorized vessel traffic may also affect manatees because it causes damages to seagrass beds, affecting critical parameters of water quality to their maintenance, such as turbidity. The author suggests that the increase of turbidity caused by vessel traffic in shallow waters limits the depth in which they develop.

4.6. Urban development

The study area comprises 14 municipalities, from which ten have a population density higher than 25 people/km2 (IBGE, 2007). However, in many of these municipalities the majority of the population live in the countryside, and coastal communities are less occupied.

The main communities with significant urban development in the coast are Touros and Cajueiro (Touros municipality), São Miguel do Gostoso and Enxu Queimado (S.M. do Gostoso municipality), estuary margin of Macau, Areia Branca and Grossos cities, Redonda (Icapuí municipality) and estuary margin of Fortim, Viçosa and Jardim (Fortim municipality). We can observe that the estuaries are more subjected to synergetic effects of urban development than the beaches in the study area. However, we should consider the consequences of estuary degradation in adjacent coastal zone.

The threats resulting from urban development in coastal zone and estuaries are more related to manatee habitat destruction and degradation than to direct effects to the animals. Lima (1999) suggests that the most important manatee occurrence areas in north-eastern Brazil correspond to the areas with lower indexes of human occupation and urban development. The author has not found significant records of the species in areas considered as “Highly impacted” by him. In the present study, the manatee occurrence was not recorded in the areas considered “Highly degraded”,

Urban development in coastal zone implicates in a considerable increase of sewage discharge, aquatic commercial and recreational activities, including port installation, as in Guamaré, Macau and Areia Branca estuaries. The development decreases marine water quality and leads to a reduction of seagrass beds. The destruction of coastal and river margin vegetation by urban edifications increases the rate of erosion and sediment transport near shore, which damages the development of seagrass (Smith, 1993).

All hydrological resources of the study area are highly endangered due to urban pressure. Many cities have developed in the margins of the main estuaries, what caused the deforestation of mangrove vegetation and river siltation. This represents a significant loss of manatee reproductive habitat, as discussed before.

4.7. Pollution

Pollution is an inherent factor related to urban development, especially in the coastal zone. In the communities where urban development is high, there are many polluted sources, such as domestic sewage discharge, solid residues and fishing equipments release.

Besides, in Tremembé community in Icapuí municipality, fishermen use iron drums and old cars as artificial reefs, which may contaminate the marine environment. These iron drums were used to stock alkyd resins, a highly toxic substance to biodiversity.

Because of its unique characteristics, such as a robust body, long life, herbivore, as well as disease and trauma resilience, manatee seems not to be an ideal species to be used as sentinel (Bonde et al., 2004). However, manatees are relatively sensitive to red tides because of the toxins produced by the algae evolved in these events (Bonde et al., 2004). In Florida, in 1996, 149 cases of manatee mortality were recorded and associated to brevetoxin, produced by dinoflagellates (Bossart et al., 1998). Other mortality cases of these animals caused by red tides were recorded (Forrester, 1992).

Due to manatee position in the food chain, their exposure to contaminants is relatively low (Bonde et al., 2004), although there are records of organ chlorines, mercury, lead, cadmium, cooper, iron and selenium in manatee tissue (Forrester, 1992). However, contaminants effects in the animals are little known (Van Meter, 1989).

Marine debris is also an impact source to manatees, because the residue can be incidentally ingested by the animals, as recorded by Beck & Barros (1991), Reynolds III et al. (1995), in Costa Rica, Mignucci-Giannoni et al. (2000), in Puerto Rico. Litter ingestion may kill the animals by peritonitis, intestinal blockage, and subsequent starvation, or massive infection (Smith, 1993).

Discarded fishing nets, lines or ropes are also a problem related to marine pollution, because manatees may be entangled, as occurred in Puerto Rico and Florida, where 17 manatees died in these circumstances between 1974 and 1991(Smith, 1993).

In addition, pollution may also affect food availability. The increase of human populations in the coastal zone is followed by a decrease in water quality (Haddad, 2002), purchased from sewage discharge. This increases water turbidity that decreases aquatic vegetation abundance (Smith, 1993). The reduction of manatee food item may cause nutritional stress and, as consequence, a decrease in reproductive success, promoting lacks in population distribution (Bonde et al., 2004).

4.8. Gas and oil exploration

It's known that fossil fuel burn has global effects, such as global warming and air pollution, but few studies evaluate the consequences of oil and gas exploration in the adjacent coastal zone and marine biodiversity. Campos et al. (2003) suggests the major impacts resulted from this activity as related to transportation, storage and refine of hydrocarbon.

For gas and oil exploration in Brazilian continental platform, as well as for seismic surveys, a continental harbour facility is necessary. In Guamaré estuary there is an industrial complex for the processing of oil and gas from marine and terrestrial exploration fields from all the state of Rio Grande do Norte.

Besides, oil spill has been recognized by its effects on seagrass beds (Smith, 1993), which may cause serious or subtle damages, depending on the circumstances. In Puerto Rico, for example, due to an oil spill in 1973, combined with strong wind and shallow water, a seagrass bed was devastated (Zieman, 1982; Zieman et al., 1984). In most cases, oil spill produces little damages to seagrass, although local fauna is severely affected (Smith, 1993),

because most seagrass have the bulk of their biomass underlying sediments, decreasing their exposure to toxins (Zieman et al., 1984).

The Antillean Manatee is a coastal species, and oil spill in continental platform configures a threat to the species only if it occurs near the coast. The effects of oil on manatees are individuals, and refer to eye irritability, incidental ingestion of crude oil, which may affect the secretion of its only gastric gland or intestinal flora (St. Aubin & Lounsbury, 1988).

4.9. MAP: Threat level of coastal communities in the study area

An individual analysis was performed for each coastal community in the study area, according to the impact setting table of each one, and a map was elaborated with the threat level of the communities' coastal zone (Fig. 24).

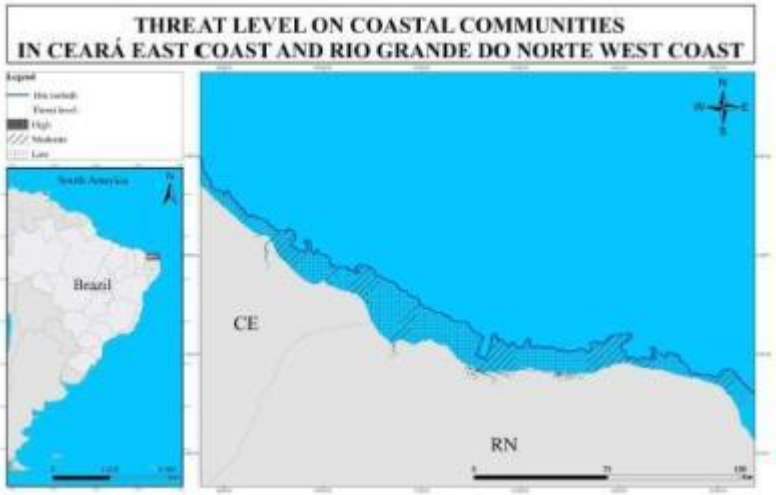


Figure 24. Coastal communities' threat level in the east of Ceará (CE) and west of Rio Grande do Norte

5. Priority areas for the conservation of the Antillean Manatee on the east coast of Ceará and west coast of Rio Grande do Norte

Setting priority areas for conservation is extremely important to direct efforts and design actions to avoid species and ecosystems extinction and ensure ecosystem services. Besides, establish conservation priorities is necessary due to high speed of natural resources degradation (Rocha et al., 2006).

In this study, it was performed a data collection to address priorities areas for the conservation of the Antillean Manatee, *Trichechus manatus*, in the east coast of Ceará and the west coast of Rio Grande do Norte. This area was considered priority for studies in a strategic planning for the species conservation since it's the major region in lack of information on manatee ecology in our region.

The methodology used to define the priority areas for manatee conservation was adapted from that developed by The Nature Conservancy (TNC) to identify high priority places and ensure biodiversity conservation ("Priority Setting Step of Conservation by Design"; Chatwin, 2007). This methodology is also used to the definition of priorities areas

for biodiversity conservation, sustainable use and benefit repartition by the Brazilian Environment Ministry (Brasil, 2007).

According to Chatwin (2007), the tools needed to establish priorities, known as "ecoregional assessment", are focused on answering four key-questions:

1. What should be protected?
2. From what should it be protected?
3. How much should be protected?
4. Where should it be protected?

Following this methodology, the establishment of manatee conservation priority areas was done answering each question.

5.1. What should be protected?

Manatee is considered a conservation target, because it satisfied three of the four criteria used in the definition of conservation targets (i.e., CR or EN species in the IUCN Red List; species with considerable population decline; key-stone species or; endemic species), and be included in only one criteria is already enough. The Antillean Manatee, *Trichechus manatus manatus*, is a subspecies of the West Indian Manatee, and is considered as endangered (EN) by the IUCN. In Brazil, the most recent records (IUCN, 2008) show a substantial decline in manatee population abundance, with an estimate of 200 individuals with discontinuous distribution (Lima, 1997) in the Brazilian coast (in contrast with the old estimate, which predicted 500 animals in our country; Lima, 1997; Luna, 2001). Besides, the species is one of the main focuses of Aquasis, considered as an umbrella species to promote the conservation of Ceará and Rio Grande do Norte coastal zone. In addition, manatee is a key-species, once it plays an important role in the maintenance of seagrass beds, an important coastal ecosystem.

In order to subsidize manatee conservation planning, information about species occurrence and its potential areas of use were obtained. Both information were considered and crossed, so it was possible to elect/choose levels of ecological importance for the coastal zone of the study area (extremely high ecological importance, very high ecological importance, high ecological importance and moderate ecological importance)

5.2. From what should it be protected?

The study about human related impacts on manatee was used to identify the level of threats intensity in the study area.

5.3. How much should be protected?

This question has the purpose to determinate conservation goals, i.e., the portion of the area that must be protected to ensure conservation targets, according to its current status, vulnerability and abundance.

In this study, the Antillean Manatee is the conservation target. Its key ecological attributes analyzed were those that directly influence the species distribution: presence of seagrass and presence of a freshwater source. Birth areas, where calves were reported were also considered a key attribute, once manatee major threat in north-eastern Brazil is the degradation and loss of reproduction areas. Considering that the species is critically endangered (CR) in Brazil (BRASIL, 2007), current occurrence areas were also considered as an ecological key attribute, so we can guarantee that these places are included in setting priorities for manatee conservation.

The key ecological attributes were classified according to its current condition, vulnerability and abundance (Table 07). Conservation goals were set to each of the attributes, and resulted from the sum of these parameters. The goals were defined according to each sum value in TNC methodology (where: sum of 0-5 is associated to a goal level of 30%; 6-7 to 65% and; 8-9 associated to a 100% conservation goal level).

Table 07. Setting table for conservation goals definition, according to current condition, vulnerability and abundance of manatee key ecological attributes.

Key ecological attribute (KEA)	Current condition	Vulnerability	Abundance	Total	CONSERVATION GOAL
Feeding area	2	2	1	5	**30**
Manatee nursery	2	2	2	6	**65**
Freshwater source	3	2	1	6	**652**
Current occurrence	2	2	2	6	**65**

(Where: for **current condition** **1**=requires little intervention for ecological quality maintenance, **2**=some intervention required for maintenance, **3**=restoring difficulty; **vulnerability** **1**=human activity has low influence in KEA status, **2**=human activities have some influence in KEA status, **3**=activities have strong influence on KEA; **abundance** **1**=abundant, **2**=common, **3**=rare).

Conservation goal was used as an index in the setting priority table for ecological importance definition of each community coastal zone in the study area.

5.4. Where should it be protected?

This question has the objective of identifying priority areas for the conservation of conservation targets.

First, the ecological importance of coastal zone to manatee was identified. It was considered in the analysis of manatee occurrence area, presence of seagrass, freshwater sources and nursery areas, according to priority levels (i.e., their conservation goals, determined in the question 3). A priority setting table was elaborated with this information, which was scored in order to constitute a ranking, in which the highest punctuations refer to areas with the highest ecological importance to manatee (Fig. 25). These areas subsidize the definition of which areas should be protected.

In Table 08, we can observe that adjacent coastal zone of 48, 2% (40/83) communities has a high level of ecological importance (extremely high and very high), and they were especially included in the definition of the priority areas.

Table 08. Number of coastal communities according to ecological importance to manatee.

Ecological importance	Number of communities	% study area
extremely high	19	24,1
very high	27	24,1
high	14	33,7
moderate	23	18,1

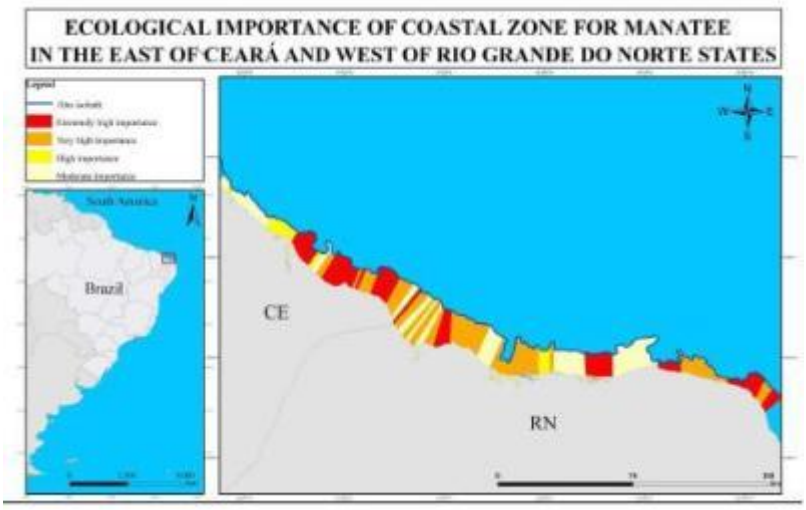


Figure 25. Ecological importance of coastal zone for Antillean Manatee conservation in the east of Ceará (CE) and west of Rio Grande do Norte (RN) states. (RN).

5.5. Priority areas setting for manatee conservation

The Antillean Manatee is critically endangered (CR) in Brazil, according to National Environment Agency (BRASIL, 2007). Therefore, all species distribution area was considered priority for manatee conservation. The priority level of each area was defined according to its ecological importance to manatees.

Areas with extremely high ecological importance to manatee were almost all defined as extremely high priority for the species conservation, except for Canoa Quebrada coastal community in Aracati city, Praia Ceará community in Tibau city and Galos community in Galinhos city. These areas are located between low important areas, as well as very impacted. Therefore, they were considered as one level below of priority, i.e., very high priority.

Extremely high important areas intercalated with very high important areas were clustered in blocks of extremely high priority areas for manatee conservation. Although there is current occurrence of manatees only in Galinhos estuary, all estuaries of the study area and their adjacent coastal zone were considered very high priority areas, because of their major importance to marine biodiversity. Besides, according to the interviews, all estuaries in Rio Grande do Norte have recent or historical manatee occurrence.

As a result of this analysis, the priority areas map for manatee conservation was elaborated, with 17 blocks of different priority levels distributed in the study area (Fig. 26), between extremely high, very high and high priority areas.

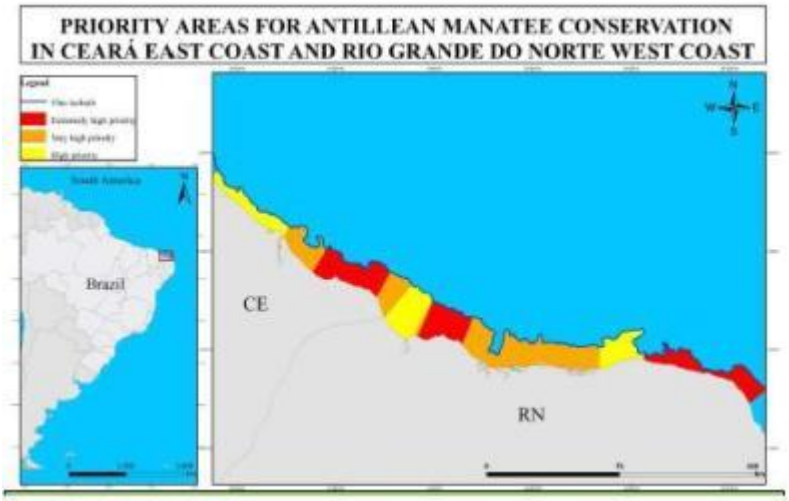


Figure 26. Priority areas for Antillean Manatee conservation in the east coast of Ceará (CE) and west coast of Rio Grande do Norte (RN).

6. Priority actions for Antillean Manatee Conservation on the east coast of Ceará and west coast of Rio Grande do Norte

Priority actions were discussed and identified as extremely high and very high priority areas. Once defined, different actions were discussed for the different areas, based on seven categories:

- Creation of Protected Area;
- Habitat restoration;
- Management of natural resources use;
- Research;
- Adequate areas for the release of rehabilitated manatees;
- Educational effort;
- Consolidation of a stranding network in coastal communities;
- Application of Law.

Priority actions were set according to each community impact setting table and urgency of needed action (urgency of needed action is the level of intervention required for restoration of environmental quality for manatee survival).

Urgency of actions for manatee conservation was set crossing the information on ecological importance of the area with its threat level (Table 09).

Table 09. Urgency level setting table, according to ecological importance to manatee and threat level of the study area.

Ecological importance	High threat level	Moderate threat level	Low threat level
Extremely high	Extremely high urgency	Extremely high urgency	High urgency
Very high	Extremely high urgency	High urgency	Moderate urgency
High	High urgency	Moderate urgency	Low urgency
Moderate	Moderate urgency	Low urgency	Low urgency

A map indicating the urgency of action was elaborated (Fig. 27). Only 8, 43% (7/83) of the coastal zone has an extremely high urgency of action, and 27, 7% (23/83) has a high urgency (Table 10).

Table 10. Number of communities according to the urgency of actions.

Action urgency	Number of communities	% of study area
Extremely high urgency	7	8,4
High urgency	23	27,7
Moderate urgency	27	27,7
Low urgency	26	36,2

Blocks of areas with equal level of priority for conservation were evaluated, as well as each community on the blocks. In this way, it was possible to establish very locally priority action. Table 11 shows the actions needed for each community.

The priority actions established in this report will direct next steps on the strategy for Antillean Manatee conservation in the study area.

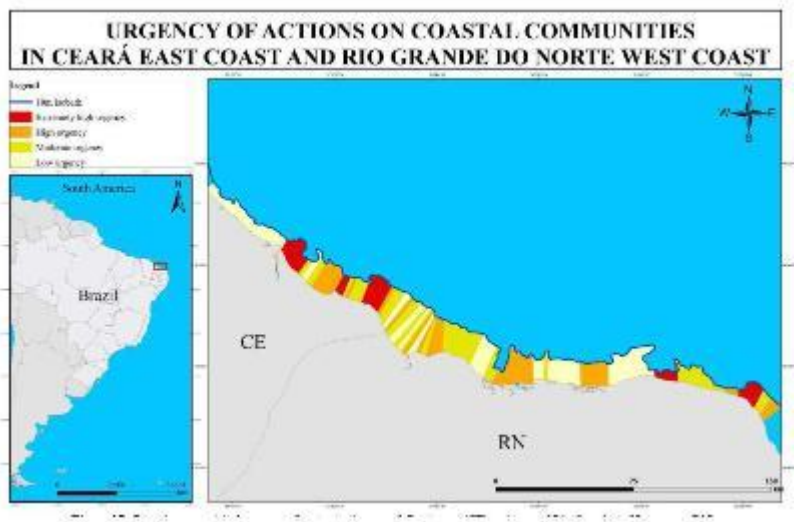


Figure 27. Coastal communities' urgency of action in the east of Ceará state (CE) and west of Rio Grande do Norte state (RN).

Table 11. Priority actions for each coastal community of extremely high and very high priority for Antillean Manatee conservation.

Coastal community	Blocks of conservation priority	PRIORITY ACTIONS
Canoa Quebrada	very high	Habitat restoration; Management of natural resources use; Educational effort.
Majorlândia		Habitat restoration.
Quixaba		Habitat restoration; Management of natural resources use; Educational effort; Application of the Law.
Lagoa do Mato		Educational effort.
Fontainhas	extremely high	Creation of Protected Area; Educational effort.
Retirinho		Creation of Protected Area; Educational effort.
Retiro Grande		Creation of Protected Area; Educational effort.
Ponta Grossa		Creation of Protected Area; Areas adequate for the release of manatees; Educational effort.
Redonda CE		Habitat restoration; Management of natural resources use; Educational effort.
Peroba		Creation of Protected Area; Educational effort.
Picos		Creation of Protected Area; Educational effort.
Barreiras de Baixo		Creation of Protected Area; Educational effort.
Barreiras de Cima		Creation of Protected Area; Educational effort.
Barrinha		Creation of Protected Area; Educational effort.
Requenguela		Management of natural resources use; Educational effort; Application of Law.
Quitérias		Management of natural resources use; Educational effort.
Tremembé	very high	Management of natural resources use; Educational effort; Application of Law.
Melancias		Educational effort.
Peixe-Gordo		Educational effort.
Manibu		Educational effort.
Praia Ceará		Educational effort.
Upanema	very high	Habitat restoration; Management of natural resources use.

Baixa Grande	**extremely high**	Creation of Protected Area; Management of natural resources use.
Redonda RN		Creation of Protected Area; Management of natural resources use.
Morro Pintado		Creation of Protected Area; Management of natural resources use.
Cristóvão		Creation of Protected Area; Areas adequate for the release of manatees.
Ponta do Mel		Creation of Protected Area.
Pedra Grande	**very high**	
Rosado		
Costa de Porto do Mangue		Management of natural resources use; Application of Law.
Costa de Macau		Management of natural resources use; Application of Law.
Costa de Barreiras		Management of natural resources use.
Costa de Diogo Lopes		Management of natural resources use.
Costa de Sertãozinho		Management of natural resources use.
Costa de Guamaré		Management of natural resources use.
Galos		
Enxu Queimado	**extremely high**	Research.
Praia do Marco		Research.
Morro dos Martins		Research.
Morro dos Paulos		Research.
São Miguel do Gostoso		Research.
Monte Alegre		Research.
São José		Research.
Lagoa do Sal		Research.
Cajueiro		Research.
Touros		Research.
Carnaubinha		Research.
Perobas		Research.
Rio Pirangi	**very high**	Habitat restoration; Application of Law.

Barra de Fortim	**very high**	Habitat restoration; Application of Law.
Fortim		Habitat restoration; Application of Law.
Viçosa		Habitat restoration; Application of Law.
Volta		Habitat restoration; Application of Law.
Pedra Redonda		Habitat restoration; Application of Law.
Jardim		Habitat restoration; Application of Law.
Cumbe		Habitat restoration; Application of Law.
Rio Barra Grande	**very high**	Habitat restoration; Application of Law.
Areia Branca	**very high**	Habitat restoration; Application of Law.
Grossos		Habitat restoration; Application of Law.
Porto do Mangue	**very high**	Habitat restoration; Application of Law.
Macau		Habitat restoration; Application of Law.
Barreiras estuário	**very high**	Habitat restoration; Application of Law.
Diogo Lopes		Habitat restoration; Application of Law.
Sertãozinho		Habitat restoration; Application of Law.
Galinhos	**very high**	Habitat restoration; Application of Law.
Guamaré		Habitat restoration; Management of natural resources use; Application of Law.

7. AQUASIS´ NEXT STEPS ACCORDING TO PRIORITY ACTIONS:

7.1. Proposal of Creation of a Marine Protected Area and Management of natural resources use

Aquasis is an institutional member of the sign team for a Marine Protected Area (MPA) in the east coast of the state of Ceará, between Beberibe and Icapuí cities. This area comprises the Ceará portion of the study area. The MPA objectives are the protection of threatened species (Antillean Manatee, migratory birds and marine turtles), key nurseries ecosystems (estuaries, seagrass beds and algae banks) and fishery management.

The information resulted from this study will compose an environmental diagnosis of the area, that will be used to endorse the MPA proposal and its zoning and managing plan.

The proposal has already been approved by the Brazilian Government Authorities and is in process, although there has not been defined a category. The MPA will permit a sustainable use by artisanal fisheries, but the highest priority areas with needed action of "creation of a protected area" for manatee conservation will be designed for future protected area with non-permitted use (only for research or other conservation action).

In the state of Rio Grande do Norte there is another area with demanding a protected area creation, and might be Aquasis' future focus for Antillean Manatee conservation.

7.2. Educational effort and consolidation of a stranding network

A recent approved project by Aquasis for Antillean Manatee conservation began January 2010. Two of the project's main objectives are consolidating a stranding network with coastal communities and their key members (in the states of Ceará and Rio Grande do Norte) and promoting educational effort in critical selected communities.

The stranding network will be consolidated through the identification of key community members that will be "joined" to Aquasis' stranding crew. They will receive a theoric and practical training course about marine mammals, human related impacts and actions in strand events. Their telephone numbers and names will be strategically put on all posters and distributed in their community, so they can be contacted in case of a marine mammal stranding. This network will contribute to a faster attendance to the animals that strand alive, increasing recovery chances.

In the east coast of Ceará there are two key municipalities for manatee conservation: Icapuí and Aracati. These are the focus of the Educational effort predicted in the approved project in which all communities should be evolved in manatee conservation issues, specially school teachers, local environmental managers and fishermen.

7.3. Adequate areas for rehabilitated manatees release

Aquasis team has been rescuing Antillean Manatee neonates that strand on Ceará and Rio Grande do Norte in partnership with the National Centre for the Conservation of Aquatic Mammals (CMA-ICMBio, Ministry of Environment) and Rio Grande do Norte State University, since 1992. The rescued calves stay on Aquasis' Marine Mammal Rehabilitation Centre only along the necessary period to stabilize their health. After that, they are sent to the CMA-ICMBio in the state of Pernambuco by airplane, provided by the Ceará Government.

After rehabilitation, these neonates are released in other states closer to the CMAICMBio, mainly in Alagoas and Paraíba (Lima et al., 2007). However, on the Marine Mammal Release Protocol of the National Oceanic and Atmospheric Administration (NOAA, 1997), and on the recent Antillean Manatee Release Protocol in Brazil, published by ICMBio (Lima et al., 2007), rehabilitated manatees should be released on the same region that they stranded, once the local have: wild manatees; feeding areas; fresh water supplies; and low motor boats traffic. This procedure is very important for the maintenance of the manatee population genetic unit, and its conservation.

If rehabilitated animals do not return to their native population, the size of this population can reach critical levels, leading to inbreeding, that can reduce the population disease resistance and compromise the adaptive response of population to a changing environment and, as a consequence, their long-term persistence, that can lead to local extinction.

As stated before, Aquasis recently approved a project for Antillean Manatee conservation that began its activities in January 2010. One of the main objectivities is the construction of a larger Marine Mammal Rehabilitation Centre, specially designed for manatee calves, what will allow complete rehabilitation of all animals recued in necessary time. In this way, it will be possible to release them near their strand local.

In this study, two areas were considered adequate for manatee stranded release: Ponta Grossa (Icapuí city) and Cristóvão (Areia Branca city). Aquasis' primary next step is to seek for resource and partnership to build a semi-captive structure in one of these areas to an adaptive time to release the rehabilitated calves in the new Centre.

7.4. Research and habitat restoration

Antillean Manatee National Conservation Plan

Aquasis, in partnership with the National Centre for the Conservation of Aquatic Mammals (CMA-ICMBio, Ministry of Environment) and other Brazilian institutions, is developing Antillean Manatee National Conservation Plan, where it will be clarified what studies are priorities for the species conservation. This study already shows that some areas have a high priority for research, where the occurrence of manatees should be more investigated. In areas where the presence of the species and some ecological aspects of the populations are known, studies such as abundance estimative and identification of spatial use area shall be taken soon. Genetics studies are already being performed, so we can understand more about the population dynamics, through kinship analysis of samples from dead and alive stranded animals.

Besides, Aquasis also maintain partnerships with institutions that have a more local performing, which drive efforts to mangrove restoration in some critical areas for manatees, such as Barra Grande estuary, in Icapuí municipality. In this area, Aquasis is working together with the *Fundação Brasil Cidadão,* a NGO that is performing mangrove restoration. Also in Icapuí, Aquasis is working with the prefecture, trying to avoid the installation of other enterprises in mangrove area, as wind farms.

Other partnerships should be taken soon, so we can also promote the restoration and preservation of other mangrove areas, dunes (that ensure freshwater supply to springs) and sea grass beds.

7.5. Application of Law

Environmental law application and control of human activities could themselves minimize major part of Antillean manatee threats, especially concerned to fishing activities, shrimp farms and oil exploitation. An adequate control, including penalty and habitat restoration promotion can contribute significantly to reduce direct and indirect impacts to the species. Aquasis is and will continue to be in permanent contact with federal, state and municipal environmental agencies to ensure law and penalties application.

8. CONCLUSIONS

According to the results of this study, we can conclude that:

- Although there are lacks among current manatee occurrence area in the east coast of Ceará and west coast of Rio Grande do Norte, we can say that the species distribution is continuous in

the region, between western of Aracati city (Canoa Quebrada community) and eastern of Touros city (Perobas community).

- The study area comprises an important reproduction habitat to the species, with propitious locals to females and their calves.
- The study area has important seagrass beds, and the study of their abundance, biomass, composition and dynamics must be emphasized. Moreover, freshwater sources were identified in the area, and need to be located and studied on seasonality and water flux quality.
- Six main threats to manatee were identified in the study area: shrimp and salt farms; fishery activities; vessel traffic; oil exploration; urban development and pollution.
- Manatee is critically endangered in Brazil (CR), and all the species distribution in the study area is considered priority for conservation, including areas with isolated but recent records.

9. RELEVANCE OF RESULTS FOR ANTILLEAN MANATEE CONSERVATION

STUDY IMPACT

The study area comprises the region where manatee is most threatened in Brazil, and it holds the national record in number of calves stranding. Although, during the two Workshops for Evaluation of Priority Areas for Marine and Coastal Biodiversity Conservation, in Tamandaré (in the state of Pernambuco) and Salvador (the capital of the state of Bahia), in 2006, held by Brazilian Environment Ministry, it was verified that this area had the major lack of knowledge about the species, especially in the state of Rio Grande do Norte. It was considered an extremely high research priority for manatee conservation in the country.

The information resulted from this project, related to manatee distribution and potential use areas are new for most of the study area, especially in the west coast of Rio Grande do Norte. From the obtained data, it was possible to establish priority levels for the whole area, based on ecological importance of the places to manatee.

The results from manatee occurrence areas, as well as important areas for the species (e.g., seagrass beds and nursery habitats) were summarized in an illustrated map of the study area for publishing. The map was placed in a folder, together with information related to the research. More than 1,500 folders were distributed in all coastal communities of the studied area, so the fishermen that collaborated with the study could have access to the knowledge they helped build.

Besides conducting the research, the team identified community members to become volunteers that received an educational folder containing information about protective laws, life history and biology of the manatee and how to act in case of stranding, especially of calves (Fig. xx).

Figure 28. Aquasis' research team distributing the educational folder and identifying volunteers in the communities.

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