



Using traditional ecological knowledge to prospect the distribution of the Antillean manatee *Trichechus manatus manatus* (Sirenia: Trichechidae) in the states of Ceará and Rio Grande do Norte, Brazil

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Abstract – The Antillean manatee occurred along 3,000 km of Brazilian coastline. However, an approximately 1,100 km decrease in its distribution has been registered. This study sought to update the information on the distribution of the Antillean manatee based on traditional ecological knowledge between Ceará and Rio Grande do Norte States, Brazil. A total of 678 interviews were conducted. The question used to define manatee distribution was "When was the last time you saw a manatee in your community?" The responses allowed for the areas to be ranked into: Current, Recent, Historical, and Non-Occurrence. Based on the responses given, we have determined the current species distribution area to be between the municipalities of Aracati and Touros. Results confirmed previous occurrence of manatee along the Rio Grande do Norte coast, but in the municipalities of Fortim and Beberibe in Ceará, the interviewees have not seen the species in recent years. Results suggest that the distribution of this species along the eastern coast of Ceará may be decreasing and becoming fragmented. Thus, it is important to make efforts to confirm species distribution in the region, as well as to estimate population size and to understand the biology and ecology of the species.

Keywords: Mangrove, estuary, conservation evaluation, endangered species, mammals

Resumo – Utilização do conhecimento ecológico tradicional para identificar a distribuição do peixe-boi das Antilhas *Trichechus manatus manatus* (Sirenia: Trichechidae) nos estados do Ceará e Rio Grande do Norte, Brasil. O peixe-boi das Antilhas ocorria ao longo de 3.000 km da costa brasileira. No entanto, registou-se uma diminuição de aproximadamente 1.100 km na sua distribuição. Este estudo buscou atualizar as informações sobre a distribuição do peixe-boi com base no etnoconhecimento de pescadores entre o Ceará e o Rio Grande do Norte, Brasil. Foram realizadas 678 entrevistas. A pergunta usada para definir a distribuição do peixe-boi marinho foi "Quando foi a última vez que você viu um peixe-boi na sua comunidade?" As respostas permitiram que as áreas fossem classificadas em: Atual, Recente, Histórica e Não

Ocorrência. Com base nas respostas dadas, a área atual de distribuição da espécie foi estabelecida entre as cidades de Aracati e Touros. Os resultados confirmaram informações sobre a distribuição do peixe-boi ao longo da costa do Rio Grande do Norte, mas nas cidades de Fortim e Beberibe no Ceará, os entrevistados não viram a espécie nos últimos anos. Os resultados sugerem que a distribuição desta espécie ao longo da costa leste do Ceará pode estar diminuindo e se tornando fragmentada. São necessários esforços para confirmar a distribuição da espécie na região, bem como para estimar o tamanho da população e entender a sua biologia e ecologia.

Palavras-chave: manguezal, estuário, conservação, espécies ameaçadas, mamíferos

Introduction

The distribution of marine mammals depends on multiple factors and the interactions among them, including demography, evolution, ecology, habitat, and anthropogenic influence, which itself includes anthropogenic sounds, hunting, habitat suppression, pollution and bycatch (Forcada 2002). Sirenians are the only strictly herbivorous aquatic mammals, and this characteristic limits their distribution. The Antillean manatee, *Trichechus manatus manatus*, inhabits mainly coastal habitats, and individuals are rarely observed at depths greater than 5m; this animal occurs mostly in coastal rivers, estuaries, and shallow coastal waters, where it finds food and calm waters for breeding (Lefebvre *et al.* 2001, Reynolds & Powel 2002).

Antillean manatees are found in western Texas, Mexico, Belize, Honduras, Guatemala, Nicaragua, Costa Rica, Panama, Venezuela, Colombia, Guiana, Suriname, French Guiana, and Brazil (Lefebvre *et al.* 2001; Reynolds & Powel 2002; Deutsch *et al.* 2008). They are also found along the coast of Caribbean islands, including Cuba, the Dominican Republic, Haiti, Jamaica, Trinidad and Tobago and Puerto Rico, and there have been rare occurrences reported in the Bahamas (Erdman 1970; Odell *et al.* 1978; Belitsky and Belitsky 1980; Mignucci-Giannoni *et al.* 2000; Deutsch *et al.* 2008). The Antillean manatee is considered Endangered by the IUCN (Deutsch *et al.* 2008).

Historically, researchers who sought to identify occurrence areas of Antillean manatees in Brazil have adopted different approaches, including interviews (Albuquerque and Marcovaldi 1982; Lima *et al.* 1992; Lima 1999; Luna 2001; Alves 2007), shore monitoring (Paludo and Langguth 2002), boat and/or airplane surveys (Alves 2007; Alves *et al.* 2013; Normande *et al.* 2014a; Alves *et al.* 2016), land-based surveys from set points (Borobia and Lodi 1992), telemetry (Normande *et al.* 2014b; Normande *et al.* 2015; Normande *et al.* 2016) and side scan sonar (Choi-Lima 2017). Literature on manatee monitoring worldwide also

reports the combined use of these techniques (Mayaka *et al.* 2013; Arévalo-González *et al.* 2014).

In Brazil, Antillean manatee distribution studies started in the 1970s (Whitehead 1978). Twelve years later, Albuquerque and Marcovaldi (1982) reported the disappearance of the species from the coasts of the states of Espírito Santo (ES) and Bahia (BA), and also reported a continuous distribution of the species from the state of Sergipe (SE) to the state of Amapá (AM). Lima *et al.* (1992) found that the species distribution area was much shorter than the area reported by Albuquerque and Marcovaldi (1982), and they reported the disappearance of the species from the state of Sergipe (SE). Furthermore, other studies on the Antillean manatee distribution in Brazil reported that the distribution area covered the state of Alagoas (AL) to the state of Amapá (AM), but with areas of discontinuity (Lima 1999; Luna 2001).

Silva (2003) reported two areas with Antillean manatee occurrences in the state of Ceará (CE): on the western coast, in the municipality of Barroquinha (on the border with Piauí state) and on the eastern coast, in the municipalities of Fortim, Aracati, and Icapuí, the latter of which is on the border between the states of CE and Rio Grande do Norte (RN). Costa (2006) considered the municipalities of Fortim, Aracati and Icapuí to be important Antillean manatee occurrence areas in Brazil.

According to the Brazilian Red List of Threatened Fauna Species (MMA 2014), the Antillean manatee is considered endangered, and it is expected that this risk will increase in the near future. The species was considered until recently as the most endangered marine mammal in Brazil, with an estimated population ranging from 500 - 1000 individuals along the entire Brazilian coast (Lima 1999; Luna 2001; MMA 2014; Alves *et al.* 2016;). In the Northeast of Brazil, the bordering area between the states of Ceará (CE) and Rio Grande do Norte (RN) corresponds to the most critical area for manatee conservation, since it holds the national

record of neonate strandings and is the area with the most significant population loss in the country. Thus, projects and priority actions have been endorsed for the conservation of the species along the Brazilian coast, within the National Action Plan for the Conservation of Sirenians in Brazil (ICMBio 2011). These actions include studies to map manatee distribution and describe the species' habitat.

Traditional ecological knowledge (TEK) is defined as the deep knowledge that traditional communities have on the environment in which they are immersed and has been frequently provided by traditional farming and fishing communities on a broad list of topics, including culture, practices, and environmental perception (Huntington 2000, Diegues and Arruda 2001, Silvano 2004). The information is based on their observations of natural phenomena, and these reports have been used to provide information mainly for conservation plans, as well as for protected areas management plans, among others (Begossi *et al.* 2002). TEK has an empirical basis. It is used to understand and predict environmental events upon which the individual's livelihood or even survival depends, and has made a demonstrable difference in many research projects and management strategies (Huntington 2000). Documenting TEK can be a long process, and the effort is not always justifiable (Huntington 2000). However, the use of TEK has been encouraged, as this method can provide important information that could likely not be obtained otherwise (Pauly 1995).

TEK has been used as part of ethno-biological studies in order to investigate the intricacies of local communities' knowledge, perception, and awareness of the environment (structure and functions), which are entwined culturally with behaviors and practices (Mayaka *et al.* 2013). This approach can contribute significantly to biodiversity conservation through the unveiling of (i) observational knowledge on nature, (ii) the practices involved in activities that require natural resources, and (iii) beliefs about relationships between people and nature (Mayaka *et al.* 2013).

Interview is the method that is most commonly used to study TEK, and it is often implemented through partially structured or semi-structured questionnaires. The questionnaires may present some predetermined topics and incorporate additional elements during the interview process in order to focus the dialogue on the issues that are being investigated (Mello 1996; Chizzotti 2000). Studies based on the knowledge and concepts developed by human populations regarding the biology of marine mammals have been increasingly

applied worldwide; such approach represents a cost-effective tool in the research and conservation of endangered species such as the Franciscana dolphin *Pontoporia blainvillei* (Souza 2005), the Bottlenose dolphin *Tursiops truncatus* (Peterson *et al.* 2005), the Guiana dolphin *Sotalia guianensis* (Souza and Begossi 2006), the West African manatee *Trichechus senegalensis* (Mayaka *et al.* 2013), the Amazonian manatee *Trichechus inunguis* (Calvimontes and Marmontel 2004; Calvimontes 2009; Franzini *et al.* 2013), and the Antillean manatee (Lima *et al.* 1992; Lima 1999; Luna 2001; Alves 2007; Ortega-Argueta *et al.* 2012; Arévalo-González *et al.* 2014).

Thus, this study used TEK to identify the occurrence areas and distribution of the Antillean manatee on the coast of the states of CE and RN in northeastern Brazil. These data will provide information that can be further used to establish priority areas for the conservation of this species.

Materials and Methods

Study Area: The study was conducted between the municipality of Beberibe (4°08'19.09"S/38°07'28"W) on the coast of the state of Ceará, and the municipality of Touros (5°14'50.36"S/35°23'44.05"W), in the state of Rio Grande do Norte State, Brazil. This area includes approximately 360 km of coastline (Figure 1), encompassing 14 municipalities and 77 traditional fishing communities.

Data Collection: The occurrence of the Antillean manatee in the study area was identified using information from the traditional ecological knowledge (TEK) of local residents, mainly fishermen. To acquire this information, ten field trips were conducted from September 2008 to June 2009 covering the entire study area. TEK information was obtained during semi-structured interviews with fishermen (n = 678) from 14 municipalities and 77 fishing communities within the study area.

To ensure reliability of the data collected and to suppress any influence on the part of the researchers at the interview, some methodological precautions were adopted. During the initial approach, interviewers introduced themselves as researchers from an NGO seeking information on the occurrence of manatees in the region. As many fishermen do not feel comfortable talking to government agencies, fearing some kind of surveillance activity, this presentation was extremely important.

Upon arriving at each location, the fishing colonies and community members were questioned

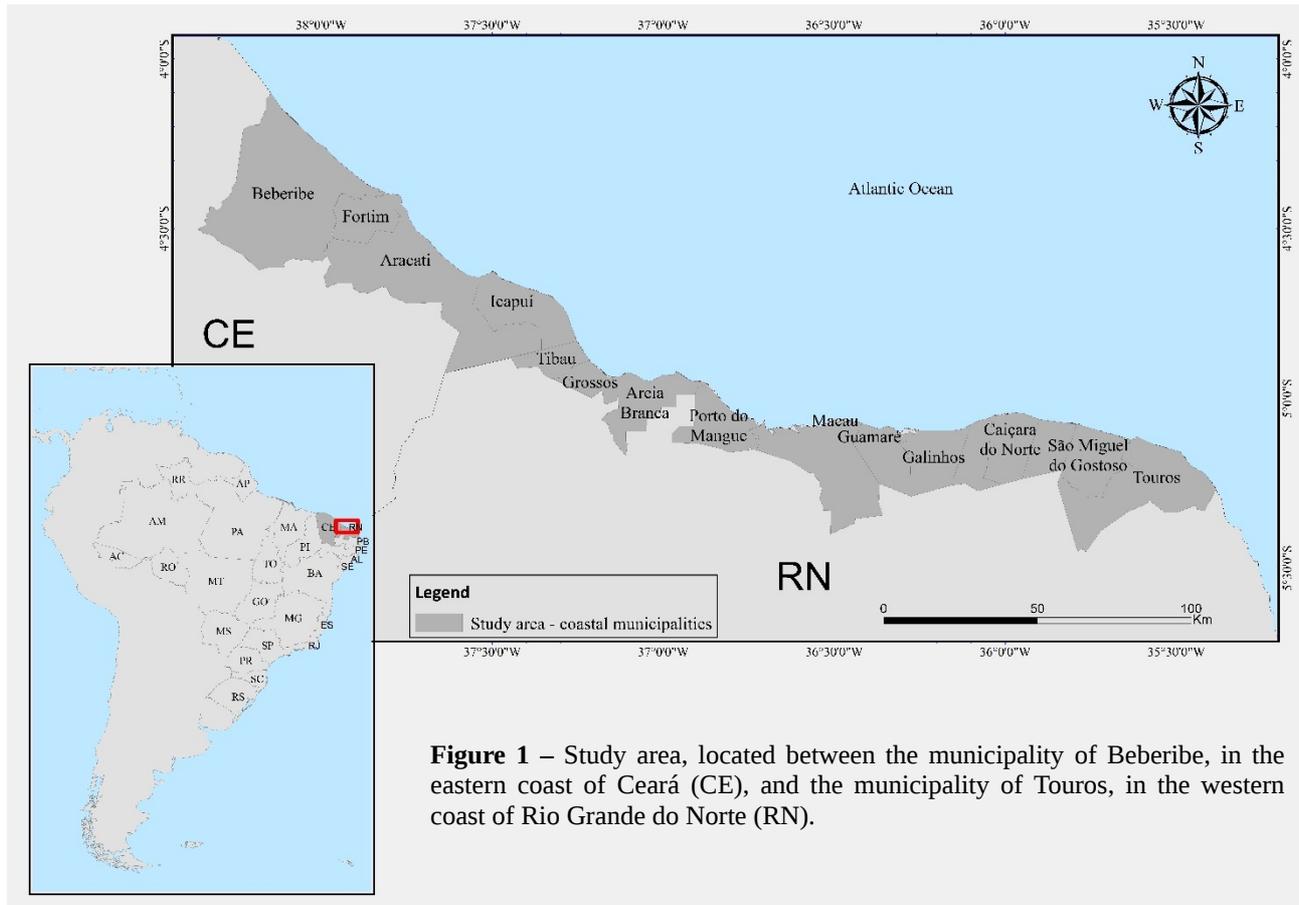


Figure 1 – Study area, located between the municipality of Beberibe, in the eastern coast of Ceará (CE), and the municipality of Touros, in the western coast of Rio Grande do Norte (RN).

in order to determine who would be the best fishermen to be interviewed based on their degree of knowledge about the species under study, their experience, how often they engaged in fishing activities, age, and time of residence in the community. We obtained a selection of individuals able to participate in the interviews in order to have less inconsistency in responses and, consequently, more reliable traditional knowledge.

The questionnaires started with a request for personal information on the respondent (full name, age, gender, location of residence, and number of years of fishing experience). The next questions requested information on fishing activities, such as the fishing area, type of fishing gear, and preferred fishing site. After the fishing activities were characterized, the questions determined whether the respondents knew what the manatee was and were able to describe it. Dubious answers, uncertain, or wrong descriptions characterized the respondent as unfit for the study. When affirmative and correct descriptions were given, the formal interview was begun.

To confirm the consistency and validity of the answers, we adopted the strategy applied by Mourão & Nordi (2003): the repetition of questions and the

use of diachronic situations (same question, repeated to the same person at different opportunities). A visual guide with pictures of marine animals (dolphins, whales, manatees, and turtles) was also used to ensure that the interviewee was, in fact, referring to the manatee (Serrano *et al.* 2007). The key question used to determine manatee distribution was, "When was the last time you saw a manatee in your community?". In areas where the respondents reported that the species no longer occurred, a detailed investigation was performed among older inhabitants to increase information reliability.

In addition, to identify manatee distribution we also crossed the information provided by the interviewees with other types of information, such as studies in the literature, reports on the occurrence of adult manatees or stranded animals in the field, and our own observations made in the field in the study area.

Data Analysis: The analysis of the information obtained was strictly qualitative, and it included the interpretation of the discourse of the interviewees. The percentage of responses on current occurrences was determined. Thus, TEK information was essentially used to produce a thematic map containing the prob-

able occurrence area and the distribution of the species. Data was analyzed within the principles of ethno-biology, and the experiences of populations were considered, a process proposed by several authors (Posey 1987, Begossi 1993, Marques 1995, Diegues 1999, Adams 2000, Begossi *et al.* 2002). Survey interpretation was based on the principle that all answers are reliable and should be considered within the data analysis. For example, even if only one fisherman claimed that manatees had been observed at the location of the interview, this information was considered to be enough to determine the presence of the species. Therefore, for the definition of the probable manatee occurrence areas in the studied region, the most recent sightings of animals were considered, even if they were not quantitatively representative of the universal sampling of that community. Affirmative responses to the question regarding the presence of the species at the site were considered more relevant than the negative ones, since some factors can influence the non-observation of manatees, primarily: (a) the manatee is a discreet animal, and it often exposes only the snout to breathe, and (b) the presence of the observer may not coincide with the periods during which the species occupies the area.

This method of data interpretation was also used because different responses regarding manatee sightings do not necessarily represent inconsistent information. If a fisherman claimed to have seen an animal in the area a year ago, we assumed that it necessarily meant that the manatee was in the region a year ago. However, if another fisherman said that he last sighted a manatee seven years ago, it did not necessarily mean that the manatee had not been in that area for the last seven years, but only that the fisherman had not seen any animals during that period.

The answers to the main question, “*When was the last time you saw a manatee in your community?*”, 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 ago were considered to be indicative of **probable current occurrence** of the species in the area; answers in which most recent sightings of manatees occurred between two and five years ago were considered to be a **probable recent occurrence**; areas where no sightings had been reported for more than five years were considered to be areas of **probable historical occurrence**; and sites where there were no animal

sightings reported were considered to be areas of **probable non-occurrence** of the species.

For the Probable Current Occurrence category, a quantitative analysis was performed, in which the responses were further divided into three sub-categories: **area with a high rate of occurrence** when the percentage of respondents reporting the current occurrence of the manatee ranged from 70% to 100%; **area with a moderate rate of occurrence** when the percentage of responses to the current occurrence category was between 30% and 69%, and **area with a low rate of occurrence** when the percentage was between 1% and 29%. This information was used to produce a thematic map (resolution 1:400,000, using Arcgis 10.1 and South American Datum 1969) with the probable occurrence areas of the Antillean manatee within the study area. This map was used to establish the probable current distribution of the species.

The following concepts were used to determine the probable Antillean manatee distribution:

- Probable occurrence area: specifically shows areas of confirmed manatee occurrence;
- Distribution: probable current occurrence areas unified in a single polygon; the distance between these areas may be used as a corridor by the manatees.

The occurrence of manatees is strongly influenced by water depth (Hartman 1979, Lefebvre *et al.* 2001, Olivera-Gomez & Mellinck 2005), and studies show the presence of these animals at a minimum depth of 0.4 m (Paludo 1998) and a maximum of 10 m (Nowak 1999). Thus, occurrence and distribution maps of the species were limited to the 10 m isobath.

Results

This study obtained an average of 8.8 interviews per community visited (n=678) within the study area.

From the total universe of the active fishermen estimated from the region (5,573 fishermen), 12.2% (n=678) were interviewed. Out of the people interviewed, 84.8% (n=575) were fishermen, 12.5% (n=85) were retired fishermen, 2.21% (n=15) had other jobs (beach tent owner, vessel owner, boat pilot) and 0.44% (n=3) were amateur fishermen. The average age of the respondents was 47 years old and the average amount of fishing experience was 29.3 years (Table 1).

Table 1. Number of active fishermen and interviews in each municipality, percentage of total active fishermen interviewed, age of respondents (average, minimum and maximum) and the amount of fishing experience (average, minimum and maximum).

Municipality	No. of Active fishermen	Interviews performed	% of fishermen interviewed	Age of respondents			Years of fishing experience		
				Average	Min.	Max.	Average	Min.	Max.
Touros	774	138	17.8	44	19	77	27.5	2	65
São Miguel do Gostoso	500	40	8	42	20	67	25	2	58
Caiçara do Norte	360	36	10	41	21	84	24	3	60
Galinhos	190	19	10	50	25	81	32	13	51
Guamaré	128	16	12.5	46	20	68	28.5	8	56
Macau	364	44	12.1	51	23	84	35	6	69
Porto do Mangue	250	25	10	45	25	81	29.7	10	69
Areia Branca	420	42	10	49	19	82	28.8	1	54
Grossos	320	36	11.3	51	18	77	31	5	61
Tibau	119	17	14.3	44	28	63	25.7	3	45
Icapuí	880	101	11.5	42	18	85	25.3	2	67
Aracati	506	66	13	48	19	90	31.9	5	73
Fortim	272	36	13.2	55	24	82	37.7	12	67
Beberibe	490	62	12.7	45	18	73	27.9	4	60
14 Municipalities	5573	678	12.2	47	21	78	29.3	1	73

Antillean manatee occurrence (current, recent, historical) or non-occurrence in each visited community are in Figure 2.

Three municipalities have a single isolated record of the species: Beberibe, Fortim and Guamaré. In these three events, additional information provided by interviewed indicated that these were isolated records associated with calf strandings, and that manatees were never observed in the region before or after these events. Thus, we decided not to consider these locations as current occurrence areas of the species.

Icapuí and Aracati were classified as **areas with a high rate of manatee occurrence**. The coastlines of the municipalities that were ranked as **areas with moderate index of occurrence** were Touros, São Miguel do Gostoso, Porto do Mangue, Areia Branca, Grossos, and Tibau. Two municipalities were classified as **areas with a low rate of occurrence**: Galinhos and Macau.

Out of the six estuaries studied, Pirangi Estuary (in Beberibe) and Barra Grande Estuary (in Icapuí), both in Ceará, were classified as areas of probable non-occurrence because there were no reports of the species. The other estuaries (Jaguaribe, in Ceará, and Areia Branca-Grossos, Macau-Porto do Mangue, and Guamaré-Galinhos, all of which are

in Rio Grande do Norte) were classified as areas of probable historical occurrence.

The probable distribution of the species in the region was established between the coastal zone of Canoa Quebrada, in the municipality of Aracati (Ceará), and the coastal zone of Perobas, in the municipality of Touros (Rio Grande do Norte) (Figure 3). The coastal regions of Beberibe and Fortim were not included in the current species occurrence area.

Discussion

According to Oliveira *et al.* (2008), the knowledge that can be provided by fishing communities is of fundamental importance in scientific studies involving coastal ecosystems and marine organisms. Because fishermen have a close relationship with the natural environment and depend on its resources, they constitute a reliable source of information for studies based on TEK. Albuquerque *et al.* (2002) stated that the knowledge held by local populations must be included in any attempt at biodiversity conservation, since local populations often possess detailed knowledge about the environment where they live. Traditional ecological knowledge (TEK) represents an important source of information on species distribution, biology, ecology, environment, among others.

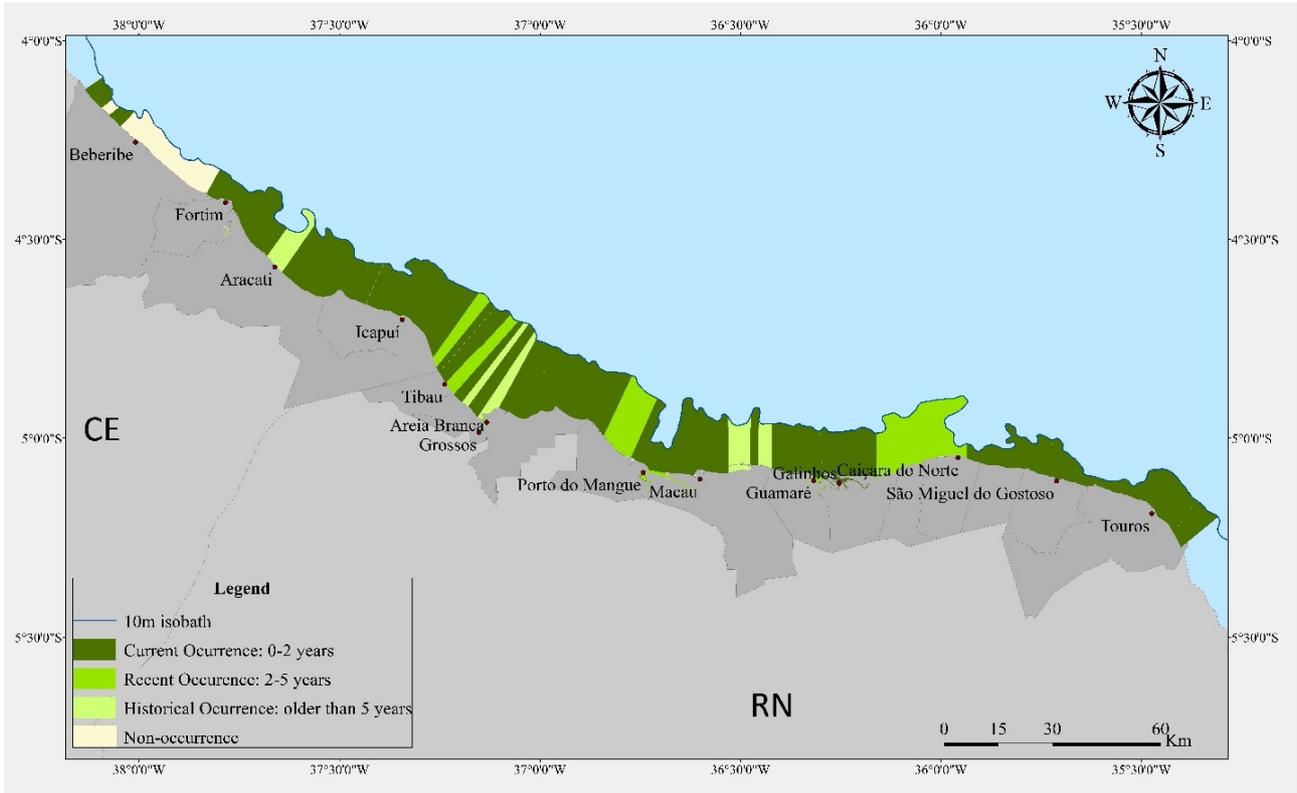


Figure 2 – Manatee occurrence areas in which community visited in the eastern coast of Ceará (CE) and the western coast of Rio Grande do Norte (RN), according to interviews.

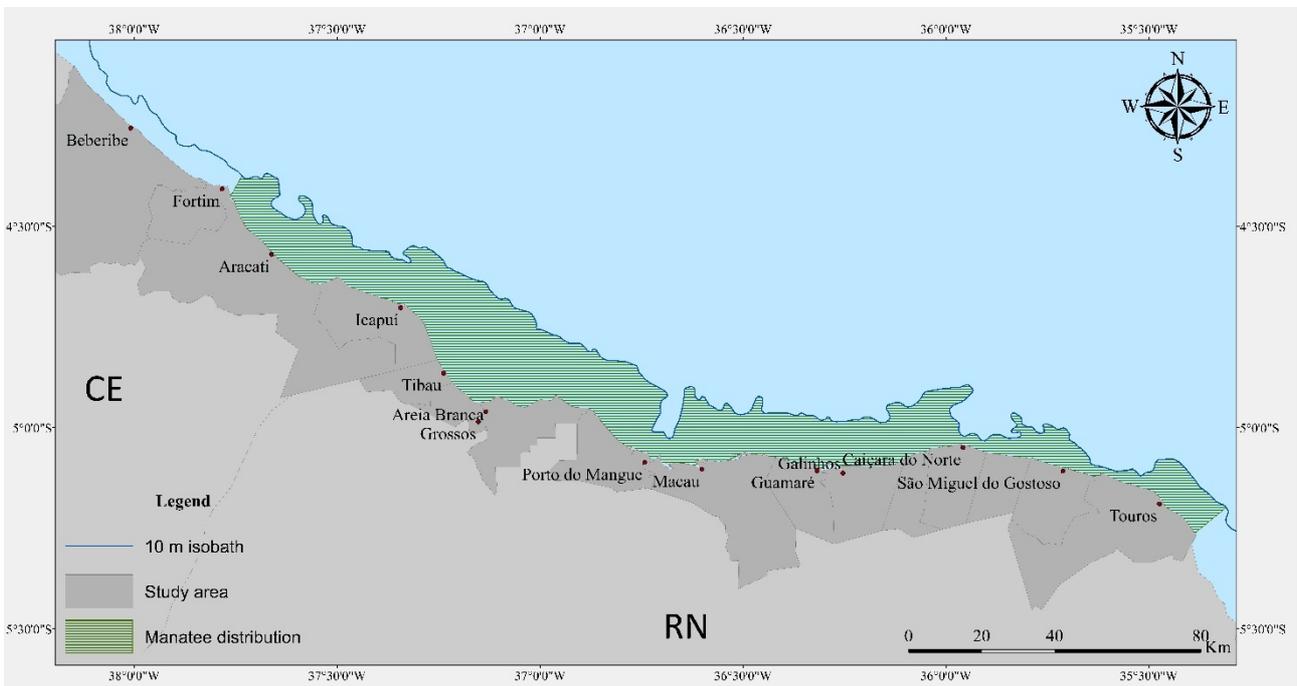


Figure 3 – Antillean Manatee distribution on the eastern coast of Ceará (CE) and the western coast of Rio Grande do Norte (RN), between the municipalities of Aracati and Touros.

However, like other forms of knowledge (including formal scientific knowledge), TEK has its own limitations. Misinterpretations among both observers (e.g., informants) and/or collectors of information (e.g., managers and researchers) may occur, or observers may not provide true

information, especially in situations involving the commercial use of natural resources or when their use is illegal or controlled (Gavin *et al.* 2009).

Because a good relationship had already been established between the communities visited and the researchers, the approach mode towards the interviewee was very productive and resulted in a large amount of reliable and non-induced information. The average of interviews per community visited demonstrates a high sampling effort and high degree of empirical knowledge on *T. m. manatus*, since the sampling was targeted in order to address individuals who truly knew about the species. This number indicates a greater sampling effort when compared to previous studies performed using interviews (Lima 1999, Luna 2001, Alves 2007).

Ethno-biological studies have been historically conducted on the Antillean manatee in Brazil in order to identify species distribution areas and the main areas of occurrence (Lima *et al.* 1992, Lima 1997, Luna 2001, Alves 2007). Alves (2007) pointed out that traditional knowledge on manatee studies is similar to scientific knowledge in that it enables coastal communities to serve as potential partners in the implementation of conservation strategies. Paludo (1998) suggested that fishermen could record Antillean manatee occurrence along the Brazilian coast in order to provide information for conservation. The proof of prior knowledge on the manatee in their natural environment demonstrates a close relationship between respondents and the species and corroborates the consistency and reliability of the information given by the respondents.

According to Arévalo-González *et al.* (2014) although interviews are not recommended as an accurate method to assess population size, other information, such as population trends (increasing, decreasing, stable), can be obtained and might provide a good indication of the manatee conservation status. The results found herein are consistent with those of other studies (Lima *et al.* 2011, Arévalo-González *et al.* 2014, Mayaka *et al.* 2013). The results also showed that TEK is a suitable tool for providing useful information for conservation and environmental management, especially when it comes to species difficult to detect and endangered such as the Antillean manatee.

The most frequent occurrences of Antillean manatees within the distribution area along the states of Rio Grande do Norte and Ceará are in accordance

with the conditions preferred by this species: calm and shallow waters with the presence of submersed aquatic vegetation and sources of freshwater (Husar 1978, Odell 1982, Bossart 1999, Jiménez 2000, Lefebvre *et al.* 2001, Reynolds & Powell 2002).

The single isolated record of manatee in Beberibe, Fortim and Guamaré, was not considered as current occurrence, nevertheless, because manatees had not been previously registered at these sites, their presence in the region is not well understood. That means some hypotheses must be investigated further: (i) the manatee population may be increasing and searching for new areas with favorable ecological conditions; (ii) breeding sites are very degraded and females may be seeking new areas to give birth; or (iii) due to population reduction caused by historical hunting, 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 newborn calves. However, these areas may be considered areas of occasional occurrence, and require further efforts to elucidate if animals are abandoning them or not.

In the Barra Grande Estuary (Icapuí, Ceará), no occurrence of manatees was reported. This estuary is located within a region where the continental shelf spreads toward the sea and forms a tidal delta (Meireles 2001) with very shallow waters due to the soft slope of the continental shelf. This factor may make it difficult for manatees to approach shallow areas. In this region, fishermen reported manatee sightings far from the coast during low tides, which expose about 6 km of mudflats (Campos *et al.* 2003). In this estuary specifically, the reported non-occurrence of the species could be influenced by the profile of the interviewees, since the oldest fisherman was 39 years old. However, the region of Icapuí was considered an area with a high rate of manatee occurrence. Thus, the animals are probably present in the vicinities of the Barra Grande Estuary. The local geomorphology is likely the main factor influencing the non-occurrence of *T. m. manatus* in the Barra Grande Estuary. In the Pirangi Estuary, the species has not been observed since 2003 (Silva 2003, Costa 2006), and previous studies reported only stranded calves (Paludo 1998, Lima 1999, Luna 2001).

The deforestation of the estuaries shores (and/or their river basins) contributes to the siltation of river mouths, which likely prevents the animals' access to these areas (Lima *et al.* 2011, Meirelles *et al.* 2014). Other possible causes that contribute to

the frightening of the animals and consequent disappearance of the species in certain areas are the fishing activity (navigation, especially with motor boats and the installation of fishing nets) and installation of polluting sources (related to the suppression of plant macrophytes and marine phanerogams). The Areia Branca-Grossos, Porto do Mangue-Macau, Guamaré-Galinhos, and Jaguaribe Estuaries were reported by the fishermen as areas of historical manatee occurrence. Their occurrence was probably more common when both the use and occupation of these estuaries were less intense. This area includes the estuaries where most dependent manatee calves have been stranded (Meirelles 2008).

Based on the probable occurrence map constructed from the interviews, the distribution of manatees seems to have small geographic gaps. The largest discontinuity area in the map is 25 km (around the municipality of Caiçara do Norte). Given the species' ability to travel large distances, travelling up to 240 km (Morales-Vela *et al.* 2000, Lefebvre *et al.* 2001; Sheppard *et al.* 2006; Lima 2008, Castelblanco-Martínez *et al.* 2013; Normande *et al.* 2014b; Normande *et al.* 2015; Normande *et al.* 2016) and the lack of physical obstacles, this distance cannot be considered mere geographical discontinuity for this species. Manatees usually move along the coastline and use deep corridors to access shallow waters, feeding areas, freshwater sources and resting areas (Morales-Vela *et al.* 2000; Jimenez 2005; Flamm *et al.* 2005; Oliveira-Gómez and Mellink 2005; Castelblanco-Martínez *et al.*, 2013; Normande *et al.* 2016).

In previous studies, the municipality of Beberibe was no longer regarded being within the manatee's distribution area, but Fortim was still reported as part of the species distribution area in the recent past (Silva 2003, Costa 2006). However, the locals interviewed herein did not observe the species in the municipality of Fortim or along some portions of the Aracati coast.

Several environmental factors appear to influence the presence of manatees in a given area. These factors include water temperature, particularly in subtropical areas, as well as water depth, water salinity, marine currents, the amount of aquatic vegetation and freshwater sources (Reid *et al.* 1991, Smith 1993, Lima 1999, Lefebvre *et al.* 2001, Jiménez 2002, Deutsch *et al.* 2003, Olivera-Gómez and Mellinck, 2005, Jiménez 2005, Sheppard *et al.* 2006, Castelblanco-Martínez *et al.* 2009, Normande *et al.* 2016).

In Brazil, studies on the distribution of the Antillean manatee originally showed that the species occurred discontinuously from the mouth of the Rio Doce (the Northern region of the state of Espírito Santo - ES) to São Luis (in the state of Maranhão - MA), along approximately 3,000 km of coastline (Whitehead 1978). Over the years, however, the literature has reported a decrease of approximately 1,109 km in the range of this species (Albuquerque & Marcovaldi 1982, Lima *et al.* 1992, Lima 1999, Luna 2001). Lima *et al.* (1992) reported the distribution of the species between the states of Alagoas (AL) and Piauí (PI), and indicated that the discontinuities of the species' distribution were increasing at that time. Recently, Alves *et al.* (2013) found the existence of an extensive area with virtually no sightings of animals along the Potiguar Basin, located on the northwestern coast of Rio Grande do Norte State (RN). However, this information was based on only one aerial survey and must be interpreted carefully.

According to Lefebvre *et al.* (1989) and Whitehead (1978), historical reports indicated that manatees were once more common and that hunting was initially responsible for the decline of natural populations. Since then, other anthropogenic pressures (such as fishing activities, pollution, mangrove deforestation, and coastal occupation) have drastically increased and now represent the main threat to Antillean manatee. Our data suggests the decline on the distribution of the species because between Ceará and Rio Grande do Norte, Antillean manatee occurrence has been decreasing over time.

This decrease in the distribution of the Antillean manatee may be related to a decrease in the population size of the species. A decrease in Antillean manatee population has been reported in other countries. In Belize, historical reports suggest that the population of Antillean manatees was once larger than in other Caribbean countries (Charnock 1968, Charnock 1970, Charnock *et al.* 1974). Studies conducted in French Guiana, which were also based on interviews, suggested that manatees are now less abundant than they were in the past, and that the main reason for the recent population decline is likely hunting for meat consumption, developmental pressures and, in some areas, pollution (Thoisy *et al.* 2003). Similar results were observed on the coasts of Venezuela (O'Shea *et al.* 1988), Mexico (Serrano *et al.* 2007), and Nicaragua (Jiménez 2002).

On the other hand, a decrease in the distribution of the species does not necessarily mean

that the population size has decreased. Individuals may simply be more concentrated in certain areas. According to Costa (2006), manatees tend to be concentrated in areas with more favorable ecological and environmental characteristics.

In addition, other factors may be influencing the manatee distribution (Olivera-Gómez & Mellink 2005), including a lack of appropriate areas for manatees to rest and interact with other manatees, as well as human activities (such as fishing activities and motorboat traffic). Although the present study did not estimate population size or assessed population trend, when we consider the distribution on a macro scale, our data are worrisome because they point to the species becoming concentrated in few places, fragmented and occupying a much smaller area than the original, which then increases its vulnerability. In light of this information, further studies to evaluate the size of local populations and the threats to this species are required in order to explain the decrease in its distribution along the Brazilian coast.

This study indicated a reduction in Antillean manatee distribution compared to other TEK studies performed in the same area. This reduction can be related to population decline and/or decline of suitable ecological characters. Efforts to identify human impacts and create protected areas in these communities with a high rate of manatee occurrence should be prioritize in action plans for the species conservation in national and regional level.

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