

SPATIAL AND TEMPORAL DISTRIBUTION OF MANATEES (*TRICHECHUS MANATUS*) REINTRODUCED IN THE NORTHEASTERN COAST OF BRAZIL

ABSTRACT

Many West Indian manatees (*Trichechus manatus*) that strand along the northeast Brazilian coast are calves, which are often rescued and carried to the Peixe-Boi Project rehabilitation facilities in Itamaracá, Pernambuco State where they are prepared for reintroduction. During the ten years period of October 1994 to December 2004, thirteen captive manatees were radio tagged, released and tracked in three main northeast coastal areas as part of the Brazilian Manatee Reintroduction Program. All individuals were monitored locally with VHF transmitters, during brief periods, four were also tracked remotely with satellite-monitored radio tags. Five manatees (39.5%) had long-term tracks over 14 months or 420 days (Total= 10166 days; Maximum=2663 days; Mean=2031 days; SD=1572 days) that met criteria for inclusion in analyses of spatial and seasonal movement patterns. Manatees were tracked from Praia do Forte, Bahia (12.538°S/38.474°W) to Macau, Rio Grande do Norte (5.084°S/36.682°W), covering around 1200 km and six states along the northeast coast. Three manatees occupied large home ranges, with each containing a few sites of high fidelity where they spent considerable time, while two used restrict home range having only one site with high fidelity. Others two manatees not showed movements along coast and occupied a restrict area like their fidelity site. Two manatees with short tracking histories showed visible weight loss soon after release and were recaptured after having moved long distances, including offshore movements into deep waters. The high rate of survival for released manatees, their adaptation to areas within the former range of wild manatees, and birth of a calf to a released captive manatee are indicators of the success of the Brazilian Manatee Reintroduction Program.

KEYWORDS: Peixe-boi; Manatee; Manati; Reintrodução; Monitoramento.

DISTRIBUIÇÃO ESPACIAL E TEMPORAL DE PEIXES-BOI (*TRICHECHUS MANATUS*) REINTRODUZIDA NA COSTA NORDESTE DO BRASIL

RESUMO

Muitos peixes-boi das Índias Ocidentais (*Trichechus manatus*), que vertente ao longo da costa do nordeste brasileiro são bezerros, que muitas vezes são resgatados e transportados para as instalações de reabilitação Peixe-Boi em Itamaracá Projecto, Estado de Pernambuco, onde eles estão preparados para reintrodução. Durante o período de dez anos de Outubro de 1994 a Dezembro de 2004, treze peixes-boi em cativeiro foram rádio Tagged, liberados e monitorados em três principais áreas costeiras do nordeste, como parte do Programa Brasileiro Reintrodução do peixe-boi. Todos os indivíduos foram monitorados localmente com transmissores VHF, durante breves períodos, quatro foram também monitorados remotamente com etiquetas de rádio-monitorado por satélite. Cinco peixes-boi (39,5%) tinham faixas de longo prazo com mais de 14 meses ou 420 dias (total = 10166 dias; Máximo = 2663 dias; média = 2031 dias; DP = 1572 dias) que preencheram os critérios para inclusão em análises de movimento espacial e sazonal padrões. Os peixes-boi foram rastreados a partir de Praia do Forte, Bahia (12.538°S / 38.474°W) para Macau, Rio Grande do Norte (5.084°S / 36.682°W), cobrindo cerca de 1200 km e seis estados ao longo da costa nordeste. Três peixes-boi ocupou grandes áreas de uso, com cada uma contendo alguns sites de alta fidelidade onde passaram um tempo considerável, enquanto dois usados ? gama restringir casa ter apenas um site com alta fidelidade. Outros dois peixes-boi não mostrou movimentos ao longo da costa e ocupava uma área restrita, como seu site fidelidade. Dois peixes-boi com histórias curtas de rastreamento mostraram perda de peso visível logo após o lançamento e foram re-capturado depois de ter movido longas distâncias, incluindo os movimentos no mar em águas profundas. A alta taxa de sobrevivência de peixes-boi liberados, a sua adaptação às áreas dentro da escala anterior de peixes-boi selvagem, e nascimento de um bezerro de um peixe-boi em cativeiro liberados são indicadores do sucesso do Programa Brasileiro Reintrodução do peixe-boi.

PALAVRAS-CHAVE: Peixe -boi; Peixe boi; Manati; Reintrodução; Monitoramento.

Natural Resources, Aquidabã, v.5, n.1, Set, Out, Nov, Dez 2014, Jan, Fev, Mar, Abr, Mai, Jun, Jul, Ago 2015.

ISSN 2237-9290

SECTION: Articles

TOPIC: Megafauna aquática



DOI: 10.6008/SPC2237-9290.2015.001.0002

Régis Pinto de Lima

Instituto Chico Mendes de Conservação da Biodiversidade, Brasil
<http://lattes.cnpq.br/5149180797409019>
regis.lima@icmbio.gov.br

Carolina Mattosinho de C. Alvite

Instituto Chico Mendes de Conservação da Biodiversidade, Brasil
<http://lattes.cnpq.br/9535914048973704>
carolina.alvite@icmbio.gov.br

James P. Reid

Unites State of Geological Survey, Estados Unidos
<http://profile.usgs.gov/jreid>
jreid@usgs.gov

Agostinho Bombassaro Junior

Universidade das Três Fronteiras, Brasil
<http://lattes.cnpq.br/5312028217761191>
abj@pop.com.br

Received: 10/05/2015

Approved: 30/09/2015

Reviewed anonymously in the process of blind peer.

Referencing this:

LIMA, R. P.; ALVITE, C. M. C.; REID, J. P.; BOMBASSARO JUNIOR, A.. Spatial and temporal distribution of manatees (*trichechus manatus*) reintroduced in the northeastern coast of Brazil. *Natural Resources*, Aquidabã, v.5, n.1, p.14-28, 2015. DOI: <http://dx.doi.org/10.6008/SPC2237-9290.2015.001.0002>

INTRODUCTION

The West Indian manatee (*Trichechus manatee*) known in Brazil as marine manatee or *peixe-boi marinho*, appears along the Brazilian northeast coast until the southeastern American coast. In the Brazilian coast, the species presented a huge distribution, from Doce River (20°S) in Espírito Santo in the southeastern coast following along the northeastern and northern coast (WHITEHEAD, 1978), within a 4000 km-long territory. It is known today that the species lives in the coastal and estuarine waters of Alagoas and Amapá, where the permanent warm waters and vegetation presence, like the marine macrophytes (algae, phanerogams and mangroves) are determinant factors in their current areas of occurrence (LIMA & BOROBIA, 1991; LIMA et al., 1992, 1994; LIMA, 1999; LIMA et al., 2000; LUNA, 2001). The marine manatee has been recently described as a specie 'critically endangered' in Brazil (IBAMA, 1997; 2001).

Several authors have described the main causes of death which affect the manatee in the Brazilian coast, where the accidental captures present important significance (OLIVEIRA et al., 1990; LIMA, 1999; PARENTE et al., 2004; MEIRELLES, 2008). The main one, the release of newborn calves, frequently occurs in the northeastern coast, within a specific area of Ceará and Rio Grande do Norte coasts. Between 1991 and 2006, forty-six orphaned calves were rescued by the Manatee Project in the northeastern coast (LIMA et al., 2007) and other partners of Northeastern Aquatic Mammals Stranding Network - REMANE (BRASIL, 2000; ALVITE et al., 2004). Since the rescues, these calves have been rehabilitated in captivity for being reintroduced in nature, where between 1994 and 2004, thirteen manatees went by this procedure (LIMA et al., 2007).

For KLEIMAN (1989), a Reintroduction program involves releasing individuals withdrawn from wild environment or raised in captivity, in an area of its historical occurrence where this species does not exist or is in decline. This first experience of manatee released in Brazil can be defined as a Reintroduction, once the manatees population is in decline along the Brazilian coast and most part of the animals (N=09) was released in a area of historical occurrence (WHITEHEAD, 1978; ALBUQUERQUE & MARCOVALDI, 1982; LIMA, 1999), situated in Porto de Pedras, north of Alagoas (9.222°/35.323°W). As a definition for Reintroduction Program, it was also considered that these herbivorous aquatic mammals were rescued when still were calves, raised in captivity and reintroduced, with few or no learning history by their mother in the natural environment. According to IUCN (1998) for captured populations' release, it must be considered that most species of mammals and poultry depend upon their individual experience and learning while juveniles for their survival.

Few are the information on the manatees' movements in the Brazilian coast, being an innovative aspect of this investigation. The main objective of this study is to describe, by telemetry radio monitoring and field observations, the individual spatial and temporal distribution of manatees reintroduced in the northeastern coast.

MATERIAL AND METHODS

The thirteen manatees' data, object of this study, with their respective sizes, period in captivity, estimated age, places of stranding and release, are presented in Anex 01, where they are characterized. All the other animals were rescued when calves and grown in captivity, except one that was found when adult (APARECIDA). The mean of total length of the animals grown in captivity when stranded, (N=12) was of 127,12cm (SD=8,3cm; min=114cm and max=140cm), being 223,40cm (SD=31,5cm; min=163cm and max=284cm) when the animals were released. The mean period for these twelve animals in captivity was of 1569 days or 52,16 months (SD=808 days; min=680 days and max=3570 days), considering their approximate age. All the thirteen animals received a veterinarian assess before being reintroduced. The procedures and criteria for choosing the animals which should be primarily reintroduced can be found in the Protocol for Marine Manatees' Reintroduction in Brazil (LIMA et al., 2007).

Three places were chosen for releasing those manatees, from the Unit for Manatees' Recovery (Itamaracá/PE), being two in the south, in the coast of Alagoas (Paripueira=280km, Porto de Pedras=230km) and one in the north, in the coast of Paraíba, in the mouth of Mamanguape River (180km). The period of permanence of the manatees in these captive places varied between seven to three years. In an only event of reintroduction (*ALDO and PIPA* – 09/98) the animals were released without a permanence period in an adaptive captivity. All the manatees reintroduced and which took part of this study were monitored by a system compounded of radio transmitters (VHF and/or UHF satellite), demarcation accessories, field monitors, tracking mobile unit, periodical visits for overseeing, veterinarian monitoring (LIMA et al., 2007) and database, according to methods used in radio monitoring (KENWARD, 1987; WHITE & GARROT, 1990). Additional technical information on radio transmitters and timing system used in this study can be found in RATHBUN & BOURASSA (1987); REID & O'SHEA (1989); REID et al. (1995) and DEUTSCH et al. (1998). Even using four UHF radios, the information here used, being one applied to the first reintroduction, came from two satellites (Nº. 4020) in 1994 (*ASTRO and LUA*) and other (Nº. 9643) in 2003/2004 (*ASSÚ and TICO*). The data collected from both telemetry radio systems used in this study (Table 1) were applied for the displacements of the reintroduced animals' data base formation.

The data analysis involves descriptive studies (WHITE & GARROT, 1990) where telemetry radio use serves to observe the processes of natural behavior, usually without meeting formulations or tests of hypotheses before data collection. For a spatial-temporal analysis aiming a macro description of the use of the manatees, the first daily record of localization by monitoring from VHF was selected, and when monitored by satellite, the first message of LC1, LC2 and LC3 classes, those of major accuracy. There were many losses and replacements of accessories of telemetry radio system. The analysis of each monitored manatee, for each one of the intervals of

geographical position, permitted measuring the use of different places within a bigger area covered by each animal. For this measuring, in order to determine four individual parameters, the analysis of variable time and distance were conducted.

Area of Life or Home Range: Defined in this study as the extension of area used by a reintroduced manatee from its respective Area of Reintroduction (AR). **Sites of Fidelity (SF):** Defined as those areas (intervals of geographical position) with major use (frequency of occurrence) by manatees along all Area of Life. **Maximum Annual Traveled Distance (MATD):** The distance traveled by monitored animals along the coast was calculated by the difference between the most northerly and southerly latitudes in one year. **Seasonality:** The spatial distribution of the geographical positions of manatees reintroduced along the period was verified (daily occurrences) so much annual as seasonally. Individual graphs were elaborated for comparative analysis, where the movement of the animal was represented by the width of geographical positions registered in a certain interval of time. The very small or null variation in this width corresponded to the lingering permanence in a certain time, or the fidelity to that geographical position.

The program used for data management and mapping was the integration of MS Access (MS Office 2003) with the data base and Autodesk Mapguide 6.5 as tool for maps publication. For describing the marine, coastal and fluvial environments, those from bibliography, IBGE letters, nautical charts, observations by field team were adopted.

RESULTS

The monitoring of all the reintroduced manatees covered the coast of six northeastern states, between Do Forte Beach (12.538° S/38.474°W) and Macau/Rio Grande do Norte (5.084° S/36.682°W), in an extension of 1105km of coastline. Five of these animals (39,5%) were monitored for a period longer than 420 days or 14 months (Total= 10166 days; Maximum=2663 days; Mean=2013 days; SD=1572 days), enabling the conduction of the spatial and temporal analysis shown presented in this work. The other animals (*APARECIDA*, *FOLIA*, *PIPA*, *TUCA*, *TICO*, *ASSÚ*, *ARAQUETO* and *BOI-VOADOR*) were not included in the analysis of spatial distribution. *TICO* and *ASSU* are presented here as a case study. The Effort Rate was considered for the time for animals' seeking and the Effectiveness Rate was considered when there was seeking animals by localization. Table 1 shows the data of all reintroduced animals' monitoring, above mentioned.

During the period of this study, and for the thirteen reintroduced animals, 4.1 manatees with annual mean were monitored (min=2, max=8), with a maximum number of eight animals in 2004. The mean effort for the five animals along the monitoring period was of 71,2% (SD=20,4%) and the

mean effectiveness of 88,4% (SD=6,42%), where the mean effort tended to drop along the monitoring years.

Table 01: Relation between manatees and their respective periods of free life, monitored life, localizations and Effort and Effectiveness Rates.

Animal	Free Life (days)	Monitored Life		Localization (days)	EFFORT Rate (%)	EFFECTIVENESSRate (%)
		(days)	(hours)			
LUA	2663	2601	18415	2250	98	87
ASTRO	2663	2206	14935	1795	83	81
ALDO	2290	1369	7982	1316	60	96
XUXU	2112	1483	13481	1243	70	84
NINA	438	199	821	187	45	94
PIPA	42	37	344	33	88	89
FOLIA	17	17	129	4	100	24
APARECIDA	5	5	48	4	100	80
ARAQUETO	146	43	262	15	29	35
BOI VOADOR	146	85	728	53	58	62
ASSÚ	130	61	421	55	47	90
TICO	34	7	41	7	21	100
TUCA	28	21	170	17	75	81
TOTAL	10714	8134	57777	6979	Mean=67,2 SD= 26,6	Mean=77,1 SD= 23,2

General Distribution

Due to better understand the analyzed data of the reintroduced thirteen manatees, a map with the distribution of all animals during the study is firstly shown.

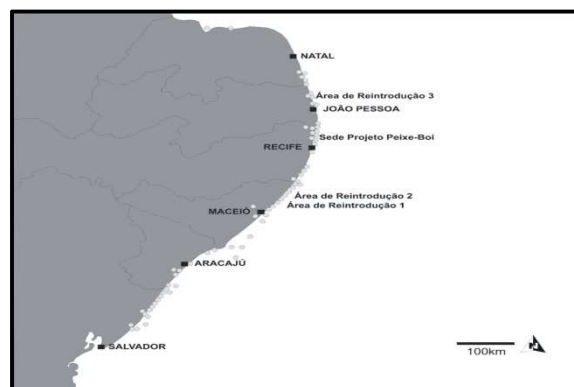


Figure 01: Map of distribution of all registrations of locations of the thirteen peixes-bois monitored in this study, indicating the Areas of Reintroduction (AR1, AR2, AR3).

The Area of Life explored jointly by the manatees from north to south corresponded to an approximate 1200km-long coastline, being limited in the south by Salvador/BA (12.964°S/38.474°W) and in the north by Macau/RN (5.192°S/35.474°W), corresponding to the macro divisions of the Brazilian coast known as 'Septentrional Coast of the Northeast and Oriental Coast of the Northeast' (AB'SABER, 2001). It is highlighted the presence of manatees reintroduced in areas of historical occurrence where the species had been extinct, such as Bahia and Sergipe coasts, northeast of Alagoas and south of Pernambuco, supporting the success of

resettlement in these areas. All coastal morphological features in the area explored by the animals, like rivers, estuaries, lagoons, protected and exposed beaches, showed records of animals' occurrences. Two manatees (*TICO* and *ASSÚ*) moved tens of kilometers to open sea and were rescued. The current limit of the southern species' distribution, Pontal do Peba in the extreme south of Alagoas, (LIMA, 1999) was extended in 350 km, until Salvador, where the state of Sergipe which does not present current occurrence of the species has an important area of permanence of the manatee *ASTRO*, in the southern coast estuaries.

Spatial and Temporal Analysis of the Reintroduced Manatees

This analysis was conducted for five animals, whose monitoring have been done for at least one year, being *LUA*, *ASTRO*, *XUXU*, *ALDO*, and *NINA*. The first have their results jointly shown, likely *ALDO* and *NINA*, because presented similarity in spatial and temporal distribution of the analyzed parameters. The manatees *TICO* and *ASSÚ*, although monitored for a shorter period after releasing, showed erratic movements and their displacements will be described as case study.

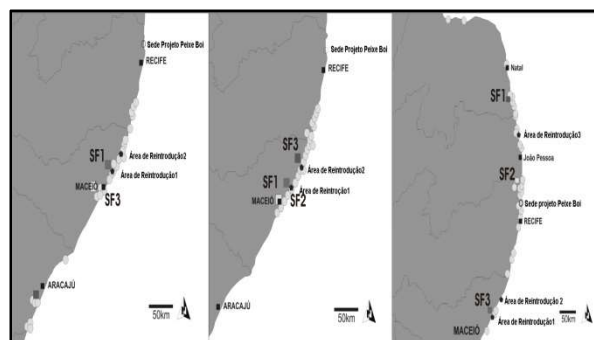


Figure 02: Individual maps of the manatees *LUA*, *ASTRO* and *XUXU* with all the registrations of locations, understanding home range, with indication of Sites Fidelity SF1, SF2 and SF3

The explored area used by the male *ASTRO* (Figure 1) was formed with displacements to the south of AR1 of until 335 km (Mangue Seco/SE-BA) and displacements to the north of until 80 km (Serrambi/PE). Its Area of Life (AL) corresponded to a 415 km-long extension. The explored area (Home Range) for the female *LUA* was built with displacements for the south of AR1, of approximately 30km to the Pond of Mundaú-Manguaba in Alagoas and of 121km of displacement for the north of AR1 to Suape, south coast of Pernambuco. Its Home Range corresponded to 151km of extension. The male *XUXU* created the widest Home Range area explored among the reintroduced peixes-bois, involving the coastal area of four Northeastern states (AL, PE, PB, RN). With displacements for the north of AR3 of up to 340km (Macau/RN) and for the south of up to 330km (Maceió/AL). Its total Home Range area corresponded approximately 670km of extension. In the Figure 3 it is represented the continuous use of the Home Range of *LUA*, *ASTRO* and *XUXU*

in the monitoring period, where the width of the displacements and the permanence areas can be observed.

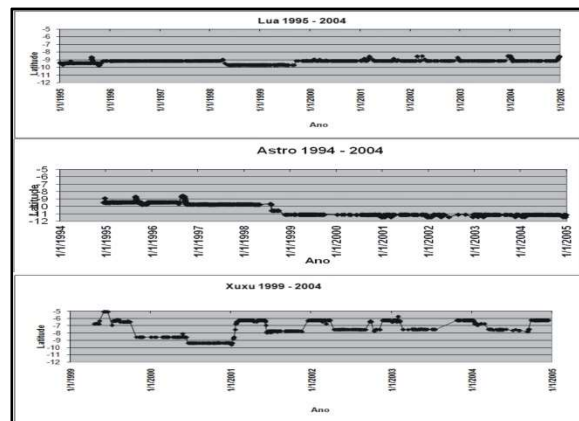


Figure 03: Model (latitude X time) of movement and occupation of the manatees *LUA*, *ASTRO* and *XUXU*'s Area of Life in the monitoring period.

The amplitude of *LUA*'s Area of Life covered the interval of the following geographical positions: 9.767°S/35.837°W and 8.597°S/34.993°W. That female presented a different behavior along the period from long to short movements along the coastline, with long term permanence in the Sites of Fidelity. The amplitude of *ASTRO*'s Area of Life corresponded to the following geographical position interval: 8.698°S/35.086°W to 11.441°S/37.377°W. It is observed that it displaced to the north only in the three first years, defining its north limit of the Area of Life for this study. The amplitude of *XUXU*'s Area of Life corresponded to the following geographical position interval: 5.083°S/36.683°W to 9.664°S/35.695°W. *XUXU* displaced for more than 5° of latitude (5.083°S/9.664°S). It is observed that it first displaced to the north and in the two following two years always to the south, establishing its areas of permanence. But in the its third release year it established a standard of moving between Itamaracá Island/PE and Sibaúma River/RN. Regarding the movements seasonality, these three animals showed a different behavior along the period from long to short movements along the coast, with periods of long permanence in these Sites. In the first years, they presented movements along the year, but after establishing their Sites of Fidelity, they showed seasonal motions along the coastline, occurring only in the summer months/dry season (September-March), returning to their Site of Fidelity.

Table 2: Frequency of the manatees *LUA*, *ASTRO* and *XUXU*'s occurrence in their three main Sites of Fidelity.

Sites of Fidelity <i>LUA</i>			
	Max Lat	Min Lat	Frequency (%)
SF1	9.108°S	9.208°S	69,43
SF2	9.608°S	9.708°S	12,6
SF3	9.408°S	9.508°S	10,52
Sites of Fidelity <i>ASTRO</i>			
	Max Lat	Min Lat	Frequency (%)
SF1	11.06°S	11.16°S	45,01
SF2	9.66°S	9.76°S	25,18
SF3	9.36°S	9.46°S	20,26
Sites of Fidelity <i>XUXU</i>			
	Max Lat	Min Lat	Frequency (%)
SF1	6.275°S	6.375°S	41,18
SF2	7.475°S	7.575°S	13,4
SF3	9.375°S	9.375°S	12,1

The frequency of the manatee *LUA*'s occurrence, in the latitude and longitude intervals of its three added SF, corresponded to more than 92% of the total of localizations along the whole Area of Life, being: SF1 (Boqueirão Beach/AL), where *LUA* presented a standard of alternating motion between the beach, place with large feed availability, making periodical incursions to the Manguaba River interior; SF2 (Maré Mansa/AL) is linked to beaches protected by reefs, banks of marine phanerogams and Santo Antônio and Sauhaçuí Rivers; SF3 (Estuarine Lagoon Complex of Mundaú and Manguaba/AL). The frequency of the manatee *ASTRO* occurrence, in the latitude/longitude intervals of its first main added SF, corresponded to more than 93% of the total of localizations along the the whole Area of Life, where: SF1 (estuary of Vaza Barris River/SE); SF2 (Estuarine Lagoon Complex of Mundáu and Manguaba/AL) and SF3 (Maré Mansa Beach/AL). The three main *XUXU*'s SF were: SF1 (region between the Sibaúma River and the Cunhaú River/RN); SF2 (Goiana River and adjacent coast, borders of the states of PE and PB) and SF3 (Maré Mansa Beach/AL). Besides these three sites, different places were important in different years for that manatee, highlighting: estuaries of Guajú River /RN) and Mamanguape River/PB (1999), Sirinhaém River/PE (1999 and 2000), Maré Mansa Beach/AL (2000 and 2001) and the area between De Itamaracá Island/PE and River Sibaúma/RN (2001 and 2004).

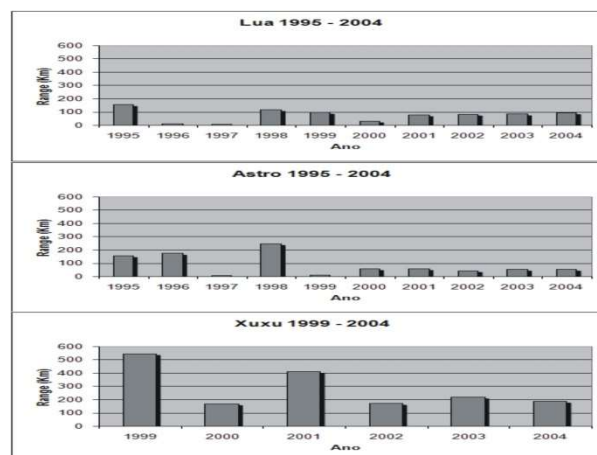


Figure 04: Annual maximum distances traveled by the peixes-bois *LUA*, *ASTRO* and *XUXU*

The Figure 4 displays the maximum extension of the displacements of *LUA*, *ASTRO* and *XUXU* for every year, being measured as the largest movement executed by the animal starting from the point where it met in the beginning of every year. The extension (Range) in kilometers only refers to the departure movement where a more than 500 km displacement from *ASTRO* in 1999 can be observed. The second group of manatees monitored in a longer term is constituted by the manatees *ALDO* and *NINA* that chose an only Site of Fidelity (Tatuamunha River/AL) near AR2 after the release, place where they stayed until this study end. They did not movements along the coastline and staying in the interior of this small estuary, along the period of monitoring, exploring it according to tide variation. The main source of food in this estuary are the banks of marine phanerogams, *H. wrightii* and mangrove vegetation.



Figure 05: Map of the marine peixes-bois *ALDO* and *NINA* with all of the registrations of locations, understanding their Home Range, with indication of Sites Fidelity SF1.

ALDO and *NINA* did not present amplitude in their Areas of Life in terms of latitude, because the geographical position interval ($9.172^{\circ}\text{S}/9.272^{\circ}\text{S}$) covered the small displacement to the south of AR2 until the entrance of the Tatuamunha River, *ASTRO* and *NINA*'s Site of Fidelity, with 100% of permanence (Figure 05). Two animals monitored in a short term presented long displacements. In the first *ASSU*'s release experience, it was monitored from October 21st, 2013 to February 05th, 2004, when it was rescued by the team of the Manatee Project (ALVITE *et al.*, 2004).

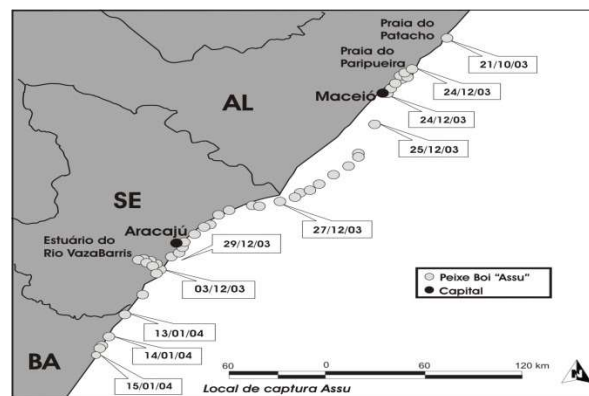


Figure 06: The manatee *ASSU*'s individual map, where the records of its localizations represent the movement to the south made during the first reintroduction between October 21st, 2003 and January 15th, 2004.

The coastline exploration made by this male was of 470 km, between Do Patacho Beach/AL and Do Forte Beach/BA, during 107 days of monitoring. However, it did a longer extension due to its return to the north (Mangue Seco) in Bahia after reaching Do Forte Beach and also to its incursion to open sea. Its latitude amplitude of displacement was of 3° of latitude between the extreme positions of its localizations ($9.173^{\circ}\text{S}/35.295^{\circ}\text{W}$ to $12.560^{\circ}\text{S}/38.000^{\circ}\text{W}$). The second *ASSU*'s reintroduction was on November 27th, 2004, jointly with the male *TICO* and the female *TUCA*, in the same AR2, with the same adaptation period and that weighed 190 kg. The monitoring period endured only 23 days when the animal was not localized by the monitoring team. On January 04th, 2005, the team was notified about a manatee occurrence in a urban beach in Salvador ($12.960^{\circ}\text{S}/38.520^{\circ}\text{W}$) in Bahia. The team decided to translocate it again to Itamaracá/PE, because the animal showed visible loss of weight. In this second reintroduction, *ASSU*, made approximately 550 km of the beach, a little more of 70 km to the south of the first capture's place.

Its latitude amplitude of displacement was of almost 4° of latitude between the extreme positions of its localizations (9.185°S/35.29°W to 12.960°S/38.500°W).

TICO weighed 160 kg when was transported jointly with the animals *ASSÚ* and *TUCA* to Do Patacho Beach/AL (AR2) on November 27th, 2004, spending a 07-day term in a nursery until was reintroduced. It made about 250 km within a period of 14 days after releasing in this period and looked very weak when captured, where the rescue operation was difficult since the depth reached over 100 meters (Figure 07).

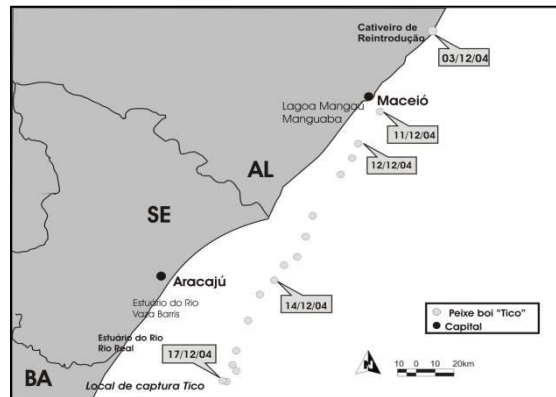


Figure 07: Map of the movement of the manatee *TICO*, showing its Area of Reintroduction to its capture in open sea.

DISCUSSION

It can be affirmed that the use of tracking methodology by telemetry radio system and by watching the reintroduced manatees was appropriate to the premise of the objectives for this study. The localization of this aquatic mammal species with estuarine and coastal ecological niche presented high effectiveness, where the field teams were responsible for data collection and information accuracy here analyzed. According to REID & O'SHEA (1989), *PTT* were much more effective than conventional telemetry radio for tracking rapid motions of animals whose displacements reached hundreds of kilometers when monitoring manatees in Florida/USA. Some animals (*FOLIA* and *PIPA*) tracked only by VHF radio system and regarded as missed after a short-term monitoring, could have been found by using satellite telemetry system, as recommended after the monitoring experience with *ASSÚ* & *TICO* (ALVITE et al., 2005).

According to REEF & BONDE (2006), the factors which can be classified as potential risks for a manatee's successful or unsuccessful reintroduction must be considered. These factors include age when released, genre, age when rescued, time of captivity and rescue-related circumstances. The results obtained in this study will be discussed regarding orphaned manatees' behavior, came from strands (LIMA, 1999; MEIRELLES, 2008) when still calves, grown in captivity and reintroduced in natural environment. During the release, the animals' age was practically considered as real age. For MARMONTEL (1995), the female manatees from Florida can sexually mature at their age of three and be already able for reproduction at their age of four. For this study,

the released animals had a medium term of captivity of 4,3 years (where *APARECIDA* was not included).

The higher latitude a reintroduced manatee reached (*ASSÚ*) refers to Salvador/BA, area recently considered of no occurrence of the species (LIMA, 1999). The manatee *ASTRO* has been in the southern coast of Sergipe since 1998, reaching a latitude of 11.441S. Its main current Site of Fidelity, Vaza Barris River, presents supply and sweet waters, while rest area in the interior of this estuary, but native manatees have not been seen in the region since the 80's decade (ALBUQUERQUE & MARCOVALDI, 1982; LIMA, 1999). The lower latitude was reached through the manatee *XUXU*'s long motion, regarding Macau (5.083°S), in Rio Grande do Norte. This area of study is included in the area of the species' recorded historical and recent distribution.

When observing the animals' movements likely *LUA*, *ASTRO* & *XUXU*, it can be noticed that the beginning of the exploratory motions happens mainly in the end of winter (rain) and during summer (dry). It was observed that these animals mutually used estuaries and coastal zone, where their motions for entrance and exit from the estuary synchronized with tide variation. SILVA *et al.*, (1992) and PALUDO (1997) describe the importance of tides for the Paraíba and Rio Grande do Norte's coast's native manatees' behavior. Observing *ALDO* and *NINA*'s behavior, there is relation for considering the rain regimen as an environmental factor able to work directly as a "trigger" to determine these animals' exploratory movements.

Food supply certainly presents a highlighted role for the manatees' distribution, animals exclusively herbivorous, being probably dependent of vegetation's distribution (ODELL, 2002). The explored coast promotes environments favorable to the manatees' permanence, excepting the coast of Sergipe, a coastal plain subject to a great flow from São Francisco River, that does not present either a protection by reefs or phanerogams and marine algae banks, but that has wider and well conserved estuaries. BEST (1981) and DEUTSCH *et al.*, (2003) suggest that they are individually very flyable in using different means of fodder in different communities of plants. The highlighted seasonality in some reintroduced manatees' movements does not find evidences in this study, like a seeking for food or the main factor which causes these displacements, once these motions always made from the Sites of Fidelity with permanent environmental characteristics favorable to the animals' permanence.

Another hypothesis that can be lifted up and tested in future studies, it is that the exploratory movement of the animals annually can be related to reproductive periods. HARTMAN (1979) was the first to suggest the occurrence of *pseudo-estrus* for the manatees in Florida. MARMONTEL (1995) found along all year pregnancy status in carcasses of females in Florida, but with indications that the births occur mainly in the end of spring and during summer, with rare births in winter, what also was found by RATHUIN *et al.* (1995). Data on an under six age orphaned female (*SEREIA*) stranded in 1991 and raised in captivity, non published by CMA/IBAMA, recorded one first twin calf (on April 10th, 1997, beginning of the rainy period). Its second calf was born on March 14th, 2004, when it was at its thirteen years. According to SILVA *et al.* (1992), the

highlighted occurrence of the species in summer months coincides with the observations of calves and also a reproductive behavior in the estuary of Mamanguape River, in Paraíba.

The summer months are also pointed as the main period of strands of orphaned calves in the northeast coast (LIMA, 1996; PARENTE et al., 2004), coinciding with the probable reproductive period of the manatees in the northeast coast in Brazil. When at its twelve age where eight was lived freely, *LUA* gave birth in the summer period (December 26th, 2003). The motion presented by this female (LIMA et al., 2005), can point this hypotheses. However, some animals did not present seasonal displacements. This factor can be related to the individual characteristics of resident animals (according the description for some manatees in Florida), or even for these individuals' age. On the other side, the small size and age of manatees residents in Tatuamunha River/AL (*ALDO and NINA*) can not still primarily influence over the exploratory movement along the coast, due to the reproductive hormonal mechanism current development. Only the long term monitoring will test this hypotheses, once the major part of the reintroduced animals are calves and/or sub-adults.

In this study, some animals presented strong evidence of fidelity to determined areas, where the Area of Life was variable according to the extension of the exploratory movements presented by each manatee. Within a bigger geographical perspective, it resulted that manatees individually occupied few relative small areas, but with high use frequency. They used coastal corridors for their exploratory movements and not only found an appropriate habitat for meeting their needs but also habitat inadequate for their permanence. DEUTSCH *et al.* (2003) conclude that in twelve years of study the tracked manatees showed a big mobility and seasonal migration through extensive geographical areas in the Atlantic coast in the United States, showing diverse models of seasonal movements, from resident in certain areas until migrants of tens of kilometers of the coastline per year.

The manatees reintroduced in the Atlantic coast of Northeast of Brazil and monitored from 1994 to 2004, presented different behaviors when their movements' extension and periodicity were linked, which may be grouped in: **Animals with extensive Area of Life/Home Range and Use of Several Sites of Fidelity:** In this group, there are those reintroduced manatees which presented a wide occurrence distribution in the region of study, with significant evidences of the exploratory behavior in the coastal space. Within the limits of the Area of Life areas of long permanence and of high temporal use were established as well as extensive areas of passage that serve as corridors between the Sites of Fidelity. They can make movements of hundreds of kilometers in few days. In this study, the manatees *LUA*, *ASTRO* & *XUXU* are considered of this profile. **Animals with Area of Restrict Life to Site of Fidelity:** The reintroduced manatees which presented a restrict geographical distribution of their post release occurrences, where the exploratory behavior covered only their permanence area near the Area of Reproduction (AR) were included in this group. This area became their Site of Fidelity which also is their Area of Life in

terms of geographical limits. The manatees *ALDO* & *NINA* can be included here. **Animals of Erratic Movements:** The reintroduced manatees *ASSÚ* & *TICO* were included in this group, because presented a continuous movement in one direction and did not use coastal environments for establishing their permanence areas. Their occurrences' distributions are big and reach hundreds of kilometers of the Area of Reintroduction. Both manatees presented a great loss of weight and dehydration. **Animals with insufficient data for analysis:** Those animals reintroduced and that did not have time of continuous monitoring for at least one year (*TUCA*), due to loss of telemetry radio equipment, visual contact loss (*FOLIA* & *PIPA*) or even difficulty on identifying and managing when seen (*ARAQUETO* & *BOI-VOADOR*), or the individual's death (*APARECIDA*), are in this group.

CONCLUSION

It can be assumed that the animals presented in these studies are probably representative from the different types of behavior the manatees grown in captivity may show. In this sense, the results from the manatees' spatial and temporal distribution from the Areas of Reintroduction, distant hundreds of kilometers from their place of stranding and without learning from their mothers, may be credited to each animal's individual learning and in its turn can reflect standards for the other manatees which present the same origin and life history: The techniques of translocation, maintenance in captivity in the natural environment and the post release monitoring were taken with criteria and supported a first understanding about the marine manatees' movements and habits in Brazil; The Monitoring System used for tracking the reintroduced manatees showed a high effectiveness, related to the great effort to keep the field teams; The results of this tracking indicate the need to monitor as a guarantee of localization for those animals which move quickly or to the open sea; The spacial distribution presented by the reintroduced peixes-bois was different from individual for individual, with extensive Home Range explored by three animals, two animals with restricted Home Range and other two animals with wandering movements and without permanence in any place. To the colleagues of the Peixe-Boi Marinho Project, Boticário Foundation for Nature Protection, Petrobras S/A, Aquatic Mammals Foundation (FMA), Aquatic Mammals Center/ICMBio, IBAMA/Northeast Superintendencies and *Sirenia Project-USGS*.

REFERENCES

AB'SABER, A. N.. (2001). **O Litoral do Brasil**. São Paulo: Metalivros, 2001.

ALBUQUERQUE, C.; MARCOVALDI, G. M.. Ocorrência e distribuição do peixe-boi marinho no litoral brasileiro (SIRENIA, Trichechidae, *Trichechus manatus*, Linnaeus 1758). In: SIMPÓSIO INTERNACIONAL SOBRE UTILIZAÇÃO DE ECOSISTEMAS COSTEIROS: PLANEJAMENTO, POLUIÇÃO E PRODUTIVIDADE. **Anais**. Rio Grande: 1982.

- ALVITE, C. M. C. et al. Northeastern aquatic mammals strandings network, Brazil (REMANE): 2000-2002. In: REUNIÓN DE TRABAJO DE ESPECIALISTAS EN MAMÍFEROS ACUÁTICOS DEL AMÉRICA DEL SUR. 11. **Anais**. 2004.
- ALVITE, C. M. C.; LIMA, R. P.; REID, J. P.; VERGARA-PARENTE, J. E.; GONZALEZ, M.; CASTRO, D. F.. Rescue of Released Manatees (*Trichechus manatus*) In: **the Northeast Coast of Brazil**. San Diego: Abstracts, 2005.
- BEST, R. C.. Foods and feeding habits of wild and captive Sirenia. **Mammal Review**. v.1, p.3-29, 1981.
- DEUTSCH, C. J.; BONDE, R. K.; REID, J. P.. Radio-tracking manatees from land and space: tag design, implementation, and lessons learned from long-term study. **Marine Technology Society Journal**. v.32, p.18-29, 1998.
- DEUTSCH, C. J.; REID, J. P.; BONDE, R. K.; EASTON, D. E.; KOCHMAN, H. I.; O'SHEA, T. J.. Seasonal Movements, Migratory Behavior and Site Fidelity of West Indian Manatees Along The Atlantic Coast Of United States. **Wildlife Society**. v.151, p.77-90, 2003.
- HARTMAN, D. S.. Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. **American Society of Mammalogists**. p.153-161, 1979.
- IBAMA. **Mamíferos Aquáticos do Brasil**: plano de ação. Brasília: IBAMA, 1997.
- IBAMA. **Mamíferos Aquáticos do Brasil**: Plano de Ação. 2 ed. Brasília: IBAMA, 2001.
- IBAMA. **Criação da Rede de Encalhes de Mamíferos Aquáticos do Nordeste**. Brasília: IBAMA, 2000.
- KENWARD, R. E.. **Wildlife Radio Tracking**. San Diego: Academic Press, 1987.
- KLEIMANN, D. G.. Reintroduction of captive mammals for conservation. **BioScience**. v.39, p.152-161, 1989.
- LIMA, R. P.; BOROBIA, M.. Peixe-boi marinho: *Trichechus manatus* (Linnaeus, 1758). **PNUMA No**. v.138, n.250, p.182-187, 1991.
- LIMA, R. P.; PALUDO, D.; SOAVINSKI, R. J.; SILVA, K. G.; OLIVEIRA, E. M. A.. Levantamento da distribuição, ocorrência e status de conservação do peixe-boi marinho (*Trichechus manatus*, Linnaeus 1758) no litoral nordeste do Brasil. **Periódico Peixe-Boi**. v.1, n.1, p.47-72, 1992.
- LIMA, R. P.; OLIVEIRA, E. M. A.; PALUDO, D.; SOAVINSKI, R. J.. Levantamento da distribuição, status de conservação do peixe-boi marinho (*Trichechus manatus*, Linnaeus 1758) no litoral do estado do Maranhão e esforços conservacionista para sua proteção. In: REUNIÃO DE TRABALHO DE ESPECIALISTAS EM MAMÍFEROS AQUÁTICOS DA AMÉRICA DO SUL, Olinda, 6. **Anais**. Universidade Federal de Pernambuco, 1994.
- LIMA, R. P.. **Peixe-boi marinho (*Trichechus manatus*): distribuição, Status de conservação e aspectos tradicionais ao longo do litoral nordeste do Brasil**. Brasília: IBAMA, 1999.
- LIMA, R. P.; CASTRO, D. F.; VERGARA, J. E.; ALVITE, C. M. C.. Avaliação do Sistema de Monitoramento de peixes-bois marinho (*Trichechus manatus*) reintroduzidos no litoral nordeste do Brasil. In: REUNIÓN DE TRABAJO DE ESPECIALISTAS EN MAMÍFEROS ACUÁTICOS DEL AMÉRICA DEL SUR. 9. **Anais**. Buenos Aires, 2000.
- LIMA, R. P.; LUNA, F. O.; PASSAVANTE, J. Z.. Distribuição do peixe-boi marinho (*Trichechus manatus*, Linnaeus 1758) no litoral norte do Brasil. In: REUNIÓN DE TRABAJO DE ESPECIALISTAS EN MAMÍFEROS ACUÁTICOS DEL AMÉRICA DEL SUR. 9. **Anais**. Buenos Aires, 2000.
- LIMA, R. P.; ALVITE, C. M. C.; VERGARA-PARENTE, J. E.; CASTRO, D. F.; PASZKIEWICZ, E.; GONZALEZ, M.. Reproductive behavior in a Captive-Released Manatee (*Trichechus manatus manatus*) along the Northeastern Coast of Brazil and the Life History of Her Calf Born in the Wild. **Aquatic Mammals**. v.31, n.4, p.420-426, 2005.

LIMA, R. P.; ALVITE, C. M. C.; VERGARA-PARENTE, J. E.. **Protocolo de Reintrodução de Peixes-bois marinhos no Brasil**. São Luis: IBAMA, 2007.

LUNA, F. O.. **Distribuição, Status de conservação e aspectos tradicionais do peixe-boi marinho (*Trichechus manatus manatus*) no litoral norte do Brasil**. Dissertação (Mestrado em Oceanografia)- Universidade Federal de Pernambuco, Recife, 2001.

MARMONTEL, M.. Age and Reproduction in Female Florida Manatee. Population Biology of the Florida Manatee. **National Biological Service**, v.289, p.98-119, 1995.

MEIRRELES, A. C. O.. Mortality of the Antillean Manatee (*Trichechus manatus manatus*) in Ceará State, North-Eastern Brazil. **Journal of the Marine Biological Association of the United Kingdom**. p.1-5, 2008.

OLIVEIRA, E. M. A.; LANGGUTH, A.; SILVA, K. G.; SOAVINSKI, R. J.; LIMA, R. P.. Mortalidade do peixe-boi marinho (*Trichechus manatus*) na costa nordeste do Brasil. In: REUNIÓN DE TRABAJO DE ESPECIALISTAS EN MAMIFEROS ACUATICOS DEL AMERICA DEL SUR. 4. **Anais**. Valdivia, 1990.

ODELL, D. K.. **Sirenia life history**. San Diego: Academic Press, 2002.

PALUDO, D.. **Estudos sobre a ecologia e conservação do peixe-boi marinho *Trichechus manatus manatus* no nordeste do Brasil**. Dissertação (Mestrado em Zoologia) - Universidade Federal da Paraíba, João Pessoa, 1997

PARENTE, C. L.; VERGARA-PARENTE, J. E.; LIMA, R. P.. Strandings of antillean manatees (*Trichechus manatus manatus*) in northeastern Brazil. **The Latin American Journal of Aquatic Mammals**. v.3, n.1, p.69-75, 2004.

RATHBUN, G. B.; BOURASSA, J. B.. **Design and construction of tethered, floating radio-tag assembly for manatees**. Virginia: National Technical Information Service, 1987.

RATHBUN, G. B.; REID, J. P.; BONDE, R. K.; POWELL, J.. **Reproduction in Free-ranging Florida Manatees**. Florida: National Biological Service, 1995.

REEP, R. L.; BONDE, R. K.. **The Florida Manatee: Biology and Conservation**. Florida: University Press of, 2006.

REID, J. P.; O'SHEA, T. J.. **Three years operational use of satellite telemetry on Florida manatees tag improvements based on challenges from field**. Maryland: Landover, 1989.

REID, J. P.; BONDE, R. K.; O'SHEA, T. J.. **Reproduction and mortality of radio-tagged and recognizable manatees on the Atlantic Coast of Florida**. Florida: National Biological Service, 1985

SILVA, K. G.; PALUDO, D.; OLIVEIRA, E. M. A.; LIMA, R. P.; SOAVINSKI, R. J.. Distribuição e ocorrência do peixe-boi marinho (*Trichechus manatus*) no estuário do rio Mamanguape, Paraíba (BR). **Periódico Peixe-Boi/IBAMA-FMM**. João Pessoa, v.1, n.1, p.06-18, 1992.

WHITEHEAD, P. J. P.. Registros antigos da presença do peixe-boi (*Trichechus manatus*) no Brasil. **Acta Amazônica**, v.8, n.3, p.497-506, 1978.

WHITE, G. C.; GARROTT, R. A.. **Analysis of Wildlife Radio-Tracking Data**. Academic Press, 1990.