FINAL REPORT

PROJECT TITLE: 12411-2 - Ecology and Conservation of the Antillean Manatee (*Trichechus manatus manatus*) on Timonha and Ubatuba Rivers, northeastern Brazil.

ORGANISATION: ASSOCIAÇÃO DE PESQUISA E PRESERVAÇÃO DE ECOSSISTEMAS AQUÁTICOS - AQUASIS

APPLICANT NAME: Ana Carolina O. de Meirelles

SUMMARY OF THE ACTIVITIES REALIZED DURING THE PROJECT

21 field trips realized to verify the viability of the use of side scan sonar to estimate the abundance of the Antillean manatee on the estuary.

99 days on board, realized during the field trips.

One data bank of the Antillean manatee acoustic repertoire.

- Utilization of hydrophone and digital recorder on 36 days on board;
- 47 hours of recordings;

Identify and monitor the environmental quality of the estuary, through estuary water and sediments analysis:

- Five samples of water collected during the field trips to toxicology analyses;
- 13 samples of sediment collected and analyzed for heavy metals;
- 12 samples of sediment collected and been prepared for organochlorines analysis.

Describe the variables (biotic, physiographic and physicochemical), that influence the spatial and temporal distribution of manatees on the estuary:

- Utilization of refractometer, digital anemometer and Secchi disk on 38 days on board;
- One partial data bank with the environmental variables collected.

Identify food availability for the Antillean manatee on the estuary:

- Dives at different points off the estuary;
- Five areas identified with the presence of food;
- None fresh water springs source found until this moment;
- Four collections realized through diving;
- Eight species and four genus of algae identified;
- Twenty-two samples of manatee faeces collected.

FIELD TRIP DATES

Table 1. Field trips realized, dates and source of the financial support.

Field trips realized		
Field trip number	**Date**	**Financial support**
1	September, 30 to October, 06, 2012	FBPN
2	January, 14 to 19, 2013	FBPN
3	March, 03 to 08, 2013	FBPN
4	April, 14 to 19, 2013	RUFFORD
5	April, 28 to May, 02, 2013	RUFFORD
6	May, 12 to 17, 2013	FBPN
7	June, 02 to 07, 2013	FBPN
8	June, 16 to 21, 2013	FBPN
9	August, 25 to 30, 2013	RUFFORD
10	November, 10 to 15, 2013	RUFFORD
11	January, 12 to 17, 2014	FBPN
12	January, 26 to 31, 2014	FBPN
13	February, 9 to 14, 2014	FBPN
14	February, 23 to 28, 2014	FBPN
15	March, 9 to 14, 2014	RUFFORD
16	March, 23 to 28, 2014	RUFFORD
17	April, 06 to 10, 2014	RUFFORD
18	May, 12 to 16, 2014	FBPN
19	May, 27 to 30, 2014	FBPN
20	June, 08 to 13, 2014	FBPN
21	June, 23 to 27	RUFFORD

Table 2 shows the stretches travelled in each trip, the time the team departure (**Hs**), the time of the arrival (**Hc**), beginning (**Hi**) and end (**Hf**) of collecting data, sampling effort (**EA**) and average speed (**VM**).

Table 2. Dates of the outputs and stretches travelled.

Day	Stretches	Hs	Hi	Hf	Hc	EA	VM
November, 11	II and III	5h50	6h40	9h46	10h45	3h06	6Km/h
November, 12	II and III	5h50	6h29	9h20	10h10	2h51	6Km/h
November, 13	I	5h50	6h50	9h50	10h40	3h	6Km/h
November, 14	I and II	5h50	6h50	9h10	10h00	3h	6Km/h
November, 15	II and III	5h50	6h44	10h20	11h55	3h36	6Km/h
January, 13	I	5h45	6h35	9h23	10h20	2h48	6Km/h
January, 14	II and III	5h50	6h35	9h30	10h10	2h55	6Km/h
January, 15	I	5h50	6h32	9h50	10h30	3h18	6Km/h
January, 16	II and III	5h50	6h34	10h00	12h40	3h26	6Km/h
January, 17	II and III	5h50	6h27	9h30	10h10	3h03	6Km/h
January, 27	I	5h50	6h45	9h22	10h10	2h47	6Km/h
January, 28	II and III	5h55	6h24	9h40	10h40	3h16	6Km/h
January, 29	II and III	5h55	6h37	9h50	11h00	3h13	6Km/h
January, 30	I	5h50	7h26	10h20	11h30	2h54	6Km/h
January, 31	II and III	4h30	5h27	7h45	08h30	2h18	6Km/h
February, 11	I	5h50	6h30	8h50	10h00	2h20	6Km/h
February, 12	II and III	5h50	6h27	9h05	10h10	2h38	6Km/h
February, 13	I	5h50	6h29	9h05	10h00	2h36	6Km/h
February, 14	II and III	5h50	6h55	8h57	10h00	2h02	6Km/h
February, 24	II and III	5h50	6h30	9h50	10h50	3h20	6Km/h
February, 25	I	6h50	7h28	10h20	11h00	3h08	6Km/h
February, 26	II and III	5h50	6h36	9h50	11h10	3h14	6Km/h
February, 27	I	5h10	6h04	10h04	10h50	3h00	6Km/h
February, 28	II and III	4h44	5h31	9h15	10h00	3h44	6Km/h
March, 10	II and III	5h50	6h30	9h40	10h10	3h10	6Km/h
March, 11	I	5h50	6h30	9h40	10h10	3h10	6Km/h
March, 12	II and III	5h50	6h34	9h48	10h20	3h14	6Km/h
March, 13	I	5h50	6h46	9h44	10h25	3h00	6Km/h
March, 14	II and III	5h50	6h32	8h45	9h15	2h13	6Km/h
March, 24	II and III	5h35	6h30	10h00	10h30	3h30	6Km/h
March, 25	I	13h30	14h25	17h40	18h00	3h15	6Km/h
March, 26	II and III	5h35	6h17	10h00	11h15	3h43	6Km/h
March, 27	I	5h35	6h20	10h00	11h15	3h40	6Km/h
March, 28	II and III	6h45	7h34	10h28	11h10	2h54	6Km/h
April, 07	II and III	5h30	6h15	11h40	12h00	5h25	6Km/h
April, 08	I	5h30	6h10	9h30	10h10	3h20	6Km/h
April, 09	II and III	5h25	6h05	9h30	10h10	3h25	6Km/h
April, 10	II and III	5h30	5h58	8h45	9h20	2h47	6Km/h
May, 12	II and III	5h50	6h30	9h50	10h50	3h20	6Km/h
May, 13	I	6h50	7h28	10h20	11h00	3h08	6Km/h
May, 14	II and III	5h50	6h36	9h50	11h10	3h14	6Km/h
May, 15	I	5h10	6h04	10h04	10h50	3h00	6Km/h
May, 16	II and III	4h44	5h31	9h15	10h00	3h44	6Km/h
May, 27	II and III	5h50	6h30	9h40	10h10	3h10	6Km/h
May, 28	II and III	5h50	6h30	9h40	10h10	3h10	6Km/h
May, 29	I	5h50	6h34	9h48	10h20	3h14	6Km/h
May, 30	II and III	5h50	6h46	9h44	10h25	3h00	6Km/h
June, 09	II and III	5h50	6h40	9h46	10h45	3h06	6Km/h
June, 10	I	5h50	6h29	9h20	10h10	2h51	6Km/h
June, 11	II and III	5h50	6h50	9h50	10h40	3h	6Km/h
June, 12	I	5h50	6h50	9h10	10h00	3h	6Km/h
June, 13	II and III	5h50	6h44	10h20	11h55	3h36	6Km/h
June, 23	II and III	5h50	6h36	9h50	11h10	3h14	6Km/h
June, 24	II and III	5h10	6h04	10h04	10h50	3h00	6Km/h
June, 25	I	4h44	5h31	9h15	10h00	3h44	6Km/h
June, 26	II and III	5h50	6h30	9h40	10h10	3h10	6Km/h
June, 27	II and III	5h30	6h15	11h40	12h00	5h25	6Km/h

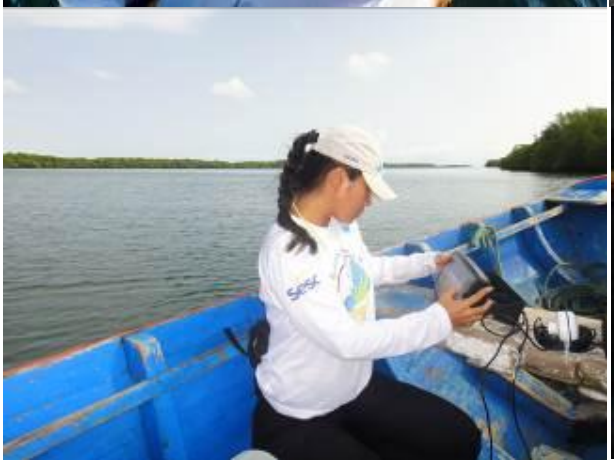
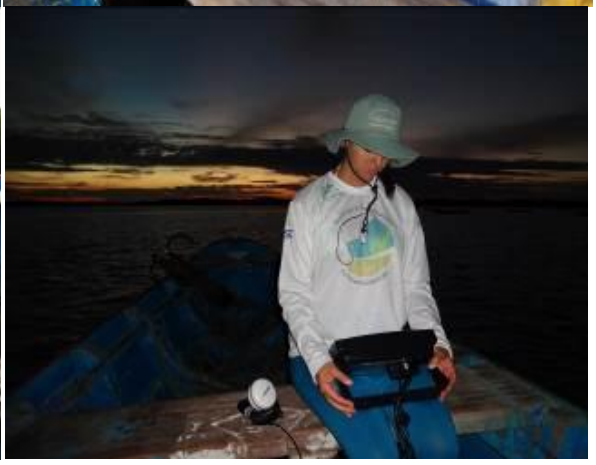
Activities

Activities 1: Verify the viability of the use of sidescan sonar to estimate the abundance of the Antillean manatee on the estuary.

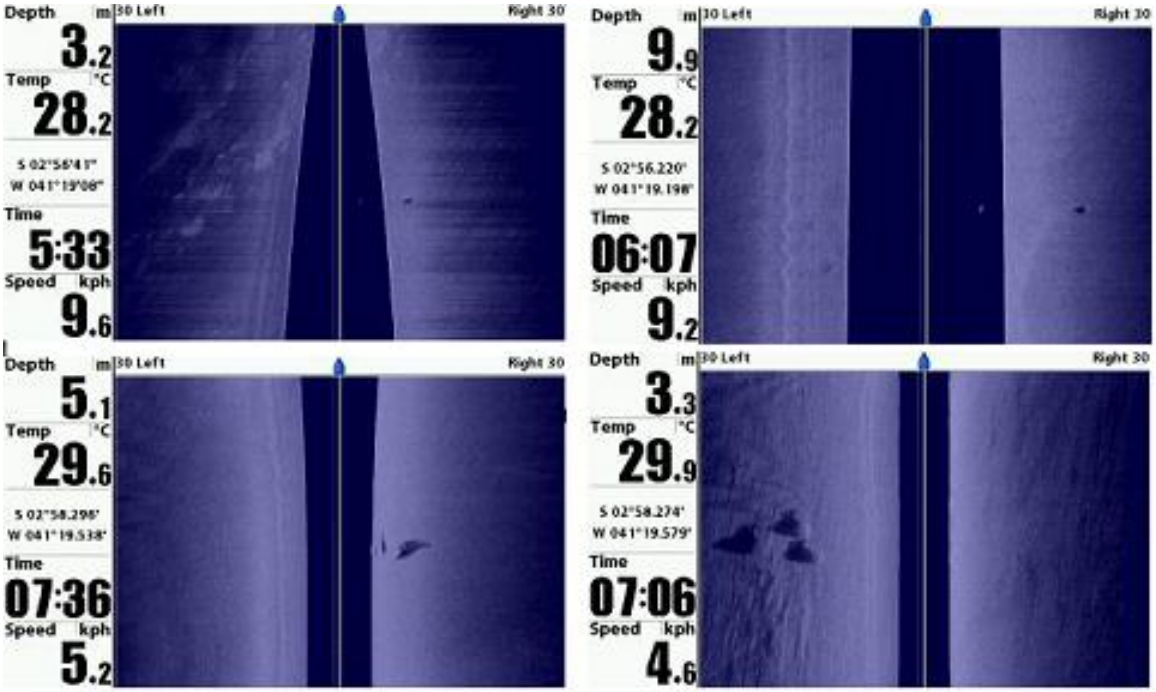






Some images from the Antillean manatee, captured with the side scan sonar



Activities 2: Describe the sound repertoire of the Antillean manatee on the estuary, checking the feasibility of using this tool to estimate abundance.

Field team recording the Antillean manatee vocalizations

Activities 3: Identify the threats and the human impacts on the Antillean manatee on the estuary.

During the field trips realized, there were identified five threats: fishing activities, boat traffic, shrimp farming, saltworks and urbanization (Table 3).

Table 3. Threats identified on the study area and their possible anthropic impacts.

Threats	Anthropic impacts (possibles)
Fishing	Bycatch; Destruction of feeding areas; Collision; Pollution (Solid waste left by the fishermen – plastic bags, remains of fishing nets and ropes, oil from the motorboats, contamination by trace elements, derived from anti-fouling paints that the fishermen uses to paint their boats); Expulsion from the living area.
Boats Traffic	Running over/collision; Pollution (oil from the motorboats, paints that the fishermen uses to paint their boats).
Shrimp farms	Expulsion from the living area, through the habitat loss; Pollution and contamination of the soil, groundwater and water of the rivers.
Saltworks	Expulsion from the living area, through the habitat loss; Pollution and contamination of the soil, groundwater and water of the rivers.
Urbanization	Expulsion from the living area, through the habitat loss; Pollution and contamination of the soil, groundwater and water of the rivers.

Activities 4: Identify and monitor the environmental quality of the estuary, through estuary water and sediments analysis.

Water samples collections during the period


Sediment samples collections during the period




Preparation of the sediment samples collected for heavy metals analysis.

Preparation of the sediment samples collected for organochlorine analysis.

Activities **5: Describe the variables (biotic, physiographic and physicochemical), that influence the spatial and temporal distribution of manatees on the estuary.**




Measurement of wind speed and air temperature using anemometer and the salinity of water using refractometer.

Activities 6: Identify food availability for the Antillean manatee on the estuary and collect manatee faeces to analyze the food items.

During the field trips conducted in March, April, May and June 2013 were identified five (05) areas with banks of algae and seagrass (Table 4). The area of the seagrass beds, located next to a corral disabled and an asset at the end the stretch III, was found with marks pectoral fins of animals that fed there (manatees rely with the pectoral fins on the substrate while are feeding). Already banks of algae were found near two large sand banks (also called regionally "crôas") that are exposed at low tide in tidal moon (full and new). All feeding areas found in this period contained in the Carpina River.

Table 4. Location of feeding areas (banks algae and seagrass).

Stretch	Waypoint	Latitude	Longitude	Type of food
I	1622	02º55'43"S	041º19'01"O	algae/seagrass
I	1623	02º55'44"S	041º19'02"O	algae/seagrass
III	1929	02º58'16"S	041º19'39"O	seagrass
III	1983	02º57'42"S	041º19'30"O	seagrass
III	2068	02º58'17"S	041º19'40"O	algae/seagrass

During the field trips conducted in the months of March, April, May and June 2013, were collected 13 faecal samples of manatee. The samples were analyzed looking for small parts of vegetation. However, the parts were too fragmented and it was not possible to identify vegetation species.

However, the samples were stored in the Laboratory of Macroalgae at the Institute of Marine Sciences (LABOMAR) in the Federal University of Ceará, and the possibility of perform biomolecular analysis for identify these items is in discussion.

Three (03) faecal samples of manatee found drifting in the same day and near the place where the animals were sighted in stretch I (bar river).

During the field trips conducted in March, May and June 2013 Samples of submerged vegetationwere collected. The researcher and algae specialist, biologist Pedro Bastos - Macroalgae Laboratory of the Institute of Marine Sciences (LABOMAR) Federal University of Ceará, identified seven (07) algae species and two distinct genus. (two (02) genus of brown algae, three (03) species of red algae and (08) species of green algae (Table 5).

Diving, submerged vegetation collection, storage of vegetable items collected.

Table 5. List of species/genus of algae identified

Brown Algae	**Red Algae**	**Green Algae**
Padina sp. (G)	*Gracilaria sp. (G)*	*Caulerpa mexicana (E)*
Dictyota sp. (G)	*Hypnea musciformis (E)*	*Caulerpa prolifera (E)*
	Osmundaria obtusiloba (E)	*Caulerpa sertulariodes (E)*
		Codium sp. (G)
		Ulva fasciata (E)
		Solieria filiformis (E)
		Acantophoro muscoides (E)
New species/genus identified	**Type**	**Level of identification**
Padina sp.	Brown	(G) genus (E) species
Dictyota sp.	Brown	
Osmundaria obtusiloba	Red	
Caulerpa mexicana	Green	
Caulerpa prolifera	Green	
Caulerpa sertulariodes	Green	
Ulva fasciata	Green	
Solieria filiformis	Green	
Acantophoro muscoides	Green	

The presence of mangrove and saltmarsh (*Spartina* sp.) in the estuary is abundant and manatees fedd on these items in other estuaries in Brazil. In fact, as observed by Ciotti (2012), studying feeding habits of manatees in different areas of Brazil, animals feed on seagrass, algae, mangrove and saltmarsh in Timonha and Ubatuba River.

MAIN RESULTS

- 918 Km traveled by boat

- 236 hours of effort: 189 hours with sidescan sonar (SSS) and 47 hours with the hydrophone.

- False negatives, where a manatee was seen by an observer and not detected by SSS existed, although the opposite has happened more frequently.

- A total of 3,489 images were captured and saved on the memory card for later analysis. Of the 3,489 recorded images, 295 contained usable data and were screened for detailed analysis. Of the 295 screened images for detailed analysis, 95 were confirmed detections of manatees by sonar and the remaining 200 images were not confirmed as manatees, because they do not fit in the established sonar model, such as body position (peanut shape and shadow produced).

- The number of manatees observed in the field was 146 by visual observations with the boat at rest in 85% of the time, in 48 detections and 158 observations by the SSS in 95 detections. This number included 102 individuals of manatee observed by SSS and 130 individuals of manatees observed visually in Rio Carpina (Stretch III), 10 manatees observed by SSS and 2 manatees observed visually in Rio Ubatuba (Stretch II) and 46 manatees observed by SSS, and 14 manatees observed visually in Barra (Stretch I).

- The probability of detection of manatees per hour of effort in total was 1.3 manatees / hour, with 0.83 manatees / hour with the SSS and 0.62 manatees / time on direct observations (visual).

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- The SSS resulted in a greater effort in terms of detection when compared to visual surveying.

- The distribution of the manatee was not uniform in the study area and they were observed more frequently in very specific areas, such as river Carpina (Map 2). Our results confirm the presence of the manatee throughout the study area, with greater use of stretch III and I, river Carpina and Barra respectively, using the stretch II (Rio Ubatuba), as a passage between the two stretchs I and III. In stretch I, manatees were observed in shallow waters with the presence of food, next to the river channel. The stretch III, Rio Carpina, is one of the shallowest channels of the estuary (less than 5 m), where manatee food is also observed. Thus, observations in the estuary confirm habitat preference of manatees described in other areas of the species occurrence.

- The results showed that the sidescan sonar is a viable method for the detection of manatees in the estuary of the rivers Timonha and Ubatuba. Preliminary analysis indicate a population of 70 animals.

- Range of the manatee in the study area was estimated using Kernel estimator in Spatial Analyst tool of ArcGis 10.1. The 95% DU was 2.36 km_2, and preferred area, all in Carpina river (50% DU), was 0,042 km_2 (Map 3). This reinforces the importance of this area of the estuary to the species. It is important to note that manatees also occur in marine adjacent area, thus this values are only related to range area in the studied stretchs.

- The research has shown the existence of a population of manatees in the study area, as evidenced by the numerous detections in many locations. The survey also showed that while manatees appear to be distributed throughout the study area, also tend to concentrate their presence and activities in specific areas. The study shows that there is a population of manatees in the region, well maintained, demonstrated by the presence of young, high frequency of occurrence, the presence of large groups of up to 12 animals and no record of deaths during the two years of study. The large number of manatees observed in the region, especially in Rio Carpina (stretch III) is in agreement with the study by Choi et al. (2009) based on interviews with local residents, who documented the presence of manatees throughout the study area with the highest frequency of occurrence in Rio Carpina, as well as the present study.

- In an environment where direct observations are difficult, the use of indirect methods is important to detect manatees. The sidescan sonar has become an important tool for detecting manatee in an environment similar to what has been studied (GONZÁLEZ-SOCOLOSKE et al. 2009).

- The methodology used in this study allowed us to obtain accurate data with a low error rate, without having to repeat the count as with other methods of capture and recapture. For developing countries, the sampling distance is an effective way to study this species (VÁZQUEZ-CASTAN 2010).

- Although the SSS is a relatively expensive equipment, this method had the most cost-effective in long-term. The initial investment is therefore offset by the reduction in fuel expenses for vessel, sampling time and field assistants. Other advantages include the absence of bias in direct human observations and the ability to cover larger areas in a short time, resulting in greater efficiency.

- The data obtained from the SSS can be applied to models used to estimate the population size and the results optimized. However, the information gathered from direct sightings are limited to infer the presence or absence and determination of relative abundance indices, as the maximum number of simultaneous sightings. On the other hand, direct observations allow the collection of other valuable information, such as age classes, behavior and even private individual characteristics (CASTELBLANCO- MARTÍNEZ, 2004).

- Low frequency sounds produced by shrimps and barnacles masked manatee vocalizations in the studied estuary. Additional effort to clean the recorded sounds is being performed in São Paulo University (USP). Before obtain this results, it is not possible to verify the feasibility of the use of manatee vocal signature as a tool to estimate abundance in the study area

- During the field trips, Aquasis team recorded a lot of human impacts on the estuary, as observed in Table 3. In Map 4, some of the impacts, as motor boats, fishing, shrimps and salt farms can be observed. The presence of motor boats in Carpina river is of great concern. Boat strikes is one of the main impacts on the species in Florida, thus it is important to include restrictive rules of use of Carpina river in the management plan of the Protected Area APA Delta do Parnaíba, to avoid boat collisions and deaths of manatees.

- The presence of fishing activity on the estuary can be a threat to manatee (Map 5). Although animals do not occur there in quantity and frequency as they occur in Carpina River, it is a movement area between Carpina river and coastal adjacent areas. Also, a huge seagrass bed in located in a mud bank in this area, where manatees were observed feeding.

- There are important sources of contamination in the estuary, as salt and shrimp farms, agriculture in upper river cities, oil from motor boats, sewage and garbage from all riverine cities. During this study, we recorded a dead manatee stranded in the beach next to Cajueiro da Praia. During necropsy, a silk rope in the animal stomach. Silk ropes are commonly used in fishing activities in the region.

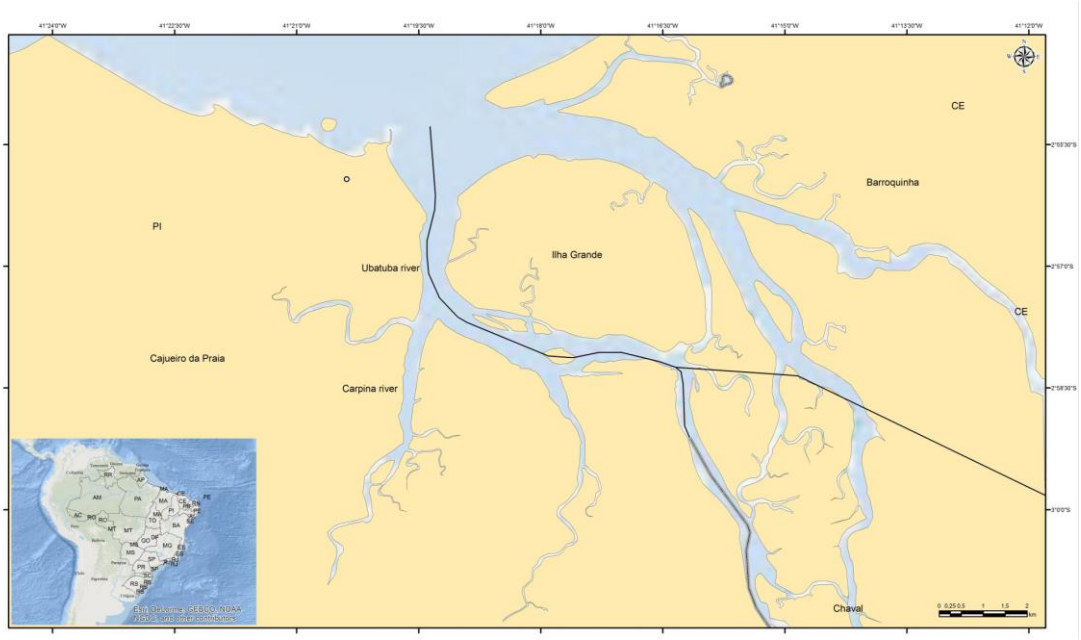
- In the sediment samples collected during this study, the follow elements were found: Oxygen, Silicon, Aluminium, Iron, Carbon, Chlorine, Sodium, Molybdenum, Calcium, Potassium, Magnesium, Sulphur, Manganese, Vanadium, Chrome, Cobalt, Titanium, Copper, Mercury, Lead and Cadmium. The last four are considered heavy metals and were in low concentrations in the samples.

- Sediment analyses also indicated a high concentration of aliphatic hydrocarbons in Carpina River, where a high concentration of manatees is observed. In some areas, the oil observed is of human origin. These findings can be related to the disposal of motor boat oil in the river, a common practice of fishermen.

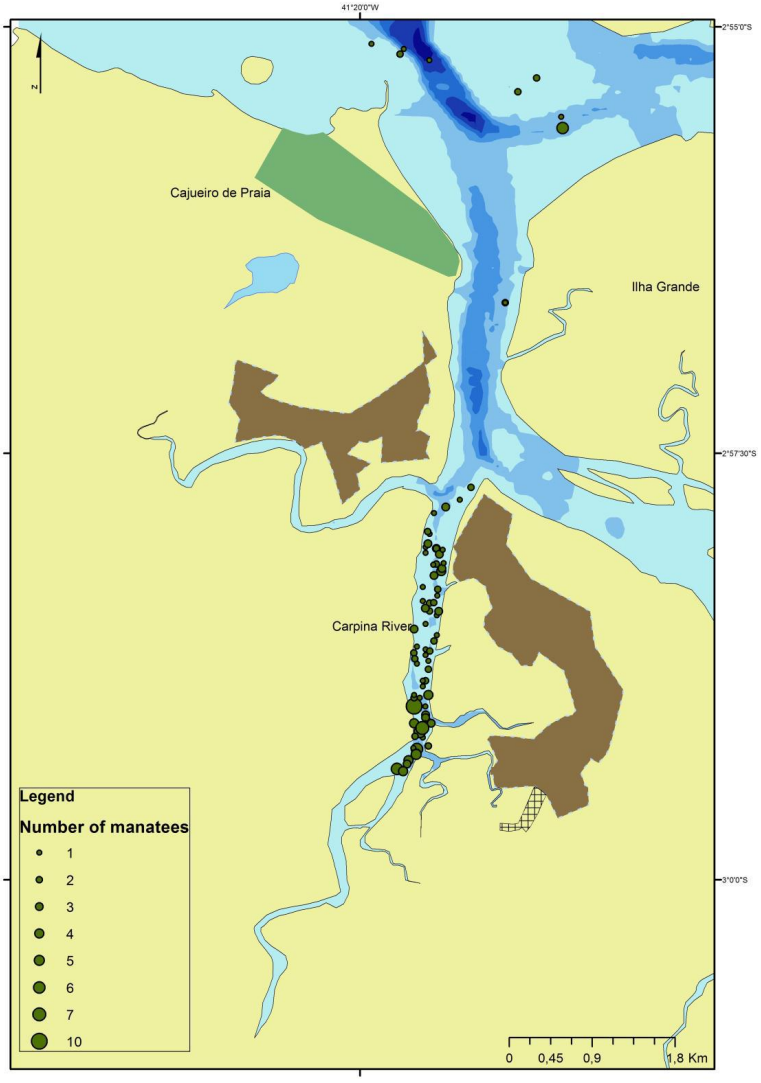
- Manatees seem to prefer shallow waters in narrow channels with seagrass beds and without the presence of nets and motor boats.

- Seagrass beds and algae banks were recorded in the study area, as observed in Table 4 (Map 3). Also, mangrove and saltmarsh are abundant in the estuary.

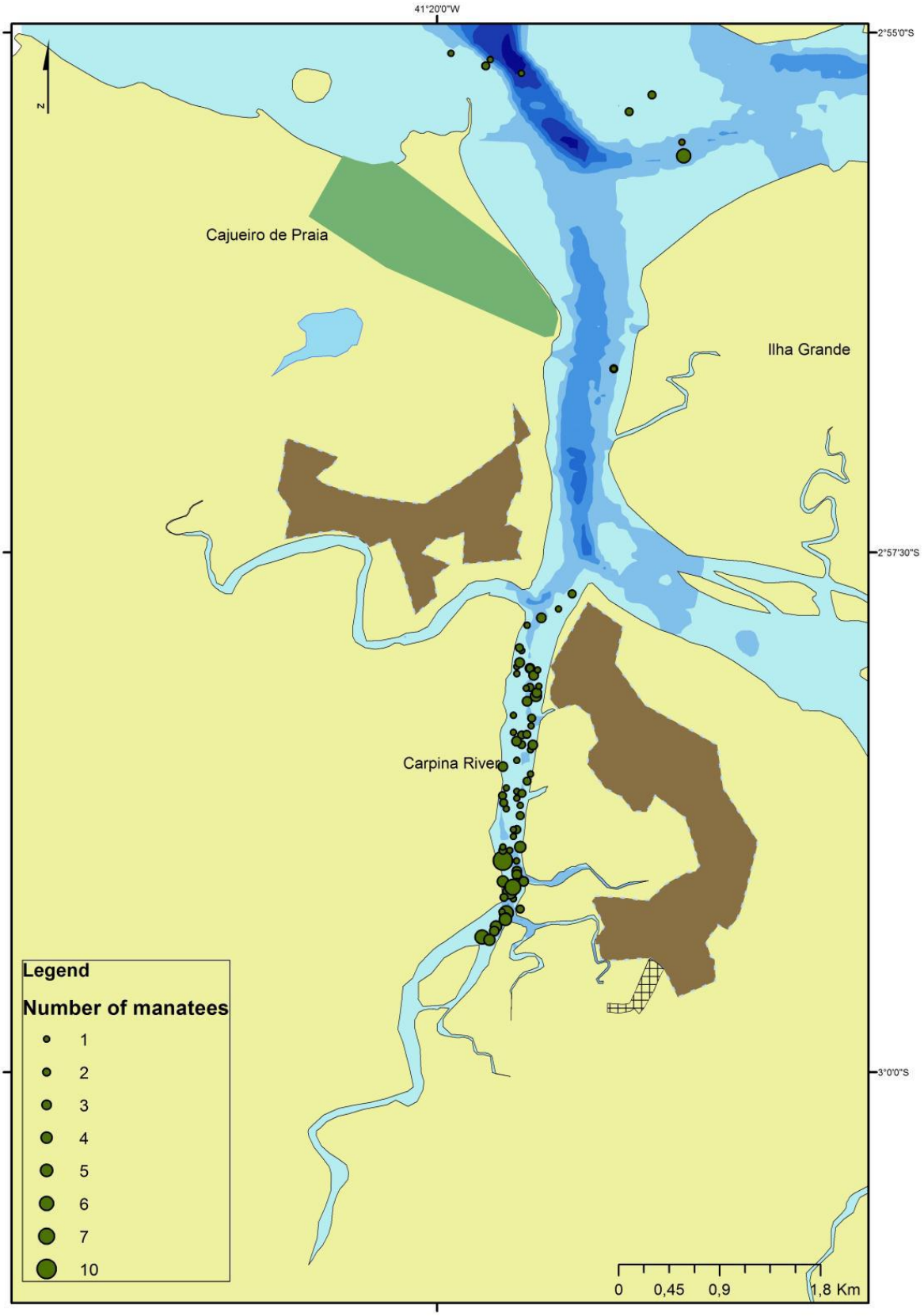
- This study reports the most recent systematic information and provide data on manatee distribution in the region, which is essential if we consider that one of the main challenges faced by this species in this area is to determine the population status. The data presented here can be used to develop management and conservation strategies to protect the species that are seriously endangered in the country.



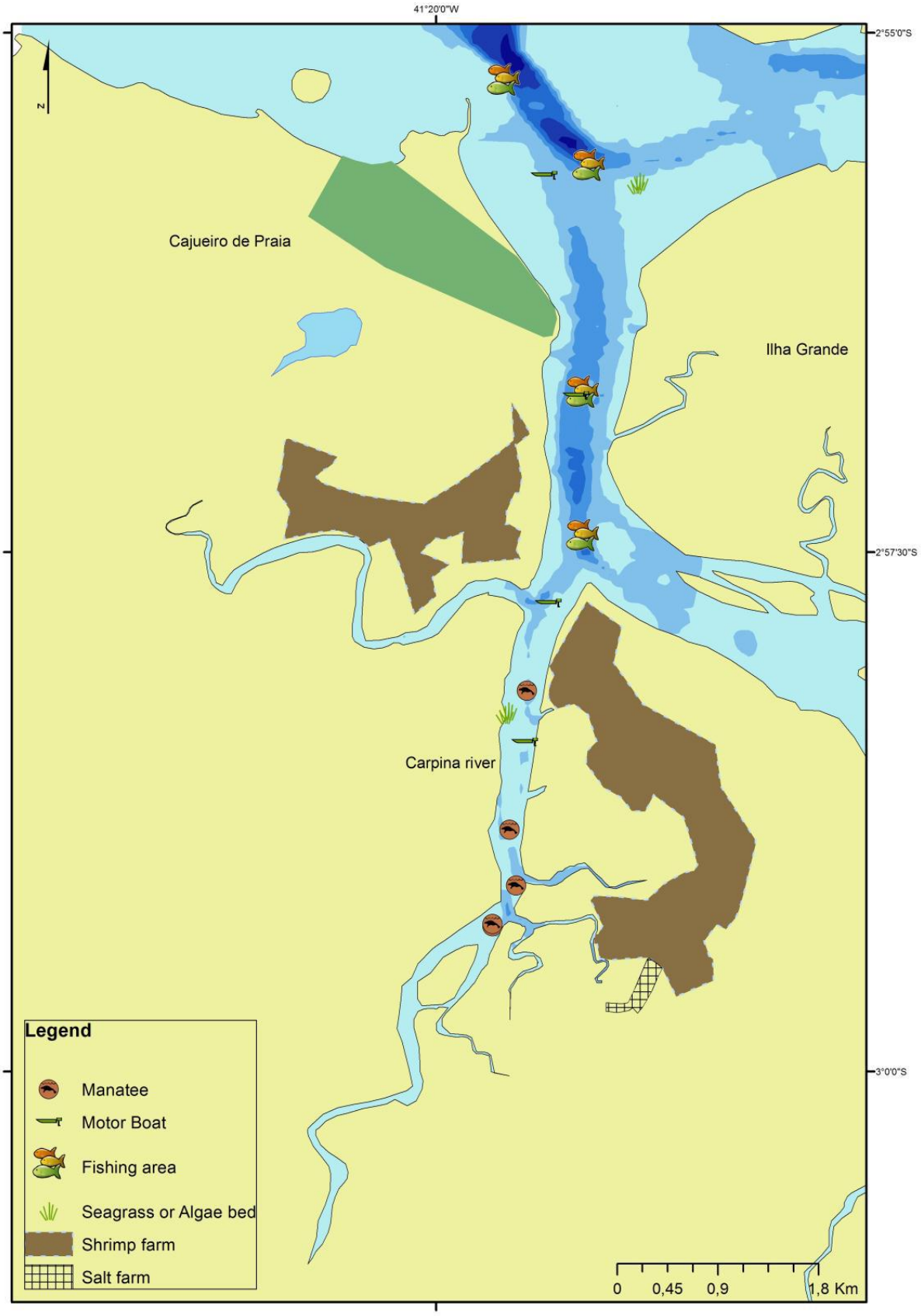
Map 1. Map of study area



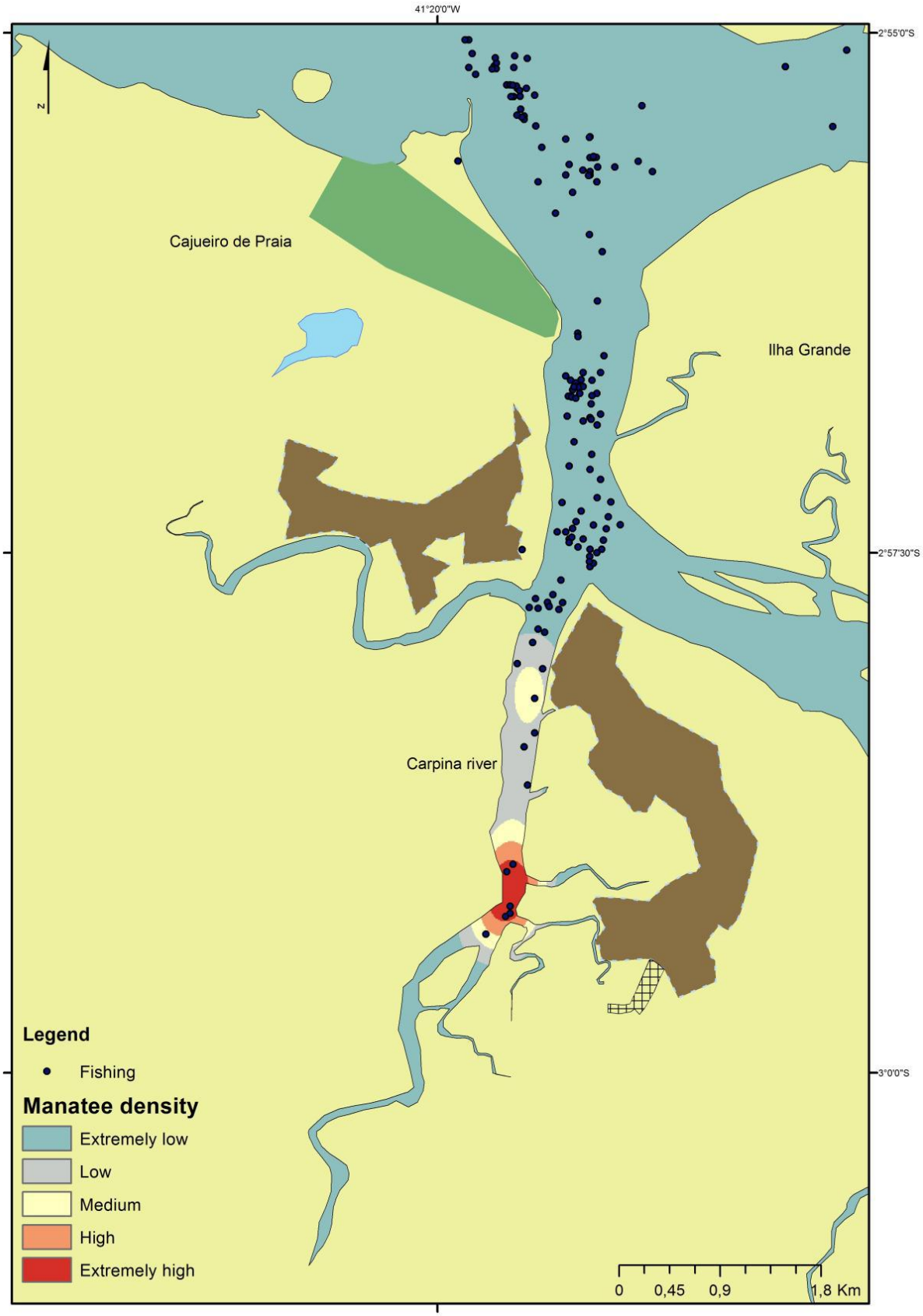
Map 2. Manatee sighting in the study area.



Map 3. Range and preferred area of manatee in the estuary.



Map 4. Anthropic impacts observed in the study area.



Map 5. Spots of fishing activity and manatee's density in the estuary.