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ARTÍCULO DE INVESTIGACIÓN / RESEARCH ARTICLE

THE ANTILLEAN MANATEE IN THE NORTH OF MARACAIBO LAKE (VENEZUELA): DISTRIBUTION, AND CONSERVATION ISSUES

El manatí antillano en el norte del Lago de Maracaibo (Venezuela): distribución y problemas de conservación

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ABSTRACT

In Venezuela, Antillean manatees (*Trichechus manatus manatus*) have declined mainly due to habitat loss and degradation, but other threats to the species persist. The objective of this work was to investigate the manatee distribution and conservation issues in Maracaibo Lake, Venezuela. Aiming to collect evidence on manatee presence, we conducted 404.14 hours of boat-based surveys and observations from the shore during 2003, 2004, 2009, and 2010. Environmental parameters were collected in areas where manatees were observed including pH, temperature, dissolved oxygen, salinity, transparency, and depth. Also, we recorded plants or algae that could serve as potential food for manatees. We developed 96 informal and opportunistic talks with local fishermen, to gather information about manatee occurrence, boat traffic, and people's perception of the species. Finally, we reviewed published and unpublished documents containing information on manatees in Maracaibo Lake. The resulting database contains information on 39 sightings and 13 reports of dead manatees. The known causes of death were poaching, vandalism, boat collision, and entanglement in fishing nets. The Maracaibo Lake offers many suitable habitats for manatees, but also faces a wide array of conservation problems that represent critical threats to this endangered subspecies. Long-term monitoring of this population and potential sources of mortality is highly needed.

Keywords: Animal Conservation, Aquatic mammals, Perception, Threats, Wild fauna

RESUMEN

En Venezuela, los manatíes de las Antillas (*Trichechus manatus manatus*) han disminuido debido a la degradación del hábitat, pero se sospecha que aún persisten amenazas para la especie, como la caza, el enmalle incidental y los atropellamientos con embarcaciones. El objetivo de este trabajo fue determinar áreas de ocurrencia y problemas de conservación del manatí en el lago Maracaibo. Llevamos a cabo 404.14 horas de muestreos visuales desde embarcación y desde la orilla en 2003, 2004, 2009 y 2010. Se recolectaron parámetros ambientales en áreas donde se observaron manatíes, incluyendo pH, temperatura, oxígeno disuelto, salinidad, transparencia y profundidad. Además, registramos plantas o algas que podrían servir como alimento potencial para los manatíes. Desarrollamos 96 entrevistas informales y oportunistas con pescadores locales, con el fin de recopilar información sobre la presencia de manatíes, el tráfico de botes y la percepción de la gente sobre la especie. Finalmente, revisamos documentos publicados e inéditos que contienen información sobre los manatíes en el lago de Maracaibo. La base de datos resultante contiene información de 39 avistamientos y 13 reportes de manatíes muertos. Las causas conocidas de muerte fueron la caza furtiva, el vandalismo, la colisión con embarcación y el enmalle en redes de pesca. El lago de Maracaibo ofrece hábitat adecuado para los manatíes, pero también enfrenta una amplia gama de problemas de conservación que representan amenazas críticas para esta subespecie en peligro de extinción. Es muy necesario realizar un seguimiento a largo plazo de esta población y de las posibles fuentes de mortalidad.

Palabras clave: Amenazas, Conservación animal, Fauna silvestre, Mamíferos acuáticos, Percepción

INTRODUCTION

Antillean manatees *Trichechus manatus* spp. *manatus* (Family Trichechidae, Order Sirenia) are herbivorous aquatic mammals inhabiting rivers, estuaries, and marine coastal areas of Mexico, Central America, South America, and the Antilles. Manatees have been threatened for centuries by anthropic-related factors such as poaching, entanglement, and habitat loss (Quintana-Rizzo and Reynolds III, 2008). For that reason, the species is listed in the Appendix I of the Convention on International Trade in Endangered Species (CITES), and the Antillean subspecies is considered Endangered by the International Union for Conservation of Nature (IUCN) (Self-Sullivan and Mignucci-Giannoni, 2008). In Venezuela, manatees are protected by the Law for the Protection of Wild Fauna, and since 1978 several legal actions have been taken to reduce manatee hunting (Rodríguez and Rojas-Suárez, 1995). By 1996, an indefinite prohibition of poaching was set up and nowadays the species is enlisted as Endangered in this country (Boede and Mujica-Jorquera, 2016). Antillean manatees have been reported in the Venezuelan states of Zulia, Apure, Sucre, and Anzoátegui (O'Shea *et al.*, 1988 Correa-Viana *et al.*, 1990); including the Orinoco River basin (Castelblanco-Martínez, 2004, Rivas-Rodríguez *et al.*, 2012), and coastal areas of the Caribbean sea (Debrot *et al.*, 2020). First interview surveys about manatee status in Venezuela permitted us to infer that an important remnant manatee population occurred in the Maracaibo Lake (O'Shea et al., 1988). The system is located at the west of the country (Montiel-Villalobos and Barrios-Garrido, 2005), and is comprised by the Gulf of Venezuela, the Tablazo Bay and the Maracaibo Strait, which connect Lake Maracaibo in the interior of the Maracaibo Basin, to the Caribbean Sea (de Meirelles *et al.*, 2018). Previous information suggests that manatee numbers in Venezuela are decreasing and it is believed that one of the major threats to the species is the loss and modification of its habitat (Quintana-Rizzo and Reynolds III, 2008). However, few studies have been dedicated to investigating the distribution, habitat quality and resources availability for the species in this South American country. The objective of this study is to improve the current knowledge on the distribution, habitat use and actual threats to the Antillean manatees in the Maracaibo Lake, Venezuela. This information would be useful to build management and conservation plans for this Endangered aquatic mammal in the country.

METHODS

Study area

The Maracaibo Lake is located in northwestern Venezuela (70° 30' - 73° 24' W and 8° 22' - 11° 51' N), and is connected to the Gulf of Venezuela by a natural channel (Laval *et al.*, 2005), which was dredged during the 1930s. Nowadays, it consists of a 100.6-km-long and a 11-metre-deep channel, navigable for oceangoing ships and tankers (Marin et al., 2022). The surface of the lake has an area of 12013 km^2, a maximum length of 155 km, from Santa Rosa coast to Punta Palmas; and a maximum width of 12 km, from Guaimito to San Lorenzo (Rodríguez, 2000). It has a relatively flat bottom of an average depth of 26 m, and a maximum depth of 34 m (Laval *et al.*, 2003). From the ecological perspective, the Maracaibo Lake basin is divided in eight regions with particular ecological features and diverse level of complexity (Medina and Barboza, 2006): (a) Gulf of Venezuela, (b) El Tablazo Bay, (c) Sinamaica Lagoon, (d) Maracaibo Strait, (e) Maracaibo Lake, (f) mouth of the rivers, (g) running waters, and (h) reservoirs. Regions a to f conform the Maracaibo system, while regions g and h include 135 permanent and intermittent rivers discharging about 40 km^3 of water yearly to the lake.

Data Collection

To compile observations on manatee presence, the area of study was divided in two zones. Zone 1 (Z1) is placed at the municipality of Almirante Padilla, located north of El Tablazo Bay. The area comprises the lacustrine archipelago encompassing five islands and eight islets. Zone 2 (Z2) at the

municipality of Miranda, on the eastern coast of Maracaibo Lake. The fieldwork was conducted during 2004 (February, Abril, July, and October) in Z1, and during 2009 (March, May, June, and July) and 2010 (May, July, August, and October) in Z2. A Relative Abundance Index (RIA) was estimated to compare among areas, expressed by the number of sightings per hour of survey effort (Martínez-Cedeira *et al.*, 2003). We made informal and opportunistic conversations with local fishermen, as well as meetings with coastal communities, aiming to gather information about manatee presence, frequency of boat traffic, and people's perception on the vessels' effect on manatees. Finally, we reviewed published and unpublished documents to compile additional data about manatee presence and mortality in the study area.

With the goal of collecting evidences on the manatee presence, we conducted visual searches applying a variety of survey methods (Aragones *et al.*, 2012). We conducted boat-based surveys following pre-designed routes (Fig. 1), using vessels equipped with outboard engines (25 hp or 400 hp) at a speed of 15 to 20 km/h. Additional, observations were made from a drifting boat with the engine off. Fixed points of observation were selected either from an anchored boat in the middle of the survey area, or from high places located at shore. Regardless the type of survey, the observations were conducted from 0600 to 1800 h; and consisted in scanning with binoculars the water surface in search of manatee evidence, such as the exposition of head, the back or the tail. Once an animal was found, its behavior (swimming, feeding, and breathing) was noted and if possible, photos or videos were taken.

We considered areas of manatee use, those informed by local inhabitants as traditional places for the species; or those in which we visually confirmed manatee presence. Those areas were described in terms of its proximity to human settlements, width of watercourses, water parameters and food availability. Water parameters obtained were pH, surface water temperature, and dissolved oxygen (with an YSI handheld multiparameter), salinity (with a refractometer), transparency (with a Secchi disk), and depth (with a portable Depth and Fish Finder, or with a graduated pole). Through boat surveys along the shore, we documented *in situ* the vernacular name of plants and algae that might be a potential food for manatees. When needed, a sample of some plants were collected in hermetic plastic bags and preserved in formalin solution at 10 %, for further identification at the laboratory of the University of Zulia.

RESULTS

We conducted a total of 407.14 h of manatee visual surveys and informal talks with 96 local inhabitants of San Carlos, San Bernardo, and Toas Islands. Through our visual surveys, we recorded 18 direct sightings of manatees with an average RIA of 0.068 sightings per hour (Table 1). Globally, we collected 39 sightings, including direct sightings (n= 18),

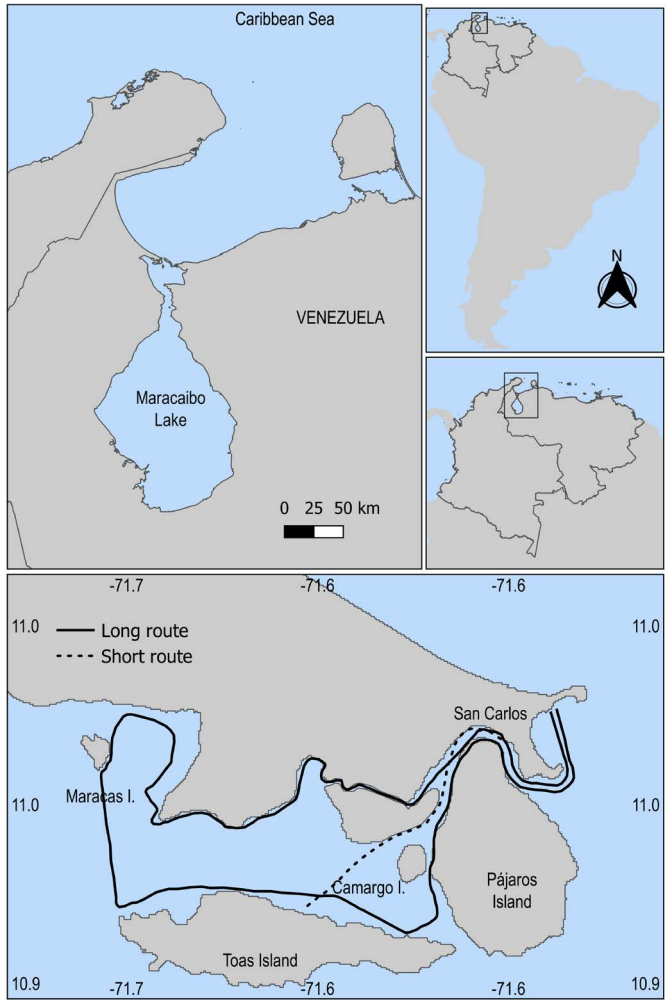

Figure 1. Routes conducted in boat in order to detect manatee

sightings reported by interviewers (n= 20), and sightings reported in published documents (n= 6).

The environmental water parameters measured in areas where manatees inhabit in Maracaibo Lake showed mean pH values of 7.53 (SD ± 1.34) (Table 2). The salinity varied between 3.2 and 12.35 %, and was greater in Z1, probably due to the constant input of seawater from the Gulf of Venezuela (Berghuis, 1995), whereas the salinity in El Tablazo bay showed lower values as consequence of the freshwater input from the Limon River. The water temperature in the Maracaibo Lake oscillated between 24 and 28 °C (average = 29.43 °C, SD ± 2.12 °C), and showed the lowest values in those areas with higher influence of tides, such as El Tablazo bay. The observed vessels that navigate the area, range from boats with small outboard engines (2 to 50 hp), medium engines (≥ 55 hp) and large diesel-based motors.

We enlisted six plant species as potential food source for manatees: *Ruppia maritima, Regnellidium diphyllum, Lemna* sp., and three species of mangrove: *Rhizophora mangle*, *Laguncularia racemosa* and *Avicennia germinans*. Also, we identified four

invertebrates associated as potential manatee food: *Polymesoda solida* (Fam. Corcubilidae), *Mytella maracaibensis* (Fam. Mytilidae), *Crassostrea rhizophorae* (Fam. Ostreidae), *Balanus anphitrite* (Fam. Balanidae).

We compiled 13 cases of manatee strandings in a span of 12 years (Table 3). All of them were found dead or died as a result of stranding. Four manatees were harpooned likely to consume their meat or to trade their meat, two were found entangled in fishing nets, and two were killed due to collision with boats. At least two manatees were killed intentionally by people with apparently no intentions of eating or trading it: in the first case (2004), a manatee was found with injuries caused by a sharp object; and in the second case (2009) a manatee was shoot by an unidentified person. The cause of death for other two individuals remain unknown. The map (Fig. 2) depicts the distribution of manatees in the study area according to our field observations and previous reports.

Table 1. Sightings of Antillean manatees in the North of Maracaibo Lake, Venezuela

ID	Date	Locality	# of ind	Method	Source
1	05/1998	Limon River	1	Literature review	Montiel-Villalobos & Barrios-Garrido 2005
2	10/2009	Isla Maraca	1	Literature review	Montiel-Villalobos & Barrios-Garrido 2005
3	01/2000	Caño Los Pericos	1	Literature review	Montiel-Villalobos & Barrios-Garrido 2005
4	04/2000	Sinamaica	1	Literature review	Montiel-Villalobos & Barrios-Garrido 2005
5	05/2000	Isla Toas	1	Literature review	Montiel-Villalobos & Barrios-Garrido 2005
6	07/2001	Ciénaga Los Olivitos	1	Literature review	Montiel-Villalobos & Barrios-Garrido 2005
7	04/2004	Recorrido corto	1	Boat surveys	This study
8	07/2004	Isla Camargo	1	Boat surveys	This study
9	08/2004	Castillo San Carlos	1	Fixed Point	This study
10	10/2004	Cerro La Cruz	1	Fixed Point	This study
11	12/02/2004	Isla San Carlos	4	Opportunistic talks	This study
12	18/02/2004	Isla San Carlos	1	Opportunistic talks	This study
13	25/02/2004	Isla San Carlos	1	Opportunistic talks	This study
14	02/03/2004	Isla San Carlos	1	Opportunistic talks	This study
15	03/03/2004	Isla San Carlos	1	Opportunistic talks	This study
16	09/03/2004	Isla San Carlos	1	Opportunistic talks	This study
17	20/03/2004	Isla San Carlos	1	Opportunistic talks	This study
18	12/04/2004	Isla San Carlos	1	Opportunistic talks	This study
19	15/04/2004	Isla San Carlos	2	Opportunistic talks	This study
20	19/04/2004	Isla San Carlos	1	Opportunistic talks	This study
21	15/06/2004	Isla San Carlos	2	Opportunistic talks	This study
22	22/06/2004	Isla San Carlos	1	Opportunistic talks	This study
23	13/07/2004	Isla San Carlos	2	Opportunistic talks	This study
24	15/07/2004	Isla San Carlos	3	Opportunistic talks	This study
25	15/08/2004	Isla San Carlos	1	Opportunistic talks	This study
26	22/08/2004	Isla San Carlos	1	Opportunistic talks	This study
27	31/08/2004	Isla San Carlos	1	Opportunistic talks	This study
28	28/09/2004	Isla San Carlos	2	Opportunistic talks	This study
29	20/10/2004	Isla San Carlos	1	Opportunistic talks	This study
30	22/10/2004	Isla San Carlos	3	Opportunistic talks	This study
31	08/03/2009	El Tanque	1	Fixed Point	This study
32	12/05/2009	El Tanque	1	Fixed Point	This study
33	08/06/2009	El Tanque	3	Fixed Point	This study
34	09/06/2009	Cerro La Cruz	1	Fixed Point	This study
35	16/07/2009	Cerro La Cruz	2	Fixed Point	This study
36	11/05/2010	El Tanque	1	Fixed Point	This study
37	29/07/2010	El Tanque	1	Fixed Point	This study
38	20/08/2010	Cerro La Cruz	1	Fixed Point	This study
39	04/10/2010	Cerro La Cruz	3	Fixed Point	This study

Table 2. Environmental characteristics of water in areas frequented by manatees in Maracaibo Lake

Month	Year	Zone	Temp. (°C)	pH	Salinity %	Diss. O2 mg/L	Transp. (m)
February	2004	1	28.00	5.00	3.50	5.48	0.48
April	2004	1	27.80	5.00	3.50	5.38	0.46
July	2004	1	24.00	6.00	3.30	6.20	0.35
October	2004	1	27.00	6.00	3.20	6.13	0.33
March	2009	2	30.00	8.32	6.00	---	---
May	2009	2	29.00	7.29	7.50	---	---
June	2009	2	30.60	8.00	10.00	---	---
July	2009	2	30.95	8.51	8.00	---	---
October	2009	2	30.70	8.72	10.00	---	---
December	2009	2	29.18	8.27	5.91	---	---
April	2010	2	30.26	8.58	9.10	---	---
May	2010	2	29.19	8.03	11.17	---	---
July	2010	2	31.53	8.80	10.50	---	---
August	2010	2	32.70	8.13	12.35	---	---
October	2010	2	30.57	8.35	5.87	---	---
Mean	29.43	7.53	7.33	5.80	0.41		
Standard Deviation			2.12	1.34	3.12	0.43	0.08
Max			32.70	8.80	12.35	6.20	0.48
Min			24.00	5.00	3.20	5.38	0.33

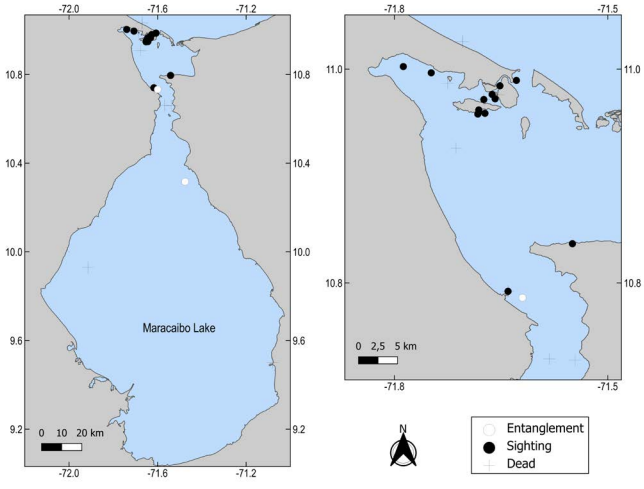

Figure 2. Antillean manatees (sighting and dead reports) in the Maracaibo Lake (Venezuela)

DISCUSSION

Occurrence and distribution

Ten hours of aerial surveys conducted by O'Shea et al. (1988) over Maracaibo Lake region resulted in only one tentative sighting of a manatee. Years later, Montiel-Villalobos and Barrios-Garrido, 2005) reported other areas of use by the species. After those previous reports, we made active and passive searching of manatees by boat survey and obtained additional observations of manatees in the Maracaibo Lake region.

To avoid biases due to differences between the two sampling periods, we do not aim to perform any comparative analysis. Therefore, our analysis is only descriptive. The Maracaibo Lake system present interesting ecological characteristics, that makes it a suitable habitat for manatees. The lake offers sheltered areas, with small effect of waves and winds, characteristics preferred by manatees, especially for resting and calving (Áxis-Arroyo *et al.*, 1998). We evidenced the presence of abundant vegetation all year round, including mangroves and algae. The Maracaibo Lake is surrounded by an extensive coastal flat, with abundant sand beaches and channels bordered by mangrove islands composed by *Rhizophora mangle, Avicennia germinans* and *Laguncularia racemosa*. The observed aquatic and semiaquatic plants, have been reported as part of manatee diet in other localities of their distribution (Castelblanco-Martínez *et al.*, 2009, Borges *et al.*, 2008, Navarro-Martínez *et al.*, 2014, Allen *et al.*, 2017).

The salinity fell within the range accepted by the Antillean manatees, which move between salty, estuarine, and freshwater environments. The salt water flux to the Gulf of Venezuela, however, is not constant along the year, being greater during the dry season (December – May) and lesser during the rainy season (May – November) (Laval *et al.*, 2005), influenced by changes of precipitation and tide regime. Since manatees are required to drink freshwater every certain days (Ortiz *et al.*, 1998), they prefer coastal areas because are associated to

Table 3. Cases of manatees Trichechus manatus manatus stranded in the Maracaibo Lake between 1997 and 2009.

ID	Date	Locality	Sex	Age	Cause of dead	Source
1	09/1997	Isla Dorada	---	---	Poaching	Montiel-Villalobos & Barrios-Garrido 2005
2	09/1997	Isla Dorada	---	---	Entanglement	Montiel-Villalobos & Barrios-Garrido 2005
3	08/1998	La Candelaria	---	---	Entanglement	Montiel-Villalobos & Barrios-Garrido 2005
4	11/2000	Barranquitas	---	---	Poaching	Montiel-Villalobos & Barrios-Garrido 2005
5	04/2001	Puertos de Altagracia	---	---	Poaching	Montiel-Villalobos & Barrios-Garrido 2005
6	03/2001	Cienaga Juan Manuel	---	---	Poaching	Montiel-Villalobos & Barrios-Garrido 2005
7	05/2001	Isla Maraca	---	---	Boat collision	Montiel-Villalobos & Barrios-Garrido 2005
8	06/2001	Caño Pájaros	---	---	Boat collision	Montiel-Villalobos & Barrios-Garrido 2005
9	03/2003	Golfo de Venezuela	Male	Adult	Unknown	This study
10	19/07/2003	Golfo de Venezuela	Male	Adult	Boat collision	This study
11	2004	Santa Rosas de Aguas	Female	Calf	Vandalism (kniffe)	This study
12	2006	El Moján	---	Adult	Unknown	This study
13	09/08/2009	La Cañada, Isla Dorada	Male	Adult	Vandalism (shooting)	This study

rivers (Áxis-Arroyo *et al.*, 1998). The sources of freshwater for manatees in the Maracaibo Lake are abundant, due to the large quantity of rivers feeding the lake system. One example of this is the Limon River, which provide an important input of freshwater to the system. Manatees are mainly found in warm water areas (> 20 °C, Bossart *et al.*, 2003), due to their incapacity to withstand low temperatures (Laist *et al.*, 2013). Therefore, the temperature values of the study area fell within the range of ideal water temperature for the species.

During our boat-surveys, we observed extensive meadows of subaquatic vegetation at less than 1m deep, mainly at the margins of channels. However, few species were recorded probably due to the small survey effort. We recommend conducting a more comprehensive aquatic and semi-aquatic vegetation assessment. Local people claimed to see manatees foraging and feeding on these meadows, particularly in Toas Island during high tide, where the animals could approach them. It is interesting to note that in both Toas Island and San Carlos, there are artificial constructions made of concrete to support docks, which serve as substrate for the growing of micro and macro algae. These substrates offer nutriment for local manatees.

Threats to manatees and their habitat

The economy of the localities of Toas Island, San Carlos Island and Sabaneta de Palmas are based on small fishery activities. Additionally, several touristic developments have been built along the shore receiving an important affluence of tourists. Thus, boat traffic is constant during the year, with hundreds of boats transiting simultaneously. The traffic of vessels could be an important disturbance factor for manatees, as has been widely reported that the species prefers areas with low anthropic presence (e.g. Jiménez-Perez, 2005). Vocal communication seems to play a critical role for manatee survival, particularly in habitats where the vision is reduced due to high turbidity, in murky coastal or riverine waters (Sousa-Lima *et al.*, 2002). Noise caused by boat engines can interfere with manatee acoustic communication by masking signals that contain biologically important information (Miksis-Olds *et al.*, 2007). If the number of boats increases without control, a probable consequence could be a modification in habitat selection by manatees for such activities as resting or calving. Additionally, boat-related accidents are considered one of the most important threats to manatees in Florida (Bauduin *et al.*, 2013), Belize (Galves *et al.*, 2023), Puerto Rico (Mignucci-Giannoni *et al.*, 2000), and Brazil (Borges *et al.*, 2007). Our compilation of manatee mortality cases (Table 2) includes four events of manatees killed by boat collision in the region of Maracaibo Lake. It is expected that the boat-related mortality will increase if the traffic of boats is not controlled either by limiting the number of vessels, or by the implementation of slow speed, no-wake zones.

Another worrisome threat to manatees in the study area, was the vandalism. Although these events occurred more than a decade ago, it would be interesting to follow-up the perceptions and feelings of local inhabitants regarding manatee conservation. Besides direct threats to manatees, several environmental pressures jeopardize the habitat for the species in the region of the Maracaibo Lake, such as intense and long-term activities of agriculture, mining, and oil exploration that have produced important runoff of contaminants to the wetlands (Corona-Lisboa, 2013, Moronta-Riera and Riverón-Zaldívar, 2016). Also, dredging and sedimentation cause severe damages on the structural and environmental properties of the estuaries, leading to hyper-eutrophication of the waterbodies and the subsequent of high phytoplankton growth and low oxygenation levels (Rivas *et al.*, 2011). As a consequence of the dredging navigation channels to facilitate the transit of large vessels, the salinity inside the system has increased significantly with time (Berghuis, 1995). This may cause critical variations in the benthic community composition of the system

(Hernández-Arana and Ameneyro-Angeles, 2011), including changes in the availability and composition of feeding resources for manatees (Medina *et al.*, 2001).

CONCLUSIONS

This work reviews and compiles information about Antillean manatees in the Maracaibo Lake and highlights several important factors that can be detrimental to the survival of the species in this area. We strongly recommend establishing a long-term monitoring of the manatee population inhabiting this area, which should include:

1. Abundance and occurrence surveys, including novel methodological approaches such as drones, side-scan sonars, and environmental DNA.
2. Habitat quality monitoring, including the assessment of quality and quantity of feeding resources for manatees.
3. Threats and human impact monitoring; including boat traffic.
4. Community engagement. Successful management plans towards the conservation of charismatic and endangered species must include a strong community involvement. Ideally, citizen science programs should be implemented.

AUTHORS PARTICIPATION

AM-F: Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing – Original draft, Supervision, Funding acquisition. **AVPdeV:** Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing – Original draft. **NC-M:** Conceptualization, Methodology, Formal Analysis, Data Curation, Writing – Original draft, Supervision. **JH:** Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing – Reviewing and editing, Supervision. **AES:** Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing – Reviewing and editing, Supervision. **RM-A:** Formal Analysis, Data Curation, Data visualization, Writing – Reviewing and editing.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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