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research paper

Status and conservation of manatees in Cuba: historical observations and recent insights

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ABSTRACT.—The Antillean manatee (*Trichechus manatus manatus* Linnaeus, 1758) is classified as endangered by the International Union for Conservation of Nature because of reduced numbers and habitat loss. Existing information about this species in Cuba is limited, but it can be synthesized into useful guidance for strategies to protect and rehabilitate this population. Anthropogenic threats have been reported to have had detrimental effects on manatees since 1970, with a major factoring being illegal hunting. Information obtained through interviews of fishers, and boat and aerial surveys has identified the Ensenada de la Broa and Hatiguanico River on the Zapata Peninsula as important areas for manatees. Historically, manatees frequented rivers and other freshwater habitats, but currently they are encountered primarily in estuarine and coastal waters, which makes availability of fresh water an important consideration. There is a pressing need to gather additional and more reliable data on the abundance, distribution, and health of Antillean manatees in Cuba as a basis for more effective and efficient initiatives to protect and rehabilitate this population.

The distribution of the Antillean manatee (*Trichechus manatus manatus* Linnaeus, 1758) is fragmented, with populations separated by large expanses of ocean and many possibly declining due to persistent, anthropogenic threats (Marsh et al. 2011). An important population of this subspecies inhabits Cuba, where rivers and shallow, sheltered, coastal waters with dense and widely distributed seagrass meadows provide suitable habitat (Alcolado 2006).

Manatees have long been reported to occur along both the north and the south coasts of the island (Thornback and Jenkins 1982), though declines in the population were reported as early as 1866 (Cuni 1918). In 1909, President Theodore Roosevelt spearheaded an initiative to pass legislation protecting the Antillean manatee in Cuba (Decreto 63/1909). Nevertheless, Varona described the status of manatees in Cuba in 1975 as rare and declining at an "alarming" rate, which was attributed to pollution and hunting (cited by Lefebvre et al. 2001). Manatees in Cuba have been protected under the Fishery Decree-Law 164 since 1996, with penalties for violations related to the capture, manipulation, and use of this and other endangered marine species (Decreto de Ley 164/1996). More recently, the Ministerio de Ciencia Tecnología y Medio Ambiente (CITMA) enacted Resolution 160/2011 that listed manatees as a Species with Special Significance for the country (Resolución 160/2011). Regionally, the Antillean manatee is classified as endangered by the International Union for Conservation of Nature (IUCN) because the populations are predicted to undergo a decline of >20% over the next two generations unless effective conservation actions address habitat loss, hunting, entanglement in fishing gear, and collisions with boats (Deutsch et al. 2008, Marsh et al. 2011).

Despite historical declines in Cuba's manatee population, the current status of manatees in this nation remains ambiguous due to limited and relatively inaccessible scientific information. Because past research and conservation efforts have been sporadic and poorly documented, our objective was to synthesize available information from Cuba and the surrounding region as a basis for future research and conservation. We focused on historical habitat use, fishers' perceptions regarding threats to manatees, surveys that document the occurrence and distribution of manatees, available information about movements of individuals, and connectivity among regional populations inferred from sightings, tagging, and genetics.

Historical Occurrence, Distribution, and Use

Anecdotal accounts of manatees in the Greater Antilles suggest that Cuba harbored and sustained a substantial population (reviewed in Lefebvre et al. 2001). Twenty-eight Pre-Columbian archeological sites dating as far back as 1140 BP confirm the island-wide presence and anthropogenic exploitation of manatees (Fig. 1; Gates 1954, Jiménez-Vázquez 2015). Archeological sites containing manatee remains are concentrated in eastern Cuba, where freshwater sources are most abundant (Jiménez-Vázquez 2015). The earliest accounts of subsistence hunting suggest that aborigines mainly pursued manatees in rivers by using tethered remoras (de Sola 1932) to aid in capture (Fernández de Oviedo 1520 as referenced in Cuni 1918). This technique was very common in Cuba, Hispaniola, and Jamaica, and it also was used to capture marine turtles (de Sola 1932). Other historical accounts documented Spaniards hunting manatees using crossbows (Cuni 1918), and Gundlach described manatees as very abundant before 1877 (in Lefebvre et al. 2001).

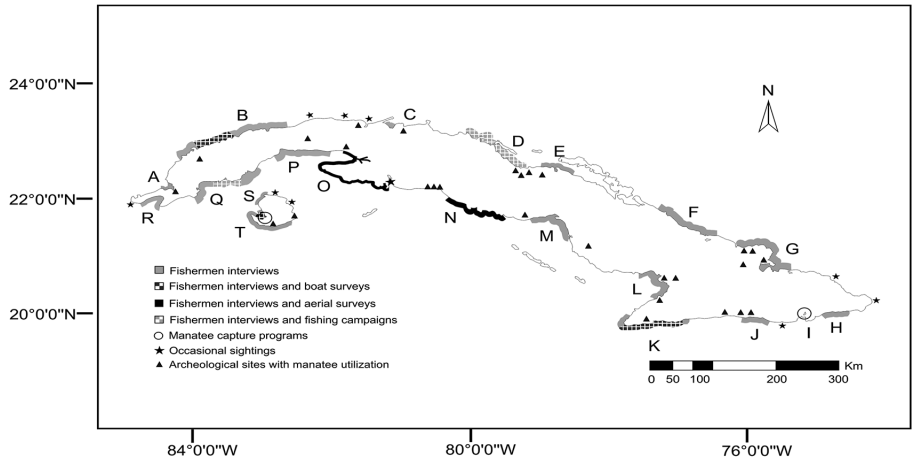

Figure 1. Areas where manatees were reported as present during interviews of fishers or where manatees were observed during aerial surveys, boat-based surveys, fishing campaigns, and programs that captured, tagged, and assessed the health of manatees. A = Bahía de Guadiana, B = Puerto Esperanza–Mariel, C = Bahía de Cárdenas, D = Carahatas-Caibarién, E = Turiguano, F = Bahía de Nuevitas–Bahía de Puerto Padre, G = Gibara–Cayo Saetía, H = Baitiquirí, I = Bahía de Guantánamo, J = San Miguel de Parada, K = Cabo Cruz–Ensenada de Mora–Marea del Portillo, L = Golfo de Guacanayabo, M = Golfo de Anamaria, N = Casilda–Tunas de Zaza, O = Ensenada de la Broa–Río Hatiguanico, P = Majana-Batabano, Q = Cortez–La Coloma, R = Golfo de Guanahacabibes, S = Punta de los Barcos, T = Siguanea–Punta del Este.

Historically, manatees exhibited a strong affinity for rivers and other sources of freshwater over marine areas, in particular the Hatiguanico River in Matanzas and the Agabama and Manatí rivers in Sancti Spiritus (Cuni 1918). Cuni (1918) also reported that aquatic plants comprised the bulk of manatee's diets, although animals also fed on riparian vegetation by partially lifting their bodies out of the water.

Over the last 65 yrs, Cuban manatees have been captured and held in captive and "semi-captive" conditions in aquariums, zoological parks, and natural areas. In 1954, Parque Zoológico de La Habana captured two manatees for display during expeditions in Zapata Swamp (Ciénaga de Zapata) and Matanzas Province (Zoológico 1954), and during the 1980s, Acuario Nacional de Cuba held one manatee taken from Zapata Swamp and two manatees taken from Batabanó, Mayabeque Province [M Blanco, Acuario Nacional de Cuba (retired), pers comm]. In the early 1960s, an attempt to preserve the species involved keeping 45 manatees in wooden corrals at the mouth of the Hatiguanico River in the Zapata Swamp for 30 mo (A Hurtado, unpubl data). In 1964, six of these manatees (two males and four females) were translocated 60 km to Laguna del Tesoro, a nearby freshwater lake that averages 4 m in depth and has a surface area of approximately 900 ha. Manatees were not present in this system prior to this introduction because it is not connected to the ocean (A Hurtado, unpubl data). In 1990, this lake received additional manatees taken from Villa Clara and Varadero along the northern coast of Cuba, and in 1991, 20 manatees were identified during boat surveys (A Hurtado, unpubl data). In subsequent years, the numbers of manatees in this lake decreased because of hunting and collisions with watercraft, and by 2010, the lake was estimated to hold only five manatees (A Hurtado, unpubl data).

Table 1. Areas where fishers encountered manatees as reported in six sets of interviews conducted between 1987 and 2010. CIM-UH = information collected by Centro de Investigaciones Marinas, University of Havana, ENPFF = information collected by Empresa Nacional para la Protección de la Flora y la Fauna, * = unpublished. ** = interviews conducted on fishing boats usually including multiple fishers. Letters (in parentheses) correspond to the geographic location of areas of interest in Figure 1.

Interviewer and years	Estrada and Ferrer 1987	Estrada and Ferrer 1993*	CIM-UH 2003–2006	ENPFF 1990–2003, 2007	Escalona 2006	Alvarez-Alemán 2010
Geographic extent in Cuba	West	All	Northwest/ southeast	West/ southeast	Granma	Isla de la Juventud
Number of interviews	51	301	212	Unknown (52 for Villa Clara Province)	325	11 boats**
Primary source of mortality	Fishing nets	Fishing nets	Poaching (northwest), natural causes (southeast)	Fishing nets (Carahatas–Caibarién)	Natural causes	Poaching
Ensenada de Guadiana (A)	X	X		X		
Mariel (B)			X			
Bahia Honda (B)			X			
La Mulata (B)			X			
Palma Rubia (B)			X			
Puerto Esperanza (B)	X	X	X	X		
Bahia de Cardenas (C)		X				
Carahatas-Caibarien (D)		X		X		
Turiguano (E)		X				
Nuevitas–Puerto Padre (F)		X				
Gibara–Cayo Saeitia (G)		X				
Baitiquiri (H)		X				
San Miguel de Parada (J)			X			
Ensenada de Mora–Marea del Portillo (K)		X	X	X	X	
Cabo Cruz (K)				X	X	
Golfo de Guacanayabo (L)		X		X		
Golfo de Anamaria (M)		X				
Casildas Tunas de Zaza (N)		X		X		
Ensenada de la Broa–Río Hatiguanico (O)	X	X	X	X		X
Majana-Batabano (P)			X			
Cortes–La Coloma (Q)	X			X		X
Golfo de Guanahacabibes (R)	X			X		
Punta de los Barcos (S)						X
Siguanea–Punta del Este (T)		X		X		X

Interviews

Interviews with fishers and coastal residents currently represent the most extensive source of information about manatees in Cuba, with six reports being completed between 1987 and 2010 by multiple Cuban agencies (Tables 1, 2). All the interviews focused on distribution, abundance, behavior, diet, and threats, although the questions were not standardized across surveys.

Table 2. Sightings of manatees in five coastal areas around Cuba. CIM-UH = Centro de Investigaciones Marinas, University of Havana, MINTUR = Ministerio de Turismo, ENPFF = Empresa Nacional para la Protección de la Flora y la Fauna. Effort = number of hours for boat-based surveys and number of years for collaboration with fishers, Encounters = number of hours for boat-based surveys and number of years for collaboration with fishers.

Area	Technique	Years	Effort	Encounters	Source
Refugio de Fauna Ciénaga de Lanier (wildlife refuge)	Boat-based surveys	2007–2013	467.0	0.20	Alvarez-Alemán et al. 2017
Parque Nacional Desembarco del Granma (national park)	Boat-based surveys	2012–2013	833.0	0.05	Alvarez-Alemán et al. 2014
Cayo Levisa, Pinar del Río Province	Boat-based surveys	2009	5.6	1.80	Figueredo and Pina 2009
Cayo Levisa, Pinar del Río Province	Boat-based surveys	2012–2013	18.0	0.20	A Alvarez-Alemán unpubl data
Parque Nacional Cayos de San Felipe (national park)	Collaboration with fishers	2011–2013	3.0	31.00	Alvarez-Alemán et al. 2014
Refugio de Fauna Lanzanillo-Pajonal-Fragoso (wildlife refuge)	Collaboration with fishers	2002–2016	15.0	11.00	E Garcia Alfonso unpubl data

Estrada and Ferrer conducted two sets of interviews (Table 1, Fig. 1). They interviewed 51fishers from five coastal communities in western Cuba, and all interviewees reported encountering manatees (Estrada and Ferrer 1987, Table 1, Fig. 1). In general, respondents had observed few mortalities, but 52% of them listed entanglement in fishing nets as the most frequent cause of mortality. In 1993, Estrada and Ferrer conducted additional interviews with 301 fishers across Cuba, and net entanglement again was identified as the primary cause of mortality, albeit an uncommon occurrence [A Estrada, Ministerio de la Agricultura (retired), unpubl data; Table 1, Fig. 1; Lefebvre et al. 2001]. Estrada and Ferrer (1987) also speculated that manatees in Cuba had likely shifted from riverine to marine habitats because of ecological changes that included increased turbidity due to erosion of deforested regions. In addition, many rivers were dammed during the 1980s, resulting in reduced access to upstream habitats, decreased freshwater flows, and increased salinities at river mouths (Claro et al. 2001), but responses of manatees to these changes remain undetermined.

The Empresa Nacional para la Protección de Flora y Fauna (ENPFF) conducted sporadic sets of interviews in the western and southeastern parts of Cuba between 1990 and 2007, but the results were not consolidated and published [JA Santos, Empresa para la Protección de la Flora y la Fauna (deceased), unpubl data; Table 1, Fig. 1]. Information from the Villa Clara Province (Carahatas-Caibarién) was the most useful, with 53% of fishers reporting that manatees drowned when they became entangled in trawls and other nets.

Between 2003 and 2006, researchers affiliated with Centro de Investigaciones Marinas at the University of Havana (CIM-UH) conducted interviews with 212 fishers (104 in the southeast and 108 in the west; R Fernandez, University of Turku, unpubl data; Table 1, Fig. 1). Results from the western region indicated that hunting, drowning after entanglement in trawls and other nets, and contamination were common threats. This was the first modern effort to report hunting as an important cause of mortality. These causes of mortality were not mentioned as frequently in the southeastern part of the country, which could point to a reluctance to provide potentially incriminating information.

Escalona (2006) interviewed 325 fishers and residents from a coastal community in Granma province in southeast Cuba (Table 1, Fig. 1). Interactions with manatees

were reported by 75% of those interviewed, with 98% affirming that manatees die mostly from natural causes and that poaching does not occur because the species is protected under the law.

Alvarez-Alemán (2010) conducted participatory interviews with crews from 11 fishing boats during their fishing campaigns near Isla de la Juventud in southwest Cuba (Table 1, Fig. 1). Some of these fishers perceived poaching as uncommon prior to 1990 because the economic environment was better and fishing communities received more support from the government. However, these fishers reported an increase in poaching when economic conditions worsened (Alvarez-Alemán 2010).

From these six reports, we can make four key generalizations. Firstly, the occurrence of manatees in the Hatiguanico River, Zapata Peninsula (Fig. 1) was highlighted in five reports, suggesting that this area was an important region for manatees. Secondly, poaching, fishing nets, and natural causes were reported as the most common causes of mortality for manatees. Thirdly, entanglement in fishing nets was reported as a cause of mortality since the 1980s, but poaching was emphasized as a substantial threat only in interviews conducted after 2000 (Table 1). If this trend is real, it could reflect economic hardships that affected Cuba since the 1990s (Mesa-Lago 1998), which may have driven people to illegally harvest manatees as an alternative source of protein. Fourthly, anthropogenic causes of mortality were reported most often in western Cuba, and natural mortality was perceived as being predominant by people in the east. This latter perception could be related to fewer interactions with manatee carcasses, hence the assumption that manatees die of natural causes. Further studies could determine if interactions are less common because manatees are less abundant in the east due to a lack of habitat or because areas used by manatees do not overlap with fishing zones. Another possibility is that people from eastern Cuba are not as open about their experiences because they fear repercussions if implicated in the death of a manatee. Overall, repeated evidence of accidental mortality as bycatch and illegal hunting raise concerns about the survival of Cuban manatees.

Field Surveys

Field surveys eliminate some of the potential biases associated with informal interviews, but they are more challenging and expensive. Nevertheless, a limited number of aerial and boat surveys have been conducted over the past 30 yrs (O'Shea et al. 1995, Morales-Vela et al. 2000, Edwards et al. 2007). From 1985 to 1987, Carlos Wotzkow, former biologist at Museo de Historia Natural de Cuba, conducted opportunistic surveys of manatees during flights to document forest fires. The surveys covered parts of the Zapata Peninsula (specifically Ensenada de la Broa and the Hatiguanico River) and estuaries and rivers along the south coast of Sancti Spiritus [Fig. 1; C Wotzkow, Museo de Historia Natural de Cuba (retired), unpubl data]. In Ensenada de la Broa and the Hatiguanico River, Wotzkow noted large numbers of fishing nets in places where manatees were sighted (C Wotzkow, unpubl data). In June 1992, Alberto Estrada conducted surveys targeting manatees in Ensenada de la Broa, the Hatiguanico River, Laguna del Tesoro, and for the first time, the southern Zapata Peninsula [A Estrada, Ministerio de la Agricultura (retired), unpubl data]. More manatees were sighted in the 1980s, but the area covered by these surveys was larger. While not directly comparable, the estimates of 4.2, 6.2, and 6.8 manatees

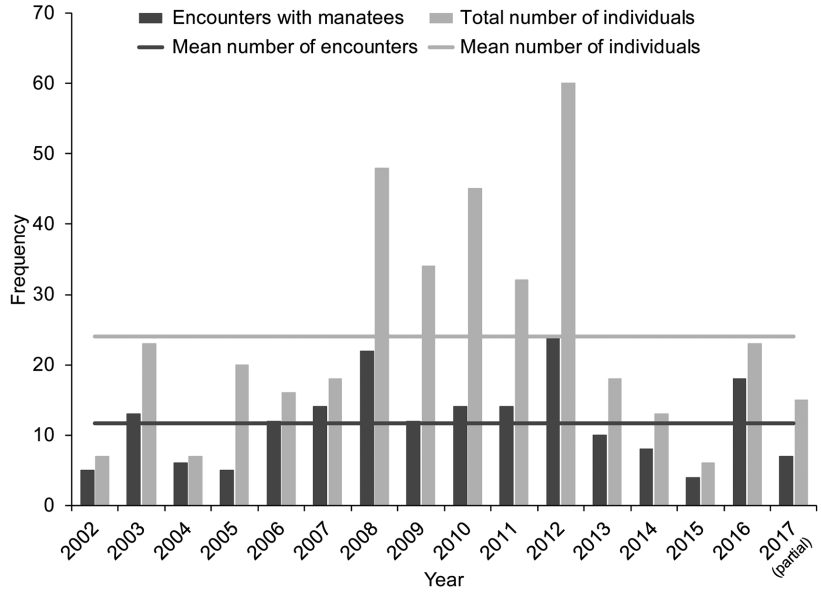

Figure 2. Summary data for reports by fishers from Villa Clara Province on the northern coast of Cuba. Note data for 2017 are for part of the year.

sited per hr were low compared to estimates obtained for Chetumal Bay and Belize during flights in January and May 1994 and January 1995 (23.3, 17.3, and 14.3 manatees per hr, respectively; Morales-Vela et al. 2000).

Managers of marine protected areas (MPAs) have collaborated with local fishers to record encounters with manatees. For example, the Lanzanillo Pajonal Fragoso Fauna Refuge and the Cayos de San Felipe National Park have employed this approach within their boundaries (areas D and P in Fig. 1, respectively; Table 2). Since 2002, 385 manatees have been sighted in 188 encounters in northern Villa Clara, with an average of 12 encounters and 24 manatees reported per yr (Fig. 2). These data also indicate more encounters with manatees between 2008 and 2012; however, the lack of data on effort obviates standardization and limits the interpretation of these numbers. Nonetheless, this approach makes excellent use of scarce resources to monitor the presence of manatees inside MPAs, it involves fishers in research to protect and conserve this endangered species, and it could be converted into valuable "citizen science" by the addition of a simple method to record trips.

After 2007, manatees in the coastal waters off Cuba were surveyed from boats. Such surveys yielded an index of manatee abundance at relatively low cost, as long as the effects of limited visibility in mangrove forests and evasive behavior remain consistent across surveys (Aragones et al. 2012). For example, boat surveys have been implemented off Cayo Levisa, Pinar del Río Province, and in two MPAs, Ciénaga de Lanier and Desembarco del Granma in the provinces of Isla de la Juventud and Granma (areas B, T, and K in Fig. 1; Figueredo and Pina 2009, Alvarez-Alemán et al. 2014, 2017). During these surveys, encounter rates ranged from 0.05 to 1.8 encounters per hr (Table 2). Based on their results, Alvarez-Alemán et al. (2017) concluded that the Ciénaga de Lanier Wildlife Refuge provided resources that were critical to manatees, including springs, sheltered mangrove creeks, other sources of fresh water, feeding areas, and thermal refugia.

Radio Tagging and Movements

There have been two primary efforts to study manatee movement in Cuba. Reid et al. (2015) studied the movement of eight manatees tagged with global positioning systems (GPS) in Guantánamo Bay between 2013 and 2014. All tagged manatees remained near the Guantánamo Bay Naval Station and within approximately 50 km of coastline, although tagged animals regularly moved between the bay, where they tended to rest or feed, and the upper Guantánamo River, where they accessed fresh water (Reid et al. 2015). Limited access makes this area an important refuge for manatees and other wildlife, such as hutias, *Capromys pilorides* (Say, 1822), and the Cuban rock iguana, *Cyclura nubila* (Gray, 1831), and it has been suggested as an appropriate place for a peace park and research site (Roman and Kraska 2016).

In 2012, Centro de Investigaciones Marinas and the Sea to Shore Alliance initiated a capture and tagging program in Siguanea Gulf off Isla de la Juventud. The capture site lies within the Ciénaga de Lanier protected area. A female manatee was tagged and tracked for 3 mo, and a male and a mother with a calf were tagged and tracked for 9 mo. The female manatee and the mother-calf pair traversed the western coastline and mangrove creeks of Isla de la Juventud (approximately 25 km). The male traveled across a wider area that included the San Felipe Keys in Pinar del Río and Punta Frances, south of Isla de la Juventud (approximately 50 km). The two female manatees and the calf periodically travelled up the Los Indios River into the west drainage of Ciénaga de Lanier, where fresh water was available (Alvarez-Alemán et al. 2014). The tagged male remained in coastal waters far from any known source of fresh water (A Alvarez-Alemán, unpubl data).

Connectivity

Connectivity between manatees in Cuba and nearby populations rarely has been documented. An adult female and calf were observed in Cuban waters near Havana in 2007 after having been photographed in Florida as recently as 2006 (Alvarez-Alemán et al. 2010). This observation and the preliminary analyses of mitochondrial DNA (see below) suggest that connectivity between Cuba and Florida historically has been high, and it may be important for continued recruitment and genetic variation of manatees in Cuba.

Preliminary analyses based on fragments of a mitochondrial DNA control region (mtDNA) identified two haplotypes in 12 manatees sampled in the western part of Cuba (Hernández et al. 2013). Haplotype A1, identified in 11 animals, is the only haplotype in Floridian manatees, and it is found in lower frequencies in manatees from Mexico, Colombia, the Dominican Republic, and Puerto Rico, where a total of 14 additional haplotypes have been recovered (Vianna et al. 2006, Satizábal et al. 2012). Haplotype A3, previously known only from Belize, also was observed in one Cuban manatee from North Villa Clara (Vianna et al. 2006). Assuming the samples yield a moderately accurate representation of mtDNA in Cuba, these results show that the Floridian and Cuban manatee populations were connected historically, with Florida probably being colonized from Cuba (Hernández et al. 2013). The limited diversity of haplotypes currently found in Cuba suggests little matrilineal connectivity between Cuba and other Caribbean populations. However, the mutation rate

for mtDNA constrains our ability to infer connectivity within the past one to three generations. Even a few immigrations across the Florida Strait from Florida's large population could maintain the documented frequencies of haplotypes, particularly if Cuban manatees are isolated from the smaller and apparently declining populations in Mexico, Belize, and Hispaniola.

Molecular markers that accumulate mutations more rapidly than mtDNA may be better tools for identifying gene flow during the past one to three generations (Pritchard et al. 2000). Studies of highly variable microsatellites in Floridian manatees have been extensive, and similar studies have been conducted elsewhere in the Gulf of Mexico and Caribbean Sea. For example, manatees from the Atlantic and Gulf coasts of Florida demonstrate little differentiation (F_{ST} = 0.02, Tucker et al. 2012), suggesting minimal restriction of movement and gene flow. This result has been supported by photographic identification and radio tagging that documented seasonal migratory movements of individuals covering 280–700 km (e.g., Deutsch et al. 2003, Aven et al. 2016). In contrast, genetic structure was more pronounced and gene flow less likely in the Caribbean region and along the Yucatán and Gulf coast of Mexico (Nourisson et al. 2011), which spans a distance that is similar to peninsular Florida. A higher degree of differentiation was found between manatees from the Gulf of Mexico and Chetumal Bay on the southern Yucatán Peninsula (F_{ST} = 0.131, Nourisson et al. 2011). Again, the results of tagging support the conclusions from genetic analyses, with the maximum recorded movement being 240 km (Castelblanco-Martínez et al. 2013, Reid et al. 2015). At a regional level, Florida's population shows moderate to high genetic differentiation from populations of Antillean manatees found along Mexico's Gulf coast (F_{ST} = 0.106), in Chetumal Bay (F_{ST} = 0.096), in Belize (F_{ST} = 0.141), and in Puerto Rico (F_{ST} = 0.163, Hunter et al. 2010, 2012, Nourisson et al. 2011).

Overall, there is evidence that traversing large expanses of oceanic water is challenging for manatees (Vianna et al. 2006). Nonetheless, manatees have been able to successfully travel through open water, such as between Florida and both The Bahamas and Cuba (Lefebvre et al. 2001, Alvarez-Alemán 2010). In addition, Bayesian analysis indicated a limited amount of genomic mixing between Mexico and Florida, which raised the possibility that migrants traveled from Florida to Cuba and then on to Mexico (Nourisson et al. 2011). Even these limited genetic exchanges may be vital for maintaining genetic diversity (Lowe and Allendorf 2010).

A closer examination of the genetic structure of manatees in Cuba would support an assessment of connections among regions of Cuba and an evaluation of the role of Cuba as a stepping stone between Florida, Central America, and the Caribbean islands. The latter role may depend on Cuba's large insular shelf, proximity to other regions, and potentially favorable oceanic currents.

Conclusions

Our knowledge of the status of manatees in Cuba is limited, despite the potential importance of the population. Information about manatees in Cuba comes from interviews with fishers, aerial and boat surveys, and tagging and tracking programs that were documented in a variety of sources, ranging from newspaper articles and scientific journals to conference abstracts and theses (Table 3). Many investigators,

Table 3. A chronology of key observations, events, and studies related to manatees in Cuba. Institutions involved in producing or archiving information and specific sources are identified.

Time	Item	Institution*	Source
Pre-Columbian	Early inhabitants hunt manatees	GA-OHC	Gates 1954, de Sola 1932, Jiménez-Vázquez 2015
1500–1800	Natural historians infer that the population of manatees around Cuba is larger than those around other Caribbean islands	CIM-UH	Fernández de Oviedo 1520 in Cuni 1918, Dampier 1699, Lefebvre et al. 2001
1866	First observations of a decline in manatee numbers in Cuba	CIM-UH, USGS	Gundlach 1866 in Cuni 1918
1909	President Theodore Roosevelt spearheads legislation to protect manatees in Cuba	Provisional administration of the United States	Official Gazette of the Republic of Cuba, Decreto 63-1909
1918	Doctoral dissertation on the biology of Antillean manatees in Cuba	University of Havana	Cuni 1918
1954	Two manatees captured and held in captivity	Havana Zoological Park	Zoológico 1954
1960	45 manatees held for approximately 30 mo in a wooden corral at the mouth of Hatiguanico River as a conservation effort during the Revolution	ENPFF	Hurtado observation
1975	First indication of an alarming decline of the numbers of manatees in Cuba	IES	Varona 1975 in Lefebvre et al. 2001
1980s	3 manatees captured and held at the National Aquarium	ANC	Anecdotal information, aquarium staff
1980–1990	First and second sets of interviews with fishers to gather data on manatees; fishers report manatee mortality caused by entanglement in fishing nets	IIF, CIP	Estrada and Ferrer 1987, A Estrada and L Ferrer unpubl data
1985–1992	Aerial surveys implemented along the southern coast of Cuba	MNHNC, IIF	C Wotzkow unpubl data, A Estrada unpubl data
1990	Trans-location of manatees from southern and northern coasts of Cuba to an isolated lagoon in Ciénaga de Zapata, southern Cuba	ENPFF	Anecdotal information
1990–2007	Third set of interviews with fishers to gather data on manatees, creation of a network for reporting stranded manatee carcasses in Villa Clara	ENPFF	Institutional reports
1994	First interagency meeting in Cuba to focus on manatee conservation	CIM-UH, ENPFF, CICA, ONIP, Pro-Naturaleza	Institutional reports
1998	J Powell initiates a long-term collaboration with the University of Havana focusing on manatee research and conservation	CIM-UH	Anecdotal information
2000–2007	Fourth set of interviews with fishers to gather data on manatees, fishermen report manatee mortality caused primarily by poaching	CIM-UH, BIOECO	Institutional reports

Table 3. *Continued.*

Time	Item	Institution*	Source
2005, 2008, 2010	Necropsy workshops, specialists train Cuban scientists and resource managers	FWC, CIM-UH, ENPFF, Wildlife Trust, Sea to Shore Alliance	Institutional reports
2006	Fifth set of interviews with fishers to gather data on manatees	University of Santiago de Cuba	Escalona 2006
2006–2007	Interagency meetings in Cuba to develop a Strategic Program for Antillean Manatee Conservation in Cuba, first attempt at a National Plan of Action	CIM-UH, ENPFF, CICA, ONIP, CNAP, CGB, TGF, CIEC, WWF, Pro-Naturaleza	Institutional reports
2008	Boat-based surveys commence in marine protected areas to document abundance and habitat use for manatees	CIM-UH, Sea to Shore Alliance, ENPFF, CNAP	Figueredo and Pina 2009,Alvarez-Alemán et al. 2014, Alvarez-Alemán et al. 2017
2009–2014	Regional approach to the management of the South Archipelagos of Cuba leads to the Manatee Monitoring Program in the National System of Protected Areas	GEF, UNDP, CNAP	Alvarez-Alemán et al. 2014
2010	Sixth set of interviews with fishers to gather data on manatees	CIM-UH	Alvarez-Alemán 2010
2012–present	Program to capture and assess the health of manatees established at Isla de la Juventud	CIM-UH, Sea to Shore Alliance	Alvarez-Alemán et al. 2014
2013–2014	Program to capture and assess the health of manatees conducted in Guantánamo Bay	USGS	Reid et al. 2015

*ANC = Acuario Nacional de Cuba. Ministerio de Ciencia, Tecnología y Medio Ambiente; BIOECO = Centro Oriental de Ecosistemas y Biodiversidad. Ministerio de Ciencia, Tecnología y Medio Ambiente; CGB = Cuerpo de Guardabosques. Ministerio del Interior; CICA = Centro de Inspección y Control Ambiental. Ministerio de Ciencia, Tecnología y Medio Ambiente; CIEC = Centro de Investigaciones de Ecosistemas Costeros. Ministerio de Ciencia, Tecnología y Medio Ambiente; CIM-UH = Centro de Investigaciones Marinas, Universidad de la Habana. Ministerio de Educación Superior; CIP = Centro de Investigaciones Pesqueras. Ministerio de la Industria Alimentaria (previously Ministerio de la Pesca); CNAP = Centro Nacional de Áreas Protegidas. Ministerio de Ciencia, Tecnología y Medio Ambiente; ENPFF = Empresa Nacional para la Protección de la Flora y la Fauna. Ministerio de la Agricultura; FWC = Florida Fish and Wildlife Conservation Commission; GA-OHC = Gabinete de Arqueología. Oficina del Historiador de la Ciudad de la Habana. Consejo de Estado; GEF = Global Environmental Fund; IES = Instituto de Ecología y Sistemática (previously Instituto de Zoología). Ministerio de Ciencia, Tecnología y Medio Ambiente; IIF = Instituto de Investigación Forestal. Ministerio de la Agricultura; MNHNC = Museo Nacional de Historia Natural. Ministerio de Ciencia, Tecnología y Medio Ambiente; ONIP = Oficina Nacional de Inspección Pesquera. Ministerio de la Industria Alimentaria; Pro-Naturaleza = Cuban NGO; TGF = Tropas Guardafronteras. Ministerio del Interior; UNDP = United Nations Development Programme; USGS = United States Geological Survey; WWF = World Wildlife Fund.

representing a wide range of institutions, have generated valuable information, but this information has not been integrated into an action plan for systematic research, monitoring, and management that will ensure the survival of manatees in Cuba. Our initial synthesis acts as a reference for researchers and conservationists seeking basic knowledge to focus future activities.

We found that manatees are distributed along much of Cuba's coastline. However, the Ensenada de la Broa and Hatiguanico River on the Zapata Peninsula appear to be important areas in historical and current reports, interviews, and aerial surveys. Historically, manatees used riverine habitats, but now they primarily occupy marine and estuarine habitats, likely due to water control structures that restrict access and reduce the flow of fresh water, as well as degraded water quality following deforestation. As a result of this shift in the use of habitats, it will be important to identify and protect key locations, including seagrass beds that supply food and reliable sources of fresh water. There also is a need to understand the extent and consistency of connections to other regional populations, such as those in Florida, the greater Caribbean region, and the western Gulf of Mexico. Overall, rigorous surveys of abundance and distribution among habitats, evaluation of the effects of bycatch, pollution and other threats, health assessments, tagging programs, and genetic analyses are needed to determine the status of manatees in Cuba. The results of such efforts can be used to elucidate spatiotemporal trends in the abundance and fitness of manatees, manage threats to their survival, and design and implement effective rehabilitation, conservation, and protection. Latent anthropogenic threats were reflected in several past reports, hence the need for an in-depth analysis of current conservation strategies and tools. MPAs should play a role in reducing poaching and entanglement in fishing nets, because they are one of the most important governmental strategies for conservation.

The need for a concerted effort is reinforced by the potential normalization of relations between Cuba and the United States of America, and subsequent expansion of the tourist and boating industries, which are priorities for the Cuban government (VI Congreso del Partido Comunista de Cuba 2011). An increase in the number of American boats in Cuba's coastal waters, for example, is likely to increase the number of manatees injured or killed by collisions, and such additional threats will compound the challenges posed by existing, local threats.

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