Stock Assessment Report (SAR)

WEST INDIAN MANATEE (*Trichechus manatus*)

PUERTO RICO STOCK
(Antillean subspecies, *Trichechus manatus manatus*)

U.S. Fish and Wildlife Service, Caribbean Ecological Services Field Office,
Boquerón, Puerto Rico

STOCK DEFINITION AND GEOGRAPHIC RANGE

The West Indian manatee (*Trichechus manatus*) is found in coastal and riverine areas of North America, Central America, and South America and islands in the Caribbean basin. Two subspecies are recognized. Hatt (1934) identified an Antillean and a Florida subspecies, *Trichechus manatus manatus* and *Trichechus manatus latirostris*, respectively, and Domning and Hayek (1986) subsequently reported that the two subspecies could be identified based on cranial characteristics. They suggested that this subspeciation could reflect reproductive isolation brought on by the intemperate northern coast of the Gulf of Mexico and characteristically strong currents found in the Straits of Florida (Domning and Hayek 1986). More recently, Barros *et al.* 2017, based on landmark 3D geometric morphometrics of cranial size and shape diversification, cast doubt on the two subspecies taxonomic classification and suggest that there may be more subspecies. Within the jurisdictional waters of the United States (U.S.), Florida manatees are found throughout the southeastern U.S. and Antillean manatees are found in Puerto Rico and rarely in the U.S. Virgin Islands.

The Antillean manatee is found in eastern Mexico and Central America, northern and eastern South America, and in the Greater Antilles (Lefebvre *et al.* 1989). The distribution of the Antillean manatee extends eastward only to Puerto Rico except for one 1988 report in St. Thomas, U.S. Virgin Islands and a more recent confirmed sighting of two manatees in St. Croix (May-June 2018). However, transient animals are known to occur in the Lesser Antilles (Lefebvre *et al.* 2001).

Previous studies in Puerto Rico suggest that manatees favor habitats that are protected from severe wave action, harbor submerged aquatic vegetation, and have some source of freshwater (Powell *et al.* 1981, Rathbun *et al.* 1985, Mignucci-Giannoni 1989, Drew *et al.* 2012). Manatees are sighted more frequently in protected coastal areas having any three of the above characteristics.

Although manatees in Puerto Rico have historically been more frequently observed on the eastern and southern coast, the most recent aerial surveys (seven surveys from June 2010 to March 2014) have shown that manatees are more widespread than previously thought (Collazo *et al.* 2019). In general, manatees are found from Dorado to Fajardo along the north coast, from Fajardo to Yabucoa on the east coast, from Patillas to Cabo Rojo on the south coast, and from Cabo Rojo to Mayagüez on the west coast (UNEP 2010)(Figure 1). Relatively higher concentrations of manatees are found in four areas: Ceiba on the east coast, Jobos Bay area between Guayama and Salinas on the southeast coast, Guayanilla and Guánica Bay area on the southwest coast, and between Cabo Rojo and Mayagüez (Guanajibo River mouth) in the west coast (Powell *et al.* 1981, Rathbun *et al.* 1985, Freeman and Quintero 1990, Mignucci-Giannoni *et al.* 2004, USFWS 2007, Drew *et al.* 2012).

Five offshore islands are significant biogeographic features in Puerto Rico: (west to east) Desecheo, Mona, Caja de Muertos, Culebra, and Vieques islands (Figure 1). Manatees are not known to use the western offshore islands of Mona and Desecheo (Collazo *et al.* 2019). The Mona Passage constitutes a migratory barrier to these islands since it is characterized by deep water, strong currents, and high surf. There have been a few sightings in Caja de Muertos on the south and Culebra Island on the east. In contrast, Vieques Island contains extensive seagrass beds and is not separated from the main island by deep channel and manatees have been documented traveling to and from the main island east coast (Magor 1979, Slone et al. 2006). Lastly, there are no known seasonal or temporal variations in the range of the Puerto Rico stock.

Figure 1. Map of Puerto Rico and U.S. Virgin Islands.

Genetic differences between the Antillean and Florida subspecies have been identified (García-Rodríguez *et al.*1998, Vianna *et al.* 2006, Hunter *et al.*2010,

Hunter *et al.*2012, Tucker *et al.*2012). García-Rodríguez *et al.* (1998) compared mitochondrial DNA (mtDNA) from eight locations and identified three geographic clusters: 1) Florida and the West Indies; 2) the Gulf of Mexico to the Caribbean rivers of South America; and 3) the northeast Atlantic coast of South America; units which are not concordant with the current sub-species designations. Vianna *et al.* (2006) assessed relatedness between the Florida and Puerto Rico populations and identified a gene flow barrier. Vianna *et al.* (2006) included 291 mtDNA samples from *T. manatus* from 10 countries. Colombia had the highest diversity of haplotypes with eight, Puerto Rico had three haplotypes, and the Dominican Republic only had two. Although Puerto Rico and the Dominican Republic share haplotype A with Florida, Vianna *et al.* (2006) found a high differentiation between the manatees in Florida and those in the Dominican Republic and Puerto Rico. This was further confirmed by Hunter *et al.* (2012), who used microsatellite Bayesian cluster analyses to detect two populations (K = 2) and noted no admixture or recent migrants between Florida (q = 0.99) and Puerto Rico (q = 0.98).

Slone et al. (2006) indicated that mtDNA haplotype distribution was further geographically divided in Puerto Rico. For example, only the A haplotype was found along the north shore of the island and the B haplotype was observed along the south shore. The authors found a mixture of A and B haplotypes at the eastern and western ends of the island, suggesting mixing between the south and north groups. Furthermore, the mtDNA is maternally inherited and is not reflective of the additional gene flow from males. Additional research by Kellogg (2008) indicated that nuclear DNA subpopulation separation was not as severe, suggesting that male manatees in Puerto Rico travel and breed throughout the population to some degree. Satellite tagging manatees in Puerto Rico have documented general behavior of manatee populations, in which males seem to move more extensively than females (Slone et al. 2006). Males may travel hundreds of kilometers while mother/calf distribution patterns could be more restricted. The authors specify that if male movements are made during the breeding season, then relatively healthy mixing between geographical areas established by females might be expected.

Based on the above, the Puerto Rico and Florida population are identified as separate stocks. The Puerto Rico manatee population should be considered a single population with minimal, if any, subdivisions within the island.

POPULATION SIZE

In the absence of historical data (previous to the late 1970s) that identifies a clear goal for population size and population parameters, such as adult survival rates, which have the highest potential effect on growth rate (Marsh *et al.* 2011, p. 255), it is not possible to stipulate with precision the population size and vital rates that should characterize a recovered, self-sustaining population of manatees in Puerto Rico. Efforts to quantify the size of the Antillean manatee population in Puerto Rico have

historically been made through a series of synoptic aerial surveys, but most surveys do not adjust for imperfect detection of manatees (Collazo *et al.* 2019). Until recently (Collazo *et al.* 2019), aerial surveys have mostly been used to describe distribution patterns or determine minimum population counts in some areas (Magor 1979, Rice 1990, and Mignucci-Giannoni *et al.*2003, 2004, 2018) or throughout the island (Powell *et al.*1981, Freeman and Quintero 1990, Rathbun *et al.*1985).

The most recent island-wide manatee surveys from an airplane were conducted from June 2010 to March 2014. Population estimates were derived using five of these surveys after accounting for apparent detection probability (Collazo *et al.* 2019). Adjusted estimates resulted in an average minimum island-wide estimate of 386 ± 89 (SD) manatees, ranging from 312 to 535 (Collazo *et al.*2019). Collazo *et al.* (2019) presents a summary of past manatee aerial surveys in Puerto Rico since 1976.

Minimum Population Estimate

The minimum population estimate (N_{min}) for the Puerto Rico manatee stock is calculated using the equation provided in NMFS (2016): $N_{min} = N/\exp (0.842 * [\ln(1+[CV (N)]^2)]^{½})$. Using the average minimum island-wide estimate of 386 ± 89 (SD) from Collazo et al. (2019), and its CV of 0.23, the calculated N_{min} is 318 for the Puerto Rico manatee stock.

Note that Collazo et al. (2019) estimates account for apparent detection probability for surveys between June 2010 and March 2014. A couple of new surveys will be completed and analyzed in 2021.

Current Population Trends

The population trend for the Antillean manatee Puerto Rico stock has been previously described as stable (UNEP 2010, USFWS 2017). More recently, Mignucci-Giannoni *et al.* (2018) suggests a possible population growth based on an observed marked increase in the number of manatees detected per hour of effort between 2007 and 2015 during helicopter surveys along the south coast of Puerto Rico. Initial surveys from 2001-2002 counted between 5 to 7 manatees per hour of effort, later increasing to more than 17 manatees per hour of hour of effort by 2007 towards 2015 (Mignucci-Giannoni *et al.* 2018).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Actual current and maximum net productivity rates for the Puerto Rico Antillean manatee population have never been calculated due to the lack of data. The Marine Mammal Protection Act (MMPA) defines net productivity rate as "the annual per capita rate of increase in a stock resulting from additions due to reproduction, less losses due to natural mortality". The percentage of Puerto Rico Antillean manatee

calves observed during aerial surveys in Puerto Rico has ranged from 6.4% to 18.1% (Collazo *et al.*2019). From the 138 (± 39.4) average total number of manatees observed per fixed wing aerial surveys from June 2010 to March 2014, 10% were calves with an average of 13.9 (± 4.8) mother-calf pairs sighted per survey (Collazo *et al.*2019). This number of calves is somewhat consistent with Mignucci-Giannoni *et al.* (2018) observations, who reported 12.4% of calves from the total manatee counts in the south coast of Puerto Rico. In addition, an average of 1.6 dependent calves per year die in Puerto Rico, and the majority of the manatees rescued for rehabilitation also are calves (USFWS 2017).

The number of calves detected per year (dead or alive) has not changed dramatically, and they usually are in concordance with the total number of sightings during aerial surveys. However, in the absence of a statistical value on net productivity rates, we have followed the recommended guidelines (NMFS 2016) of using a 0.04 value for manatees and cetaceans as the maximum net productivity rate for this stock.

POTENTIAL BIOLOGICAL REMOVAL (PBR)

Potential Biological Removal (PBR) is the product of three elements: the minimum population estimate (N_{min}), half of the maximum net productivity rate (0.5 R_{max}), and a recovery factor (F_r). Recovery factor values range between 0.1 and 1.0. Population simulation studies demonstrate that a default value of 0.1 should be used for endangered stocks and a default value of 0.5 should be used for threatened stocks or stocks of unknown status (NMFS 2016). The West Indian manatee is listed as threatened throughout its range (81 FR 1000) under the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*), as amended (ESA). Thus, by default the recovery factor for the Puerto Rico stock is 0.5.

Based on the SAR guidance (NMFS 2016), we assessed the need to adjust the recovery factor for the Puerto Rico manatee stock since its ESA listing status is nested within the broader ranking at the species level listing along its entire range (i.e., the West Indian manatee). In addition, the IUCN lists the West Indian manatee as vulnerable, but lists the Antillean manatee subspecies as endangered throughout its range (Self-Sullivan and Mignucci-Giannoni 2008). The Puerto Rico Department of Natural and Environmental Resources (PRDNER) also lists the Antillean manatee population in Puerto Rico as endangered.

According to the NMFS (2016), the recovery factor can be decreased from the default value if, for example:

- human-caused mortalities include more than 50% females;
- if the stock is declining;

- if the coefficient of variation (CV) of the mortality estimate is greater than 0.3.

Confirmed human-caused manatee mortalities in Puerto Rico are considered low, only four from 2015 to 2019 (Table 1), and none were caused by fishery interactions, but rather by watercraft related injuries. In addition, available information suggests the Puerto Rico Antillean manatee stock is not declining (see Current Population Trends section above). However, the CV of the human-caused mortalities from 2015-2019 (four cases, Table 1) is 0.94, and of the four cases, three were females and one male. Thus, following the NMFS (2016) guidance, we are using a lower recovery factor of 0.4 for the Puerto Rico Antillean manatee stock.

Using the calculated N_{min} of 319 manatees and the default maximum net productivity rate of 0.04 for sirenians, the calculated PBR for the Puerto Rico manatee stock is 2.55, less than 1% of the N_{min}.

$$PBR = (N_{min})\ (½ \text{ of } R_{max})\ (F_r) = (319)\ (½0.04)\ (0.4) = 2.55$$

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

Carcass salvage efforts were initiated in April 1974 by the USFWS and local entities and continued through 1989. The Caribbean Stranding Network (CSN) then initiated a dedicated salvage, rescue, and rehabilitation program, assuming responsibility for all carcass recovery efforts in Puerto Rico. Currently, carcass salvage efforts are led by the PRDNER with help from the CSN. From 1990 through 2019, 240 manatees have been found dead (Mignucci-Giannoni 2006, PRDNER and CSN unpublished data).

Manatee carcasses that show evidence of serious injuries that may have been human-caused are reported as mortalities in Table 1 with most casualties from watercraft impacts. In Puerto Rico, most manatee stranding events consist of single individuals. Unlike Florida, mass mortality or unusual mortality events have not occurred in Puerto Rico since the etiological cause (e.g., red tide or the need for warm water habitats) has not presented an issue to a coastal tropical marine species. Moreover, except for mating herds, manatee groups detected during aerial surveys are small, mostly consisting of single sightings, or 2-3 individuals (e.g., mother and calf). There is only one mass mortality case documented in 2006 when a mating herd (4 males and one female) was impacted by a large vessel in the San Juan Bay.

Table 1. Manatee mortality in Puerto Rico from 2015 to 2019 (PRDNER and CSN unpublished data).

Year	Natural			Human		Undetermined	Total
	Dependent Calves / Perinatal	Dystocia*	Illness	Watercraft	Entanglement		
2015	1	0	0	0	0	3**	4
2016	0	0	2	2	0	6	10
2017	1	0	1	0	0	5	7
2018	2	1	3	1	0	0	7
2019	3	0	1	1	0	2	7
Totals	**7 (20%)**	**1 (2.9%)**	**7 (20%)**	**4 (11.4%)**	**0**	**16 (45.7%)**	**35**
5-Year Avg.	**1.4**	**0.2**	**1.4**	**0.8**	**0**	**3.2**	**7**

*Dystocia = parturition difficulties ** One carcass not recovered

In the past five years, 35 manatees were reported dead (Table 1). Most of the causes of death (COD) were either undetermined (16 manatees [45.7%]) or natural (15 [42.9%]), and the highest human-related COD are watercraft related casualties (4 [11.4%]). In most watercraft-related cases, manatees are killed by a blunt trauma to the head or the thoracic area, which produces an internal hemorrhage, injuries, and subsequent death. The undetermined COD category means that there is no evidence that COD can be assigned to any of the available categories, either natural or human related.

In most cases, the reporting of a stranded manatee after death takes more than one day and most CODs are deemed undetermined because the carcass is too decomposed. Remote locations of stranding may hinder recovery of manatee carcasses and carcasses decompose quickly in the tropical climate making it difficult to conduct a timely determination of mortality. The PRDNER's Marine Mammal Stranding Program has developed a protocol to report and quickly act on marine mammal strandings, which are mostly manatees. This program is institutionalized, and first responders are usually the PRDNER rangers that have the mandate and capacity to quickly act to increase detection and prevent death of animals. Because of this system, the number of strandings currently reported by the PRDNER helps to provide a better estimate of manatee mortality in Puerto Rico.

Until the mid-1980's, some coastal families captured and killed manatees for human consumption. Manatees were captured in gill nets and/or turtle nets purposely or inadvertently during fishing activities. Mignucci-Giannoni *et al.* (1993) indicates that from 1974 until 1988, 41.5% of the documented mortality was attributed to poaching. The authors further indicate that meat was sold to ready buyers although

the extent to which this occurred was unknown. After the rescue of a baby manatee in 1991 and subsequent media uproar because its mother was poached, there have been no records of manatee captures for human consumption and there are no indications that poaching of manatees in Puerto Rico still occurs.

Fisheries-related Mortality and Serious Injury

The Antillean subspecies of the West Indian manatee was removed from the list of species/stocks incidentally killed or injured in the Category III "Caribbean gillnet" and "Caribbean haul/beach seine" fisheries (NMFS 2010). There are no other commercial fisheries listed to take manatees in Puerto Rico.

There are two documented cases of accidental entanglement (beach seine net) and successful release of adult manatees: July 2009 and February 2018. Both of these cases could have resulted in manatee fatalities. Fortunately, the persons involved made the effort to untangle the manatee, and both manatees seem to have escaped with no further injuries. The 2009 case was brought to the attention of NMFS for consideration under their 2012 List of Fisheries (LOFs), but the manatee remains off the beach seine list (NMFS 2018). In 2014, one adult female manatee died from being entangled in a large seemingly illegal fishing net (PRDNER 2014), but no further investigation was pursued. Significant exposure was given to this case through the local and social media. That same year, two other adult manatees were also entangled in fishing nets, but there is no additional information regarding these cases.

In November 2010, the PRDNER (2010) issued a new Puerto Rico fishing regulation (Regulation 7949), which supersedes the former Regulation 6768. Under this regulation, beach seine gear is permitted except within Puerto Rico inner water and rivers mouths. Although this type of gear may affect and cause take of Antillean manatees in Puerto Rico per the previous examples, there is no other indication that the use of beach seine nets in Puerto Rico has caused an increase in entanglements. According to the Puerto Rico manatee stock mortality database, there have only been four manatee mortality cases attributed to entanglements since 1980, one per decade (PRDNER and CSN unpublished data). The PRDNER, USFWS, and other partner's manatee education programs should target fishermen and address the possible effects of this type of gear on manatees. The USFWS will work with NMFS to ensure any future take that occurs with this fishery (beach seine net) are considered in future LOFs.

The fisheries in the U.S. Caribbean are multi-species, multi-gear, artisanal in nature, and principally coral reef-based (CFMC 2004). A total of 670 active fishing vessels and 868 active commercial fishers were reported in Puerto Rico during 2008 (Matos-Caraballo and Agar 2011). They also reported that 75% of interviewed commercial fishers fished full-time and 25% part-time. In total, 49.7% of the

fishing vessels are 20-29 feet in length followed by 47.6% from 10-19 feet. Of these, 32% fished along the shoreline, 82% on the continental shelf, 59% on the shelf edge, and 36% on oceanic waters. Most commercial fishers used hook and line gear to obtain their catch, followed by traps, nets, and skin/scuba. Since the beach seine was banned at the time of interview (2008), data from this gear were not requested (Matos-Caraballo and Agar 2011). Of the total net gears used by commercial fisheries in Puerto Rico, lobster trammel nets, gill nets, fish trammel nets, and cast nets represented 44%, 21%, 6 %, and 29% respectively. Matos-Caraballo (2009) described changes in the fisheries from 1988 to 2008; the most dramatic was the reduction in the number of fish traps (52% reduction in 20 years). On the other hand, an increasing trend was observed in the use of hand lines and rod and reel. Another significant change observed was a 42% reduction in active commercial fishing vessels from 1996 to 2008. Boats larger than 30 feet also decreased from 44 in 1988 to only 16 in 2008 (Matos-Caraballo 2009). From 2007-2011, the highest percentage of landings by weights were lines, followed by skin/scuba, traps and lastly nets accounting for 9% of the total reported catch (Matos-Caraballo 2012). Matos-Caraballo (2012) reports that commercial landings reported from 2007-2011 were low compared with previous years.

Documented manatee entanglement in fishing gear and debris ingestion rarely occurs. From 1990-2019, only three manatees had COD related to entanglement (3 [1%] out of 240 cases), with the most recent one from 2014 (Mignucci-Giannoni 2006, PRDNER and CSN unpublished data, PRDNER 2014). Further, in all of the fisheries related cases documented, it was not possible to determine if it was due to a commercial or recreational fishery or if there was any illegality in the nets being used. The use of beach seine nets is still allowed with certain prohibitions that need to be carefully monitored. Agencies, community groups, and non-governmental organizations in Puerto Rico consistently educate the public about the use of fishing gear and waste disposal that can affect manatees.

Based on the above, the incidental mortality and serious injury of manatees related to commercial fisheries in Puerto Rico and the U.S. Virgin Islands is considered minimal or approaching zero mortality and serious injury. The USFWS acknowledges that there may be limits to the data available because it is possible takes could occur and may not be observed or reported, as some may occur in remote areas or the people involved may be hesitant to report to authorities. However, the USFWS considers that public manatee awareness has increased as most of the stranding cases or manatee sightings in common areas have been reported by the general public. In addition, protocols for necropsies and assigning probable cause of death categories are reviewed thoroughly.

From 2015-2019, no manatees were reported dead related to fisheries. The only possible evidence for commercial fisheries interaction would be within the 45.7% undetermined COD category (Table 1). The COD category means that there is no

evidence that COD can be assigned to any of the available categories, either natural or human related. In addition, manatees injured by commercial fisheries interactions would most likely present signs of the activity and every necropsy includes a specific evaluation of human interactions.

Besides the beach seine net cases already mentioned, a few other manatees have been found to have severe entanglements in monofilament line in their appendages but to our knowledge, have not yet resulted in deaths. For example, in 2006, one dead manatee was found with its right flipper entangled in monofilament and still this COD was deemed undetermined. In August 2014 and September 2016, an adult female was confirmed to have both flippers severely entangled in monofilament line. Attempts to capture the female manatee from the shore were unsuccessful. This female is observed and reported quite frequently by the public since it is easy to identify by her severely injured flippers. As recently as June-July 2018, this female was still alive and except for her further deteriorated flippers, the manatee seemed normal.

STATUS OF STOCK

In 2017, the West Indian manatee was reclassified to threatened under the ESA (81 FR 1000) throughout its entire range. Thus, by default, the Puerto Rico stock of the Antillean manatee is considered a "strategic stock" and "depleted" under the Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1361 *et seq*.). The Antillean manatee population in Puerto Rico continues to be listed as endangered at the state level (PRDNER).

We currently do not have sufficient information about the Puerto Rico manatee population to determine the optimal sustainable population (OSP). Differences in size, threats (i.e. cold spells and red tide), and habitat use between the Puerto Rico manatee stock and the Florida manatee stock preclude us from using Florida manatee data on survival rates and reproduction to reach an OSP.

REFERENCES

Barros, H. M., A.C. Meirelles, F.O. Luna, M. Marmontel, E. Cordeiro Estrela, N. Santos and D. Astúa, 2017. Cranial and chromosomal geographic variation in manatees (Mammalia: Sirenia: Trichechidae) with the description of the Antillean manatee karyotype in Brazil. Journal of Zoological Systematics and Evolutionary Research, 55, 73– 87.

CFMC (Caribbean Fishery Management Council). 2004. Final Environmental Impact Statement for the Generic Essential Fish Habitat Amendment to: spiny lobster, queen conch, reef fish, and coral fishery management Plans for the U.S. Caribbean. 499 pp. Available online:

https://caribbeanfmc.com/fishery-management/2-uncategorised/173-feis-to-the-efh

CSN (Caribbean Stranding Network). Unpublished data. Available from: Caribbean Stranding Network, PO Box 361715 San Juan, PR 00936.

Collazo, J.A., M.J. Krachney, K.H. Pollock, F.J. Pérez-Aguilo, J.P. Zegarra, and A.A. Mignucci-Giannoni. 2019. Population estimates of Antillean manatees in Puerto Rico: an analytical framework for aerial surveys using multi-pass removal sampling. Journal of Mammalogy 100(4): 1340-1349. DOI:10.1093/jmammal/gyz076

Drew, C.A., L.B. Alexander-Vaughn, J.A. Collazo. 2012. Science summary in support of manatee protection area design in Puerto Rico. North Carolina Agricultural Research Service, Technical Bulletin 330. North Carolina State University, Raleigh, NC. 63 pp. Available online: https://digitalmedia.fws.gov/digital/collection/document/id/1907/

Domning, D.P. and L.C. Hayek. 1986. Interspecific and intraspecific morphological variation in manatees (Sirenia: *Trichechus*). Marine Mammal Sci. 2:87-144.

Freeman, J. and H. Quintero. 1990. The distribution of West Indian manatees (*Trichechus manatus*) in Puerto Rico: 1988-1989. NTIS PB91-137240. Springfield, VA. 43 pp.

García-Rodríguez, A.I., B.W. Bowen, D. Domning, A.A. Mignucci-Giannoni, M. Marmontel., R.A. Montoya-Ospina, B. Morales-Vela, M. Ruding, R.K. Bonde, and P.M. McGuire. 1998. Phylogeography of the West Indian Manatee (*Trichechus manatus*): how many populations and how many taxa? Molecular Ecology 7: 1137-1149.

Hatt, R. 1934. A manatee collected by the American Museum Congo Expedition, with observations of recent manatees. Bulletin of the American Museum of Natural History 66:533-566.

Hunter, M.E., N.E. Auil-Gomez, K.P. Tucker, R.K. Bonde, J.A. Powell, and P.M. McGuire. 2010. Low genetic variation and evidence of limited dispersal in the regionally important Belize manatee. Animal Conservation: 1-11.

Hunter M.E., A.A. Mignucci-Giannoni, K.P. Tucker, T.L. King, R.K. Bonde, P.M. McGuire. 2012. Puerto Rico and Florida manatees represent genetically distinct groups. Conservation Genetics 12:1623-1635.

Kellogg, M.E. 2008. Sirenian Conservation Genetics and Florida Manatee (*Trichechus manatus latirostris*) cytogenetics. Doctoral dissertation, University of Florida, Gainesville, Fl. 159pp.

Lefebvre, L.W., T. J. O'Shea, G.B. Rathbun and R.C. Best. 1989. Distribution, status, and biogeography of the West Indian manatee. Biogeography of the West Indies, 1989: 567-610.

Lefebvre, L.W., M. Marmontel, J.P. Reid, G.B. Rathbun, and D.P. Domning. 2001. Status and biogeography of the West Indian manatee. Pages 425-474 in C.A. Woods and F.E. Sergile, editors. Biogeography of the West Indies: Patterns and Perspectives. CRC Press, Boca Raton, FL. 582 pp.

Magor, D.M. 1979. Survey of the Caribbean manatee (*Trichechus manatus, L.*) on Vieques Island, Puerto Rico. 9 p. + appendices. Report to the Navy.

Matos-Caraballo, D. 2009. Lessons learned from the Puerto Rico's Commercial Fishery, 1988-2008. Proceedings of the 61st Gulf and Caribbean Fisheries Institute. p. 123-129.

Matos-Caraballo, D. and J.J. Agar. 2011. Comprehensive Census of the Marine Commercial Fishery of Puerto Rico, 2008. Proceedings of the 63rd Gulf and Caribbean Fisheries Institute. p. 99-112.

Matos-Caraballo, D. 2012. Puerto Rico/NMFS Cooperative Fisheries Statistics Program April 2007 – September 2012 NAO7NMF4340039. Final Report submitted to NOAA NMFS. Department of Natural and Environmental Resources, San Juan, PR. 67 pp.

Mignucci-Giannoni, A.A. 1989. Zoogeography of marine mammals in Puerto Rico and the Virgin Islands. Unpublished master's thesis, The University of Rhode Island, Kingston, RI.

Mignucci-Giannoni, A.A., B. Pinto-Rodriguez, R.A. Montoya-Ospina, D.P. Moore, and E.H. Williams. 1993. Stranding and mortality assessment of marine mammals in Puerto Rico and the Virgin Islands. Presented at the Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, TX, 11-16 November.

Mignucci-Giannoni, A.A., M.M. Alsina Guerrero, V.M. Rosado, G.M. Toyos, and R.J. Rosario. 2003. EcoMap: Southwest Puerto Rico Endangered Marine Wildlife Conservation Project. Caribbean Stranding Network. Report to EcoElectrica. 16 pp.

Mignucci-Giannoni, A.A., M.M. Alsina Guerrero, G.M. Toyos, and R.J. Rosario. 2004.
Aerial Surveys for marine mammals and sea turtles off the southeast coast of Puerto Rico. Caribbean Stranding Network. Report to EcoElectrica. 16 pp.

Mignucci-Giannoni, A.A. 2006. West Indian manatee (*Trichechus manatus*) mortality analysis for Puerto Rico: 1990-2005. Caribbean Stranding Network. Unpub. Report.

Mignucci-Giannoni, A.A., C. Iglesias-Escabí, R.J. Rosario-Delestre, y M. Alsina-Guerrero. 2018. Variación en la distribución del manatí antillano (*Trichechus manatus manatus*) en la costa sur de Puerto Rico a través de censos aéreos en helicóptero. Rev. Mar. Cost. ESSN 1659-407X. Vol. 10(1): 97-121.

NMFS (National Marine Fisheries Service). 2010. List of Fisheries for 2011; Final Rule. Federal Register Vol. 75, No. 215 (8 November 2010), pp. 68468-68504.

NMFS 2016. Guidelines for Preparing Stock Assessment Reports Pursuant to the 1994 Ammendments to the MMPA. Assessing Marine Mammal Stocks. Department of Commerce, NOAA NMFS. 23 pp. Available at: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks.*

NMFS. 2018. List of Fisheries for 2018; Final Rule. Federal Register Vol. 83, No. 26 (7 February 2018), pp. 5349-5372.

Powell. J. A., D.W. Belitsky, and G.B. Rathbun. 1981. Status of the West Indian manatee (*Trichechus manatus*) in Puerto Rico. J. Mamm. 62: 642-646.

PRDNER (Puerto Rico Department of Natural and Environmental Resources). Unpublished data. Available from: Department of Natural and Environmental Resources, PO Box 366147, San Juan, PR 00936.

PRDNER. 2010. Reglamento de Pesca de Puerto Rico, 2010. 99 pp. Available from: http://drna.pr.gov/documentos/reglamento-num-7949/

PRDNER. 2014. Stranding report DRN0109. Marine Mammal Rescue Program, Commonwealth of Puerto Rico, DNER. 16 pp.

Rathbun, G.B., N. Carr, T. Carr, and C.A. Woods. 1985. The distribution of manatees and sea turtles in Puerto Rico, with emphasis on Roosevelt Roads Naval Station. NTIS PB 85-151847 AS. Springfield, VA. 83 pp.

Rice, S. M. 1990. Aerial Survey of West Indian Manatee *Trichechus manatus*. FWS. Unpub. Report. 19 pp.

Self-Sullivan, C. and A. Mignucci-Giannoni. 2008. *Trichechus manatus ssp. manatus*. The IUCN Red List of Threatened Species 2008: e.T22105A9359161. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T22105A9359161.en

Slone, D.H., J.P. Reid, R.K. Bonde, S.M. Butler, and B.M. Stith. 2006. Summary of the West Indian manatee (*Trichechus manatus*) tracking by USGS-FISC Sirenia Project in Puerto Rico. Report Prepared for the US Fish and Wildlife Service. 9 pp.

UNEP 2010. Regional Management Plan for the West Indian Manatee (*Trichechus manatus)* compiled by Ester Quintana-Rizzo and John Reynolds. CEP Technical Report No. 48. UNEP Caribbean Environment Programme, Kingston, Jamaica.

USFWS. 2007. West Indian Manatee. 5-year review: Summary and Evaluation. Jacksonville Ecological Services Office, Florida; Caribbean Field Office, Puerto Rico. 79 pp.

USFWS. 2017. Endangered and Threatened Wildlife and Plants; Reclassification of the West Indian Manatee from Endangered to Threatened. Final Rule. Federal Register Vol. 82 No. 64, pp. 16668-16704.

Vianna, J.A., R.K, Bonde, J.P Caballero, J.P. Giraldo, R.P. Lima, A. Clark, M. Marmontel, B. Morales-Vela, M.J. de Sousa, L. Parr, M.A. Rodríguez-López, A.A Mignucci-Giannoni, J.A. Powell, and F.R. Santos. 2006. Phylogeography, phylogeny, and hybridization in trichechid sirenians: implications for manatee conservation. Molecular Ecology 15:433-447.