FastTrack publication

Bull Mar Sci. 94(2):000–000. 2018
https://doi.org/10.5343/bms.2016.1123

Blue Sanctuary

research paper

Achievements and challenges of marine turtle conservation in Cuba

Julia Azanza Ricardo [1, 2 *]
José L Gerhartz Muro [3]
Yanet Forneiro Martín-Viaña [4]
Félix Moncada Gavilán [5]
Fernando Bretos [6]
Yosvani Medina Cruz [7]
Gonzalo Nodarse Andreu [7]
René Pérez Martín [8]
Eddy García Alfonso [3]

[1] *Instituto Superior de Tecnología y Ciencias Aplicadas, Avenida Salvador Allende 1110 e/ Infanta y Avenida Boyeros, Quinta de los Molinos, Havana, Cuba.*

[2] *Centro de Investigaciones Marinas, Universidad de La Habana, Calle 16 No 114 e/1ra y 3ra, Playa, Havana, Cuba.*

[3] *Fundación Antonio Núñez Jiménez de la Naturaleza y el Hombre, 5ta B # 6611 e/ 66 y 70 Miramar, Playa, Havana, Cuba.*

[4] *Empresa Nacional para la Protección de la Flora y la Fauna, MINAGRI, Calle 42 # 514 Esq. 7ma., Havana, Cuba.*

[5] *Centro de Investigaciones Pesqueras, MINAL, 248 No. 0603, e/5ª ave y mar, Santa Fe, Playa, Havana, Cuba.*

[6] *Phillip and Patricia Frost Museum of Science, 1101 Biscayne Blvd, Miami, Florida 33132.*

[7] *Marina Marlin Azulmar, MINTUR Club de Pesca Cayo Largo, Cuba.*

[8] *Instituto Nacional de Higiene, Epidemiología y Microbiología, Infanta No. 1158 entre Llinás y Clavel. Cerro, Havana, Cuba.*

* *Corresponding author email: <julia_dragmarino@yahoo.es>.*

Date Submitted: 2 December, 2016.
Date Accepted: 21 November, 2017.
Available Online: 2 January, 2018.

ABSTRACT.—Marine turtle populations have become seriously depleted throughout the world as a result of factors such as overharvesting and habitat degradation. Conservation efforts in Cuba have led to important achievements, with several species increasing in population. However, illegal capture continues, the black-market trade in marine turtle products is increasing, and new threats are being identified. Here, we: identify and assess threats and challenges to sea turtle conservation in Cuba; evaluate the management, monitoring, and protection capacity to address specific threats; and summarize achievements, drawbacks, and challenges over the last 6 yrs. Fourteen threats to nesting populations of marine turtles in Cuba were identified, with illegal fishing and poaching in nesting areas being the most critical. Management and enforcement in protected areas are uneven, and as a result, some nesting areas have benefited from marine turtle conservation, but others remain seriously threatened.

There is great concern around the world about the future of marine turtles. Five of seven known species are listed as endangered or critically endangered by the IUCN (http://www.redlist.org/). While some populations are recovering after years of conservation efforts (Broderick et al. 2006, Mazaris et al. 2017), others are rapidly

declining (Mazaris et al. 2017). Causes of depletions are diverse and complex, but direct exploitation has been a long-lasting threat. In the Caribbean Sea, sea turtle harvest has been documented since the colonial period (Jackson 1997), and it persists in some countries (Lagueux et al. 2017), making direct and incidental fishing persistent threats for these animals (Bell et al. 2006, Sasso and Epperly 2006). Legal fisheries in Cuba extracted an average of 836 t of sea turtles per year in the 1980s; before their official closure in 2008, the catch had been progressively reduced to <15 t as a result of regulatory measures (Moncada et al. 2014). Nevertheless, marine turtles continue to be subjected to several sources of anthropogenic threats during their life cycle (Lutcavage et al. 1997, Chaloupka et al. 2008).

Survivorship and reproductive rates are highest for sea turtles that have reached or are approaching maturity (Crowder et al. 1994), thus protecting these life stages from anthropogenic threats is especially important. Although threats have been identified on Cuban nesting areas (Moncada-Gavilán et al. 2003, 2011, Moncada et al. 2014, Russet 2016), their severity and the actions that should be taken in each case are yet to be evaluated. For this reason, marine turtles and their nesting sites are conservation priorities in the National System of Marine Protected Areas (Hernández-Ávila 2014).

Marine turtle conservation in Cuba has undergone several phases, mostly in accordance with changes in fisheries regulations (Moncada-Gavilán et al. 2014). As a result, the Fisheries Research Center (Centro de Investigaciones Pesqueras, or CIP) had the leading role in marine turtle conservation in Cuba for several decades. In the 1990s, however, the conservation spectrum expanded with the incorporation of new institutions devoted to the study and conservation of marine turtles such as the University of Havana's Marine Research Center (Centro de Investigaciones Marinas, Universidad de La Habana, or CIM) and the National Enterprise for the Protection of Flora and Fauna (Empresa Nacional para la Protección de la Flora y la Fauna, or ENPFF). An important milestone for sea turtle conservation was the creation of the National Subsystem of Marine Protected Areas (Subsistema Nacional de Áreas Marinas Protegidas, or SAMP) that started in the early 2000s (Hernández-Hernández 2007). Since 2008, with the issuance of Resolution 009/2008 by the Ministry of the Fishery Industry, Cuba declared a total prohibition of legal turtle catch. In 2011, the Ministry of Science, Technology, and Environment (Ministerio de Ciencia, Tecnología y Medio Ambiente, or CITMA) passed Resolution 160/2011, which banned any capture, use, or traffic of marine turtles, except for research and conservation purposes. Furthermore, the Strategic Plan of the National System of Protected Areas for the period 2014–2020, identified marine turtles as prioritized species for conservation.

After >30 yrs, Cuba has greatly advanced marine turtle conservation. Yet, illegal take continues, the black-market trade in marine turtle products is increasing, and new threats continue to emerge. Here, we: identify and assess these threats; evaluate the management, monitoring, and protection capacity of key areas to address the threats; and discuss the main achievements and challenges to the conservation of marine turtles in Cuba over the last 6 yrs.

Table 1. Identified threats for marine turtles in Cuban Archipelago, categorized as (1) direct human activity (increased mortality induced directly by human activity) and (2) habitat degradation (feeding and reproductive habitat degradation).

Threats	Indicator	Score range
1. Direct human activity		
Physical harm by boats	Presence/absence	0–1
Pollution	Presence/absence	0–1
Illegal take	Maximum number of turtles illegally taken*	0–4
Bycatch	Presence/absence	0–1
Diseases	Presence/absence	0–1
2. Habitat degradation		
Sea level temperature increase	Presence/absence	0–1
Increase in hurricane intensity	Presence/absence	0–1
Sea level rise	Presence/absence	0–1
Nest temperature increase	Presence/absence	0–1
Presence of invasive species	Number of invasive species present	0–2
Beach erosion	Presence/absence	0–1
Beach pollution	Presence/absence	0–1
Sargasso influx	Presence/absence	0–1
Disturbance by touristic uses	Number of disturbances	0–2

* Scoring criteria: 1 = fewer than 10; 2 = 10–20; 3 = 20–30; 4 = more than 30 sea turtles.

Materials and Methods

To initiate the systematic identification and assessment of major threats to marine turtle conservation in Cuba, a review of experiences in other countries was carried out, mainly using global and regional reports such as State of the World's Sea Turtles (SWOT), from which a preliminary list of threats was compiled. A workshop featuring Cuban experts was organized, and the main direct threats, contributing factors, and driving forces were identified. These were linked into a conceptual model by applying the World Wildlife Fund's Standards of Conservation Project and Programme Management (WWF 2012).

Threat monitoring was initiated in 2010. The number of turtles killed on nesting beaches, the quantity of illegal fishing nets confiscated, and the amount of turtle meat seized was recorded every year. To assess bycatch, interviews were carried out with fishers. These data were used to assess the impacts of threats as an indication of success (or failure) of the sea-turtle-protection program at the most important nesting beaches (defined as those with average annual nesting more than 50 nests). Beaches were classified into four categories according to their historical level of nesting: low nesting (50–100 nests), medium nesting (100–200 nests), high nesting (200–1000 nests), and very high nesting (more than 1000 nests). Frequency of threats was calculated as the percentage of beaches where the threat was present. A scoring system was used to assess the impact of these threats at selected nesting beaches. Presence/absence of threat was used for those threats lacking quantitative information, providing a score of one when the threat was present and zero if the threat was absent. In the case of illegal take, quantitative information scores were assigned according to ranges of maximum removals reported (Table 1). Scores were then added to obtain a total threat index by nesting beach.

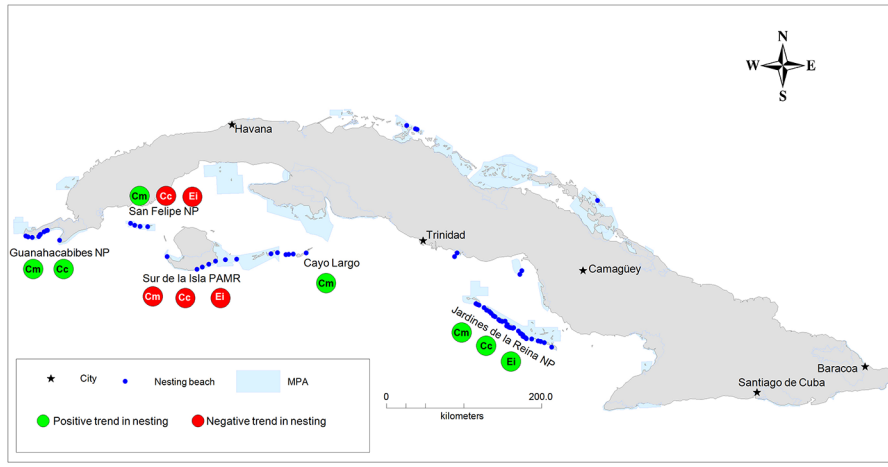

Figure 1. Location of marine-turtle nesting areas in the Cuban archipelago in relation to the distribution of the marine protected areas (MPAs). Green circles represent nesting populations with positive trends and red circles represent negative trends. Cities where black-market surveys were conducted are also presented.

Information about conservation effort in nesting areas was extracted from all available reports from the last 6 yrs (Azanza-Ricardo et al. 2013, 2015, 2017, Forneiro Martín-Viaña et al. 2013, Moncada-Gavilán et al. 2014). Black market sales were investigated through field visits from October 2014 to January 2015, searching for the availability of sea turtle products (meat and hawksbill shell craft) in handicraft markets, and in stores and restaurants in five cities across Cuba (Havana, Trinidad, Camagüey, Santiago de Cuba, and Baracoa; Fig. 1).

Management, monitoring, and enforcement capacity of nesting was assessed using five indicators to obtain a total score for each selected beach (Table 2). A relational analysis was carried out using threat and management-monitoring-capacity indices to identify four categories of nesting beaches, which could determine capacity-building priorities: (1) beaches with high level of threat and low management capacity, (2) high level of threat and high management capacity, (3) low level of threat and high management capacity, and (4) low levels of threat and management capacity. Finally, the most pressing challenges for the conservation of marine turtles in Cuba were identified.

Results and Discussion

Threats to Marine Turtles in Cuba

We identified fourteen threats affecting nesting populations of marine turtles in Cuba (Table 1). Threats were clustered into two types of direct pressure: human-induced mortality of sea turtles, and degradation of feeding, nursery, and reproductive habitats. The most important impacts are described below.

Illegal Take.—Illegal take is considered the most severe threat to marine turtles in Cuba and the most frequent threat to marine turtles in marine protected areas, occurring in 33% of protected beaches. The availability of meat other than chicken and pork is limited in Cuba, and the demand for marine turtle meat is very high.

Table 2. Ranking criteria for management/monitoring/surveillance capacity of nesting beaches.

Ranking criteria
Management infrastructure
0 = Absence
1 = Presence
Presence and technical capacity of field staff
0 = No field staff
1 = Untrained field staff
2 = Trained field staff
Enforcement
0 = Absence
1 = Presence
Type of monitoring
1 = Sporadic monitoring
2 = Systematic diurnal monitoring
3 = Systematic nocturnal monitoring
State of the World's Sea Turtles (SWOT) standard
0–3 = Number of species being monitored with standard L1*

* L1 is one of the International standards of monitoring established by SWOT and it includes: total abundance counts, total abundance estimates with sampling error of less than or equal to 20% (CV ≤ 0.2), or a reliable index of seasonal abundance. See SWOT (2011) for more details.

A network of private restaurants in coastal cities with a large number of foreign visitors—such as Havana, Camagüey, Trinidad, Santiago de Cuba, and Baracoa—increases the demand, as turtle meat is clandestinely offered to costumers and promoted as an aphrodisiac delicacy. About 15% of the restaurants visited offered turtle meat. Illegal commerce and trafficking of hawksbill shells and handicrafts also occur in these cities as a result of tourist demand. Hawksbill shell crafts were offered at 29 out of 42 stores visited (Fig. 2), with prices reaching up to US$200 per object.

Poaching is carried out in two ways: illegal fishing in feeding areas or migratory corridors mainly using nets, and capture of nesting females at some nesting beaches where surveillance is weak. In the water, illegal activity appears to be more intense

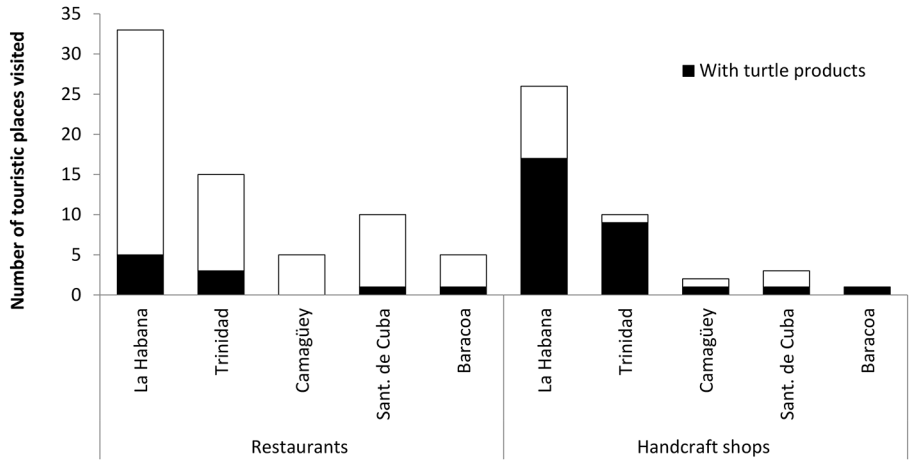

Figure 2. Incidence of turtle products in handicraft shops and private restaurants in five cities popular with tourists in Cuba, surveyed in 2015.

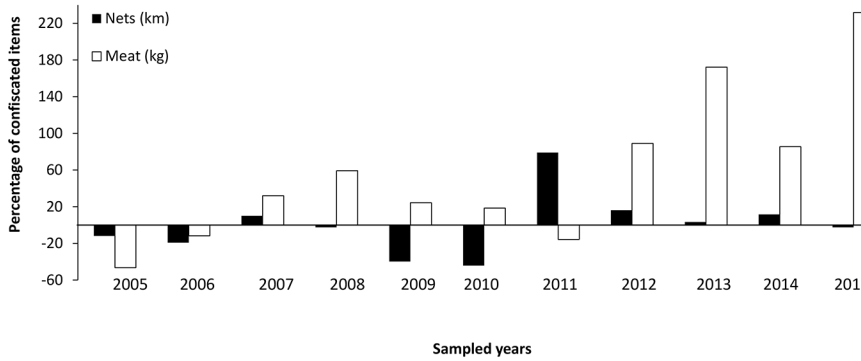

Figure 3. Annual variation in the amount of turtle meat (kg) and total length of nets seized (km) as a result of fish inspections from 2005 to 2014, using 2004 as the baseline.

on the north Cuban shelf due to the presence of an important migratory corridor. Ninety-one percent of meat and net seizures occur in northwestern Cuba. Spear guns are also used along some coral reefs to catch juvenile hawksbills. Greater than 3000 kg of turtle meat and dozens of kilometers of nets are seized every year by the authorities, although the quantities show large annual variation (Fig. 3), perhaps because of irregular enforcement effort. Seven of 10 surveyed years had an increase in seizures compared with the baseline year (2004).

In general, access to nesting beaches is limited because most are remotely located, and in many cases, within the confines of marine protected areas (MPAs). However, poachers often visit beaches or beach sections that have lower protection to kill nesting females and sometimes collect eggs. Frequency of poaching varies in time (Fig. 4) and among areas (Table 3), but total observed poaching represents <6% of nesting females per year.

Overfishing and Bycatch.—Regulated sea turtle fishing was legal in Cuba until 2008. Fishing during the 1960s and 1970s most likely contributed to population depletions. The use of certain nets, J-shaped instead of circle-shaped hooks, and other fishing practices put marine turtles at risk of incidental capture, although the fisheries statistics system does not account for turtle bycatch.

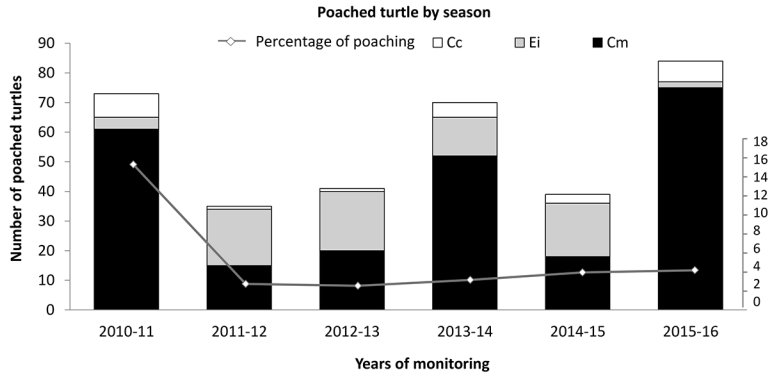

Figure 4. Number of observed poaching events on marine turtle nests on monitored beaches, from 2010–2011 to 2015–2016 nesting seasons. Cc: *Caretta caretta*; Ei: *Eretmochelys imbricata*; Cm: *Chelonia mydas*

Table 3. Sea turtles killed by species and season on protected areas were most nesting occurs in Cuba, 2010–2015. Cm: *Chelonia mydas*; Cc: *Caretta caretta*; Ei: *Eretmochelys imbricata*; NR: not registered.

	2010–2011			2011–2012			2012–2013			2013–2014			2014–2015			2015–2016			
Protected area	Cm	Cc	Ei	Cm	Cc	Ei	Cm	Cc	Ei	Cm	Cc	Ei	Cm	Cc	Ei	Cm	Cc	Ei	Total
Sur de la Isla de la Juventud	31	6	2	7	1	1	11	1	2	35	4	0	4	2	1	29	3	2	142
Cayos de San Felipe	24	2	0	0	0	2	1	0	0	7	0	0	3	0	0	15	0	0	54
Guanahacabibes	6	0	0	3	0	3	4	0	1	7	0	0	4	0	1	24	1	0	54
Jardines de la Reina	NR	NR	2	2	0	5	2	0	0	2	0	4	6	0	8	3	3	0	37
Cayos de Ana María	NR	NR	NR	3	0	8	2	0	17	1	1	9	1	1	8	0	0	0	51
Total	61	8	4	15	1	19	20	1	20	52	5	13	18	3	18	71	7	2	338

According to Moncada-Gavilán et al. (2003), sea turtle bycatch in Cuba between 1968 and 1993 represented 15% of the marine turtle legal fishery and occurred mostly in fisheries that targeted rays [*Hypanus americanus* (Hildebrand and Schroeder, 1928), *Aetobatus narinari* (Euphrasen, 1790), and *Himantura schmardae* (Werner, 1904)]. After 1994, when only two communities were allowed to operate turtle fisheries, incidental capture was reported infrequently and only for hawksbill [*Eretmochelys imbricata* (Linnaeus, 1766)]. In the community of Cocodrilo, off Isla de la Juventud, 4–56 hawksbills were caught incidentally every year between 1999 to 2007, while 3–10 hawksbills were reported annually in Nuevitas, which is located on Cuba's northeastern shelf. Information obtained through fisher interviews suggested that 1200 animals, of all species, are captured annually along the Cuban shelf (Moncada et al. 2003).

Pollution.—Marine turtles mistakenly feed on plastic bags and other garbage, and litter in nesting beaches can obstruct nesting activity and access of newborns to the sea. This threat is present in 29% of beaches considered in our analysis. Pollution from heavy metals, pesticides, and other inorganic substances could also contribute to increased observations of fibropapillomatosis (Alonso Aguirre et al. 1994). The observation of fibropapilloma tumors has been infrequent in both fishery and nesting reports in Cuba; but in recent years, an increase in the number of dead animals severely covered with fibropapillomas has been observed in the north-central region (Azanza et al. 2015). Different causes for this phenomenon are still being evaluated (Russet 2016), but it has been established that the disease is caused by an herpesvirus, which can be activated by environmental stressors, such as biotoxins, biological vectors of the virus, or chemical pollutants (Alonso Aguirre et al. 1994, Arthur et al. 2008). Russet (2016) proposed that heavy-metal pollution could be contributing to the rise in tumors in Cuba.

Degradation of Feeding, Nursery, and Reproductive Habitat.—Key habitats for marine turtles—such as coral reefs, sea grass beds, and nesting beaches—are affected by a number of human activities in Cuba, including bottom trawling, overfishing, anchoring, and diving (Hernández-Ávila 2014), although not all of them have direct impacts on turtle populations.

Of biggest concern is the degradation of nesting beaches (Table 1). Twenty-seven percent of identified nesting areas, especially those located on small keys, have already been affected by beach erosion and could disappear altogether (Moncada-Gavilán et al. 2011). Increased intensity of hurricanes and other extreme meteorological events have caused intense physical damage to nesting beaches, affecting habitat and reproductive success by destroying nests (Azanza et al. 2010). Sea-level rise places additional stress on Cuban nesting beaches (Moncada-Gavilán et al. 2011), and it has been identified as the most common threat, likely affecting 77% of nesting beaches. Global warming could also affect reproductive success of marine turtles by altering sex ratios (Hawkes et al. 2007). Monitoring of nest temperature during the last few years has demonstrated that a bias toward increased female production could already be occurring on some beaches (Mitchell and Janzen 2010, Ricardo et al. 2013). The reduction in incubation duration is also affecting reproductive output of loggerheads [*Caretta caretta* (Linnaeus, 1758)] (Azanza-Ricardo et al. 2017), an issue that has been observed elsewhere (Fisher et al. 2014). The spreading of invasive alien plant species, such as the Australian pine (*Casuarina equisetifolia* Linneaus) and

bitter panicgrass *Panicum amarum* (Elliott), are compromising the normal dynamics of sand dunes, causing erosion and loss of the quality of nesting sites in San Felipe National Park, and El Guanal beach on Isla de la Juventud. Additional modifications to nesting beaches have been observed after the arrival and deposition of large amounts of *Sargassum* (Azanza-Ricardo and Pérez-Martín 2016), obstructing the access of females and hatchlings to the beach or the sea. *Sargassum* blooms have been proliferating outside the Sargasso Sea, affecting the Caribbean region and Gulf of Mexico (Gower et al. 2006, Maurer et al. 2015). Finally, tourism could create conflicts with marine turtle conservation if development is conducted without taking into account the needs of nesting turtles, and if visitation to nesting beaches is not carried out following adequate protocols and respecting the carrying capacity of each nesting beach. Such conflicts with tourism have been observed in Cayo Largo (i.e., the use of artificial lights near nesting areas, obstacles being left on beach, etc.).

Management, Monitoring, and Protection Capacity

The National System of Protected Areas protects 14 marine turtle nesting sites (Fig. 1). It also includes 411 km^2 of coral reef formations (35.8% of the total), 1579 km^2 of seagrass beds of medium to high density (26.1%), and 5245 km^2 of low density seagrass beds (25.9%; Hernández-Ávila 2014). These are key habitats for hawksbill and green turtles [*Chelonia mydas* (Linnaeus, 1758)]. Complementing this protection system, there is a set of government, scientific, and civil institutions tasked with conservation. Efforts are directed not only to protect turtles, but also to increase environmental education of local communities and the general public.

Several capacity limitations hinder the effectiveness of management and conservation success, both inside and outside of MPAs. Logistical limitations, instability of trained personnel, and low enforcement capacity are the main problems faced by MPAs (Azanza-Ricardo et al. 2015). As a consequence, commercial, recreational, and illegal fisheries often operate inside MPAs limits without proper control, even when management plans, restricted-use zones, and regulations are in place.

Enforcement needs to be strengthened. The National Office of Fishery Inspection (Oficina Nacional de Inspección Pesquera, or ONIP) is in charge of enforcing fishing regulations and other measures related to the use of marine resources. They have well-trained personnel, but not enough staff to tackle all of the problems concerning dozens of marine species in a territory with >5000 km of coast, more than 4000 keys and small islands, and about 56,760 km^2 of sea on the island platform.

Based on existing management capacity, nesting areas in Cuba can be divided into four categories: nesting areas in MPAs with favorable conditions for robust conservation management; nesting areas in MPAs with management problems for marine turtle conservation; nesting areas in MPAs with no management capacity for marine turtle conservation; and nesting areas with no legal protection. Cayo Largo, the principal nesting site for green turtles and loggerheads in Cuba, is in this last category (Medina et al. 2009).

Three groups were found when we examined the management capacity index for beaches with more than 50 nests per year against threat scores (Fig. 5). The first occupies the upper left quadrant and is comprised of beaches where management actions are urgently needed because they have a high number of threats and low management capacity. Cayo Largo is one of the most conspicuous examples here because of its importance as a nesting site, along with El Guanal, which has the highest

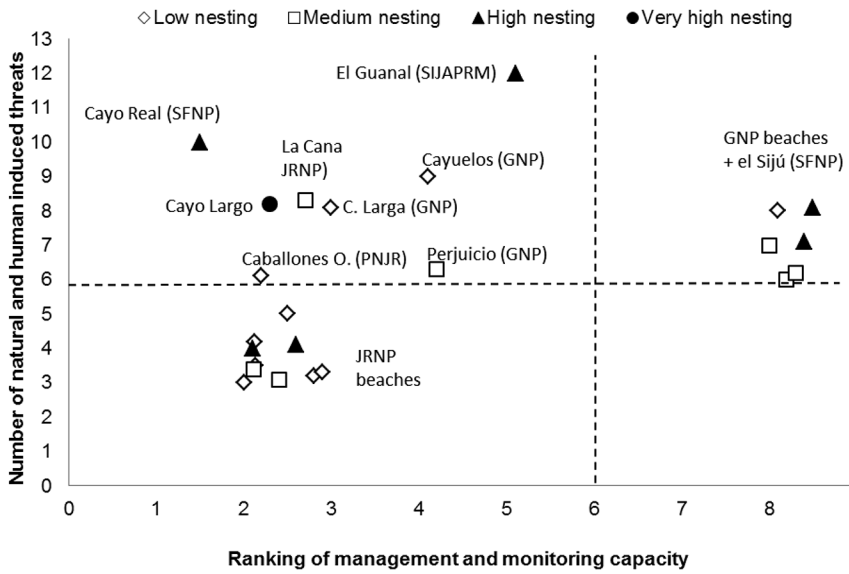

Figure 5. The number of natural and human induced threats on the main nesting beaches in Cuba (with more than 50 nests per year) and the management and monitoring capacity avaibale to address them. SFNP: San Felipe National Park; SIJAPRM: Sur de la Isla de la Juventud Protected Area with Resources Management; JRNP: Jardines de la Reina National Park; and GNP: Guanahacabibes National Park.

level of poaching on nesting females in the country. Areas in the best condition are Guanahacabibes and San Felipe; they have strong management capacity, but must continue to address persistent threats. Beaches of Jardines de la Reina form the third group, with fewer threats to face, but with management capacities there are poor.

Achievements and Challenges in Marine Turtle Conservation in Cuba

Achievements and challenges of marine turtle conservation in Cuba center around three interrelated topics: protection and monitoring capacity, knowledge of sea turtle biology, and threat mitigation. A key factor for strengthening protection and monitoring capacity was the establishment of a National Coordination Group in 2010 with the participation of all institutions engaged in marine turtle conservation. This team of experts developed an integrated monitoring network and boosted capacity-building efforts, resulting in a 48% increase in the number of areas being monitored, systematic training of field staff in six of the 14 areas, and improvement of basic working conditions in most key areas, except Cayo Largo. Increased monitoring and protection efforts in nesting areas resulted in a 66% reduction in poaching, probably one of the most important achievements of the marine turtle conservation program in Cuba (Fig. 4). Capacity-building efforts also facilitated the reduction of beach invasion by *C. equisetifolia* at El Guanal beach (20% reduction) and San Felipe National Park on Cayo Juan García (100% reduction).

The implementation of a standard monitoring protocol (Moncada-Gavilán et al. 2013), including records on nesting and threats, allowed for the integration of data gathered by different organizations in a single, shared database. This protocol initiated the compilation of the first national reports on marine turtle conservation status

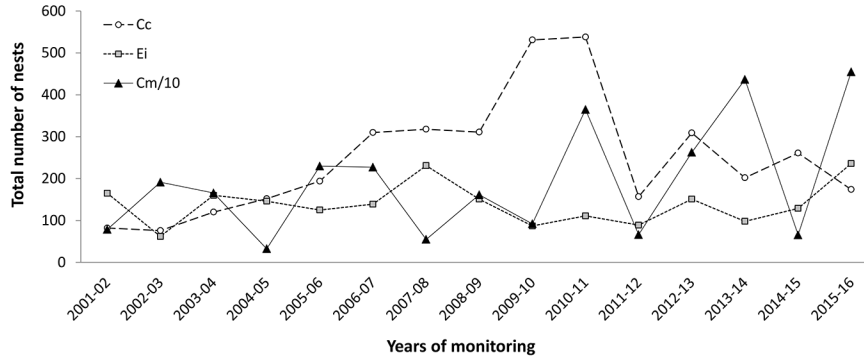

Figure 6. Number of marine turtle nests on monitored nesting beaches from 2001–2002 to 2015–2016 nesting seasons. Cc: *Caretta caretta*; Ei: *Eretmochelys imbricata*; Cm: *Chelonia mydas*

in Cuba. The information collected was then used to support management decisions, especially in MPAs.

The monitoring system also became an important source of knowledge about the nesting biology of marine turtles in Cuba (Azanza-Ricardo et al. 2015). Data on the three nesting species were gathered for the first time in the five most important sites (i.e., 90% of total recorded nesting in Cuba, Table 4), although monitoring effort is not equal across species and sites (Azanza et al. 2015). In areas with systematic monitoring, it was possible to collect information about reproductive behavior and success (Azanza et al. 2013, 2017), as well as physical factors affecting nesting and incubation success, especially temperature (Azanza et al. 2017, Gerhartz et al. in press). The first genetic characterizations of the most important rookeries on the western Cuban platform were conducted by Ruiz et al. (2008, 2010).

Increased protection and monitoring in nesting areas, combined with the closure of legal fisheries, appear to have helped increase nesting levels for the green turtle in the last decade (r = 0.81, P = 0.01), although high temporal variation has been observed among seasons (Fig. 6). Hawksbill nesting also appears to have increased, mostly in the area of Jardines de la Reina (r = 0.78, P = 0.04), though this could be the consequence of an expanded monitoring effort. The number of monitored beaches increased from 28 to 44 after 2010, and this level has been maintained according to Azanza et al. (2013). In contrast to other areas in the Atlantic Ocean (Antworth et al. 2006, Marcovaldi and Chaloupka 2007), Cuban loggerhead nests are decreasing (r = −0.77, P = 0.04). According to Moncada et al. (2014), this species was heavily harvested during the 1990s, with the fishery operating during the time of reproductive migration. Recent studies off the northern coast of Cuba also reported low presence of loggerheads (Caderno 2017). Yet Cuba remains essential for sea turtles of the Caribbean Sea, with several nesting areas containing more than 100 nests of green, hawksbill, and loggerhead sea turtles. Such large nesting beaches account for 15% of Caribbean nesting areas (Dow et al. 2007). Nesting trends of species over the last 6 yrs differ among areas: the Sur de la Isla protected area shows declines in all species, whereas Guanahacabibes and Jardines de la Reina exhibit positive trends for all nesting species (Fig. 1). The decline in Sur de la Isla might be the result of a deficient protection system, combined with easy access to the nesting beaches for poachers, which is not the case of Jardines and Guanahacabibes.

High emergence success of green and loggerhead hatchlings recorded in sampled nests (>84%) could also be considered a positive sign for marine turtle conservation in Cuba. Hawksbills, however, had <60% success in most areas, a potentially worrisome sign that requires further research.

Marine turtle conservation is promoted through public awareness and environmental education campaigns. Key audiences for the campaigns are consumers of illegal turtle products and fishing communities. Great effort has been devoted to prevent illegal trade and international commerce of marine turtle products through graphic messages intended to provoke reactions in local consumers and tourists and reduce demand. For several weeks during the summer of 2015, messages were displayed on a variety of media and formats, in the most visited areas of Havana, reaching tens of thousands of people. At the same time, year-round educational campaigns were launched in 14 fishing communities, designed to raise awareness on sea turtle biology and status in an informative and entertaining manner. Turtle festivals were included as educational efforts in the community of Cocodrilo, addressing turtle fishers before the permanent closure of this fishery, and have since been expanded to other communities (Bretos et al. 2017).

Sustaining and enhancing these achievements will require overcoming several challenges. Long-term efforts are needed to achieve effective conservation of long-living species with complex life cycles and migratory patterns (Hays 2004). We will need to fill knowledge gaps about marine turtles in the region to support sound management and conservation policy.

Sustainability of nesting and threat monitoring is only possible through the permanent presence of suitable workers in the most important nesting areas. Unfortunately, frequent changes of staff in many MPAs result in new and inexperienced people conducting monitoring. Securing well-trained, permanent personnel in nesting area stands is a major challenge in Cuba, as remoteness, harsh working conditions, and low wages limit the number of qualified personnel willing to work in MPAs. There is an urgent need to improve lodging conditions for conservation workers in the field, create better incentives to secure their employment, and attract more highly-qualified candidates. The personnel problem also hampers the collection of important environmental parameters, such as beach dynamics and temperature, which are key to understand emerging threats from climate change on reproductive success. The social and economic changes being promoted by the Cuban government could eventually provide new opportunities to address this challenge, as new economic tools could become available to MPA managers to better incentivize conservation workers.

Despite current educational and awareness efforts, reducing the illegal killing of sea turtles remains as an enormous challenge, driven by a growing black market for meat and hawksbill shells. Local fishers find poaching a relatively easy way to make money, particularly in coastal communities with very few alternative livelihoods. Activities related to ecotourism and stewardship have been successful abroard and could be used in Cuba to reduce poaching, such as sea turtle dive tourism in Barbados (Schuhmann et al. 2013). Unfortunately, deep-seated beliefs about the properties of turtle meat, particularly the alleged aphrodisiac properties of hawksbill meat and eggs, sustain the demand in Cuba. At the same time, tortoise shell handicrafts are sold at high prices to foreign visitors. Controlling illegal take, intentional bycatch, and the black market driving these activities will require better enforcement in MPAs, fishing ports, retailer networks, and borders. This effort will require

additional resources and capacity building. Rangers are needed in MPAs to enforce regulations, a shortcoming that is being addressed by the creation of a group of MPA inspectors. Moreover, enforcement needs to be backed up by increased turtle awareness in coastal communities and among consumers. Cuba has experience in educational and awareness campaigns, but finding resources for activities that focus on sea turtles is challenging with so many competing financial needs. The support of the international conservation community has been essential in this effort, and it will continue to be of paramount importance in the future.

Acknowledgments

We thank the World Wide Fund for Nature, The Ocean Foundation, and the GEF-PNUD project Archipiélagos del Sur de Cuba for financial and logistic support of the national monitoring system in marine-turtle nesting areas. And thanks to B Johnston for her critical contribution to field research on the turtle black market; the administration of protected areas and the forest rangers for the protection and monitoring of marine-turtle nesting areas; the Ministry of Science, Technology, and Environment for the authorization to access natural areas and monitoring support; to the workers and volunteers for their effort in the conservation of marine turtles in Cuba. And finally, we thank F Cartaya and K Thompson for their exhaustive review of the manuscript.

Literature Cited

Alonso Aguirre A, Balazs GH, Zimmerman B, Galey FD. 1994. Organic contaminants and trace metals in the tissues of green turtles (*Chelonia mydas*) afflicted with fibropapillomas in the Hawaiian islands. Mar Pollut Bull. 28(2):109–114. https://doi.org/10.1016/0025-326X(94)90547-9

Antworth RL, Pike DA, Stiner JC. 2006. Nesting ecology, current status, and conservation of sea turtles on an uninhabited beach in Florida, USA. Biol Conserv. 130(1):10–15. https://doi.org/10.1016/j.biocon.2005.11.028

Arthur K, Limpus C, Balazs J, Capper A, Udy J, Shaw G, Keuper-Bennett U, Bennett P. 2008. The exposure of green turtles (*Chelonia mydas*) to tumour promoting compounds produced by the cyanobacterium *Lyngbya majuscula* and their potential role in the aetiology of fibropapillomatosis. Harm Alg. 7:114–125. https://doi.org/10.1016/j.hal.2007.06.001

Azanza J, Forneiro Y, Moncada F, Gerhartz JL, Medina Y, Nodarse G, Gerhartz A. 2013. Monitoreo y conservación de las tortugas marinas en Cuba: Mayo 2010–Febrero 2012. Informe del Programa Cubano de Tortugas Marinas. La Habana, 2013. 47 p.

Azanza J, Forneiro Y, Moncada F, Gerhartz JL, Medina Y, Nodarse G, Gerhartz A. 2015. Monitoreo y conservación de las tortugas marinas en Cuba: Marzo 2012–Febrero 2014. Informe del Programa Cubano de Tortugas Marinas. La Habana, 2015. 43 p.

Azanza J, Forneiro Y, Moncada F, Gerhartz JL, Medina Y, Nodarse G, Gerhartz A. 2017. Monitoreo y conservación de las tortugas marinas en Cuba: Marzo 2014–Febrero 2016. Informe del Programa Cubano de Tortugas Marinas. La Habana, 2017. 45 p.

Azanza J, Ibarra-Martín ME, Hernández J, Díaz R. 2010. Impact of high intensity hurricanes on the reproductive biology of marine turtles' reproductive rookery of Guanahacabibes Peninsula, Cuba. *In*: Dean K, López Castro MC, editors. Proceeding of the Twenty-Eighth Annual Symposium on Sea Turtle Biology and Conservation. Loreto, Baja California Sur, México. NOAA Technical Memorandum NMFS-SEFSC-602. p. 159

Azanza-Ricardo J, Gerhartz-Muro JL, Forneiro Martín-Viaña Y, Moncada-Gavilán F. 2015. Efectividad del monitoreo de la anidación de tortugas marinas para determinar el éxito reproductivo en playas del sur de Cuba. LAJAR. 43(3):548–556. http://dx.doi.org/10.3856/vol43-issue3-fulltext-16

Azanza-Ricardo J, Ibarra-Martín ME, González-Sansón G, Abreu-Grobois FA, Eckert KL, Espinosa-López G, Oyama-Nakagawa K. 2013. Nesting ecology of *Chelonia mydas* (Testudines: Cheloniidae) on the Guanahacabibes Peninsula, Cuba. Inter J Trop Biol Conser. 61(4):1235–1945.

Azanza-Ricardo J, Ibarra-Martín ME, González-Sansón G, Harrison E, Medina-Cruz Y, Bretos F. 2017. Possible effect of global climate change on *Caretta caretta* (Testudines, Cheloniidae) nesting ecology at Guanahacabibes Peninsula, Cuba. Chelonian Conserv Biol. 16(1):12–19. https://doi.org/10.2744/CCB-1241.1

Azanza-Ricardo J, Pérez-Martín R. 2016. Impacto de la acumulación de sargazo del verano del 2015 sobre las tortugas marinas de playa la Barca, Península de Guanahacabibes. Rev Inv Mar. 36(1):54–62.

Bell CD, Blumenthal JM, Austin TJ, Solomon JL, Ebanks-Petrie G, Broderick AC, Godley BJ. 2006. Traditional Caymanian fishery may impede local marine turtle population recovery. Endanger Species Res. 2:63–69. https://doi.org/10.3354/esr002063

Bretos F, Ricardo JA, Moncada F, Peckham SH, Valdés JA, Diego A, Thompson KR. 2017. Fisheries learning exchanges and sea turtle conservation: an effort between Mexico, Cuba and the US to engage Cuban coastal communities in non-consumptive alternative behaviors. Mar Policy. 77:227–230. https://doi.org/10.1016/j.marpol.2016.05.022

Broderick AC, Frauenstein R, Glen F, Hays GC, Jackson AL, Pelembe T, Ruxton GD, Godley BJ. 2006. Are green turtles globally endangered? Glob Ecol Biogeogr. 15(1):21–26. https://doi.org/10.1111/j.1466-822X.2006.00195.x

Caderno A. 2017. Análisis de la pesquería furtiva de tortugas marinas en aguas de la plataforma cubana. Bachelor thesis, Havana University. 55 p.

Chaloupka M, Work TM, Balazs GH, Murakawa SK, Morris R. 2008. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago. Mar Biol. 154(5):887–898. https://doi.org/10.1007/s00227-008-0981-4

Crowder LB, Crouse DT, Heppell SS, Martin TH. 1994. Predicting the impact of turtle excluder devices on loggerhead sea turtle population. Ecol Appl. 4:437–445. https://doi.org/10.2307/1941948

Dow W, Eckert K, Palmer M, Kramer P. 2007. An atlas of sea turtle nesting habitat for the Wider Caribbean Region. The Wider Caribbean Sea Turtle Conservation Network and The Nature Conservancy. WIDECAST Technical Report No. 6. Beaufort, North Carolina. 267 p. + electronic appendices.

Fisher LR, Godfrey MH, Owens DW. 2014. Incubation temperature effects on hatchling performance in the loggerhead sea turtle (*Caretta caretta*). PLoS One. 9(12):e114880. https://doi.org/10.1371/journal.pone.0114880

Forneiro Martín-Viaña Y, Azanza-Ricardo J, Moncada-Gavilán F, Gerhartz-Muro JL. 2013. Programa de Monitoreo de Tortugas Marinas. *In:* Reporte de avance del Sistema de Monitoreo de la Biodiversidad. Hernández-Ávila, editors. Centro Nacional de Áreas Protegidas. La Habana. Cuba. Impresos Dominicanos s.r.l. p. 96–104.

Gerhartz JL, Azanza J, Moncada F, Gerhartz A, Espinosa L, Forneiro Y, Chacón D. In press. Sand and incubation temperature in a sea turtle nesting beach at the Cayos de San Felipe National Park, Pinar del Río, Cuba, during the 2012–2013 season. Rev Inves Mar. 37(1).

Gower J, Hu C, Borstad G, King S. 2006. Ocean color satellites show extensive lines of floating Sargassum in the Gulf of Mexico. IEEE Trans Geosci Remote Sens. 44(12):3619–3625. https://doi.org/10.1109/TGRS.2006.882258

Hawkes LA, Broderick AC, Godfrey MH, Godley BJ. 2007. Investigating the potential impacts of climate change on a marine turtle population. Glob Change Biol. 13:923–932. https://doi.org/10.1111/j.1365-2486.2007.01320.x

Hays GC. 2004. Good news for sea turtles. Trends Ecol Evol. 19(7):349–351. https://doi.org/10.1016/j.tree.2004.05.009

Hernández-Ávila A. 2014. Estado actual de la biodiversidad marino-costera, en la región de los Archipiélagos del Sur de Cuba. Centro Nacional de Áreas Protegidas. La Habana. Cuba. Impresos Dominicanos s.r.l. 200 p.

Hernández-Hernández E. 2007. The implementation of the Strategic Plan of the National System of Protected Areas of Cuba. Medio Ambiente y Desarrollo; Rev Agen Med Amb. 7(13).

Jackson J. 1997. Reefs since Columbus. Coral Reefs. 16:S23. https://doi.org/10.1007/s003380050238

Lagueux CJ, Campbell CL, Strindberg S. 2017. Artisanal green turtle (*Chelonia mydas*) fishery of Caribbean Nicaragua: II. Characterization and trends in size, sex, and maturity status of turtles killed, 1994–2011. Mar Biol. 164(3):60. https://doi.org/10.1007/s00227-017-3092-2

Lutcavage ME, Plotkin P, Witherington B, Lutz PL. 1997. Human impacts on sea turtle survival. *In:* Lutz P, Musick JA, editors. The biology of sea turtles. Boca Raton, FL: CRC Press. p. 387–409.

Marcovaldi MA, Chaloupka M. 2007. Conservation status of the loggerhead sea turtle in Brazil: an encouraging outlook. Endanger Species Res. 3(2):133–143. https://doi.org/10.3354/esr003133

Mazaris AD, Schofield G, Gkazinou C, Almpanidou V, Hays GC. 2017. Global sea turtle conservation successes. Sci Adv. 3(9):e1600730. https://doi.org/10.1126/sciadv.1600730

Maurer AS, De Neef E, Stapleton S. 2015. Sargassum accumulation may spell trouble for nesting sea turtles. Front Ecol Environ. 13(7):394–395. https://doi.org/10.1890/1540-9295-13.7.394

Medina Y, Moncada F, Nodarse G, Blanco R. 2009. Anidación de la tortuga verde (*Chelonia mydas*) y caracterización de las playas en Cayo Largo, Cuba. Rev Cub Invest Pesq. 26(1):66–72.

Mitchell NJ, Janzen FJ. 2010. Temperature-Dependent Sex Determination and Contemporary Climate Change. Sex Dev. 4:129–140. https://doi.org/. https://doi.org/10.1159/000282494

Moncada F, Font L, Morales E, Escobar E, Nodarse G, Valle S, García J, Meneses A. 2003. Bycatch of marine turtles in Cuban shelf-waters. *In*: Seminoff JA, editor. Proceedings of the Twenty-second International Sea Turtle Symposium Biology NOAA-TM-MFS-SEFSC-503. p. 8–9.

Moncada F, Tizol D, Nodarse G, Medina Y. 2014a. Efecto de las vedas en las poblaciones anidadoras de tortuga verde (*Chelonia mydas*) y caguama (*Caretta caretta*) en la playa El Guanal, Isla de la Juventud, Cuba. Rev Cub Inves Pesq. 31(2):1–6.

Moncada-Gavilán F, Azanza-Ricardo J, Forneiro Martín-Viaña Y, Gerhartz-Muro JL, Nodarse-Andreu G, Medina-Cruz Y. 2014b. Programa de Monitoreo de Tortugas Marinas. En Estado actual de la biodiversidad marino-costera, en la región de los Archipiélagos del Sur de Cuba. Hernández-Ávila, editors. Centro Nacional de Áreas Protegidas. La Habana. Cuba. Impresos Dominicanos s.r.l. p. 130–141.

Moncada-Gavilán F, Azanza-Ricardo J, Nodarse-Andreu G, Medina-Cruz Y, Forneiro Martín-Viaña Y, Gerhartz-Muro JL. 2013. Protocolo para el monitoreo de la anidación de tortugas marinas en Cuba. Grupo Nacional para la Conservación de las Tortugas marinas en Cuba. Proyecto GEF/PNUD "Aplicación de un enfoque regional al manejo de las áreas marino-costeras protegidas en la Región Archipiélagos del Sur de Cuba". La Habana, Cuba. 84 p.

Moncada-Gavilán F, Nodarse-Andreu G, Azanza Ricardo J, Medina Cruz Y, Forneiro Martín-Viaña Y. 2011. Las tortugas marinas y el cambio climático en Cuba. Cuba: Medio Ambiente y Desarrollo. Rev Agen Med Amb. 11(20).

Ricardo JA, Muro JLG, Bretos Trelles F, Abraham AG. 2013. Temporal variation of incubation temperature of Green turtle nest in the southwestern Cuban archipelago. *In*: Tucker A, Belskis L, Panagopoulou A, Rees A, Frick M, Williams K, LeRoux R, Stewart K, editors. Proceedings of the 33rd Annual Symposium on sea turtle biology and conservation. Sea Turtle Biology and Conservation. NOAA Tech. Mem NMFS-SEFSC-645. p. 194.

Ruiz A, Riverón FB, Pérez E, Abreu FA, Vega M, James-Petric BL, Díaz-Fernández R, Álvarez-Castro JM, Jager M, Azanza J, et al. 2010. Population genetic structure of Greater Caribbean

green turtle (*Chelonia mydas*) based on mitochondrial DNA sequences, with emphasis on roockeries from southwestern Cuba. Rev Invest Mar 31(1):33–2.

Ruiz A, Vega M, Riverón FB, Abreu FA, Solano J, Pérez T, Pérez E., Azanza J, Frías R, Díaz R, Ibarra ME and Espinosa G. 2008. Estructura genética de poblaciones de *Caretta caretta* en el Gran Caribe y la costa Atlántica de Estados Unidos, con énfasis en colonias de anidación del suroeste cubano. Rev Invest Mar. 29(2):151–160.

Russet A. 2016. Impacto de la calidad del ambiente en la salud y la dieta de juveniles de *Chelonia mydas* (Testudines, Cheloniidae) al norte de Villa Clara, Cuba. Bachelor thesis, Havana University. 68 p.

Sasso CR, Epperly SP. 2006. Seasonal sea turtle mortality risk from forced submergence in bottom trawl. Fish Res. 81:86–88. https://doi.org/10.1016/j.fishres.2006.05.016

Schuhmann PW, Casey JF, Horrocks JA, Oxenford HA. 2013. Recreational SCUBA divers' willingness to pay for marine biodiversity in Barbados. J Environ Manage. 121:29–36. https://doi.org/10.1016/j.jenvman.2013.02.019

SWOT (State of the World's Sea Turtles). 2011. The State of the World's Sea Turtles (SWOT) Minimum Data Standards for Nesting Beach Monitoring, version 1.0. Handbook. SWOT Scientific Advisory Board. 28 p.

WWF (World Wildlife Fund). 2010. WWF Standards of Conservation Project and Programme Management (PPMS). Version: 30 June, 2017. Accessed November 2017. Available from: http://www.panda.org/standards