

THOUGHTS AND THREATS: UNDERSTANDING THE
CURRENT SEA TURTLE LANDSCAPE
IN SOUTHERN BELIZE

by

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ABSTRACT

Belize has the potential to be a sea turtle refuge due to its low population density and wealth of critical nesting and foraging habitat. The last known nationwide assessment was completed in 1992 as a part of the WIDECAST Sea Turtle Recovery and Action Plan (STRAP). Since, limited turtle nest monitoring and reporting has influenced a belief that Southern Belize may no longer be an active region for sea turtle species, including the critically endangered Hawksbill, *Eretmochelys imbricata*. This study uses an interdisciplinary approach to examine the current sea turtle landscape by conducting both ethnographic and threat surveys within three critical Marine Protected Areas (MPAs) in Southern Belize. While among stakeholders there appears to be clear misconceptions about sea turtle nesting activities and threats, sea turtles are generally viewed as valuable and positively influenced by the protective measures of the reserves. Belizean sea turtle nesting sites are currently facing both natural and anthropogenic threats at varying severities, however there are still several active sites that are relatively un-threatened. This research provides critical information regarding sea turtle nesting in Southern Belize at a time when management agencies have the opportunity to reduce threats and hopefully strengthen local nesting populations.

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CHAPTER 1

INTRODUCTION

Marine turtle populations throughout the Caribbean are at only small percentages of historic populations; according to the IUCN Red List for Threatened Species, all six Caribbean sea turtle species are listed as at least 'Vulnerable.' This designation denotes that sea turtles are at a higher risk for global extinction. The dramatic decline in sea turtle numbers is a combined result of anthropogenic and natural threats. Human influence (e.g. harvesting, coastal development, excessive plastic marine debris, and irresponsible fishing gear) is estimated to have contributed to tens of thousands of sea turtle deaths annually by destroying critical nesting and foraging habitat (Smith et al., 1992). In 2006, greater Caribbean populations of Green, *Chelonia mydas* and Hawksbill, *Eretmochelys imbricata*, were recorded at only 0.33% and 0.27% respectively of historic numbers (McClenachan et al, 2006). As a response to the dramatic decline, sea turtle research, monitoring, and conservation efforts within the Caribbean environmental community has increased (Dow, 2007). These efforts, however, rarely address the complex human-environmental issues embedded in sea turtle conservation, including drivers for local perceptions and actions relating to sea turtle threats. My research aims to address such problems specific to Belize.

Belize serves as an excellent case study for greater sea turtle conservation issues research because of its sea turtle history rich with cultural and environmental changes. In the early 1900s, shells of the now critically endangered Hawksbill (*Eretmochelys*

imbricata) played an important economic role in trade (Smith et al., 1992). Turtle meat was frequently eaten by locals, and sea turtles were culturally significant for the Garifuna people of Belize. Due to declining turtle populations and rise in general awareness, Belizean conservation groups advocated for national-scale legislative action for marine turtle protection by the early 1990s. As a result, the Fisheries (Amendment) Regulations outlawed the collection or possession of sea turtle individuals and eggs from shore, limited catch length of green and loggerhead turtles, and fully protected hawksbill turtles during their primary mating and nesting periods from April 1 to October 31. As a precursor to this legislative change, the Wider Caribbean Sea Turtle Recovery Team and Conservation Network (WIDECAST) completed the last nationwide assessment of sea turtle nesting sites in 1992 as a part of their Sea Turtle Action and Recovery Plan (STRAP). This assessment was one of several completed for Caribbean sea turtle populations. The STRAP document described the status and distribution of sea turtles and relevant threats while also proposing solutions to mitigate the identified issues. Serving as a nationwide assessment and an action plan, this report included information of known nesting and landing sites. The report suggested two areas for immediate protection due to the identification of these areas as vital for the critically endangered hawksbill turtle. Since the STRAP report's publication, several new MPAs have been designated in Belize, including Sapodilla Cayes (one of the suggested sites) in 2006 (Foster et al., 2012). Currently, there are over ten managed MPAs in Belize. The large number of MPAs leave relatively little areas of Belizean waters unprotected compared to other Central American countries.

The combination of sea turtle regulations and general marine ecosystem protection theoretically should indicate that Belize could be a refuge for sea turtle populations; ample protected habitat with limited perceived human interaction could give Belizean turtles a break in

comparison to their Caribbean counterparts. However, recent reports indicate this may not be true. The latest report published by the Belize Fisheries Department in cooperation with the World Wildlife Fund Research indicates that there are only 11 current active sites (WWF, 2017) as of 2016. Historically, sea turtle nesting sites for hawksbill, green, and loggerhead turtles were widespread throughout Belize; the 1992 STRAP report listed 52 dispersed sea turtle nesting sites nationwide. This WWF Belize Marine Turtle Report 2017 was designed as a re-evaluation of turtle nesting activity twenty-five years post STRAP publication to examine nesting activity changes post national regulations. The report indicates that historic hub areas of Hawksbill nesting, particularly in the Sapodilla Cayes Marine Reserve area, are “like fairytales to biologists that monitor these areas” (WWF, 2017). The report indicated that long term data has only been collected in two locations: Ambergris Caye/Manatee Bar and Gales Point (Northern Belize), with some data collected in the Port Honduras Marine Reserve (Southern Belize). This means that no long term data has been collected for historically important nesting areas in Southern Belize. Understanding the roles that current threats and monitoring efforts play in Southern nesting site survival is critical; is this reported lack of activity a question of an actual lack of activity or a result of a lack of recording of the activity? The answer to this question could impact management efforts and future sea turtle survival. My study investigates on the ground issues in Southern Belize that could fill this knowledge gap.

Just as there is a lack of nesting records in Belize, there is limited research discussing the threats to sea turtles that are specific to Belizean nesting locations. For southern Belize, most of the literature regarding turtle nesting sites are outdated status reports for the Port Honduras Marine Reserve from the Toledo Institute for Development and Environment (Polonio, 2006; TIDE 2011; Foley and Williams, 2012). These reports only document sporadic incidents of turtle

killings or nest disturbances from predators. Local research or reporting also does not explore the extent that outside development and coastal commodification is impacting Belizean shores as the tourism industry continues to increase. As human-environment interactions have been explained to be governed by both the access to and control of local natural resources, external coastal influences are too a part of the sea turtle landscape (Watts, 2000).

In order to mitigate both local and national threats to turtle nesting sites and turtle populations in Belize, it is important to understand the frequency and severity of such threats. As well, it is necessary to understand the underlying socio-economic issues that may be playing a role in direct threats to sea turtle nesting. My research aims to fill these gaps by providing an analysis of threats present at various nesting locations throughout the Port Honduras, Sapodilla Cayes, and South Water Caye Marine Reserves and incorporate analysis of local stakeholder perceptions of these threats to make suggestions for future management of sea turtles throughout Belize.

CHAPTER 2

LITERATURE REVIEW

The value of this study extends beyond sea turtle protection and management alone. Two themes that are central to this project, place and human-environment interactions, are two of the five fundamental themes within the discipline of Geography (Hill, 1989; Natoli, 1994). Within place, understanding the inherent natural and human characteristics of the landscape (landforms, waterways, settlement patterns, etc.) are examined, and these variables lend well to spatial representation on maps. My study examines various characteristics of Belize that cause threats to sea turtle nesting sites. Because of the similarities amongst other Caribbean countries, these spatial trends can comment on greater sea turtle threat relationships. Human-environment interactions include the resulting conflicts created along the human-natural landscape. By linking past and present perceptions of sea turtles and their threats to the spatial context of Belize, this study will fill gaps that are present in the current sea turtle landscape of Belize.

Previous sea turtle literature examines turtles from various angles, including their biological characteristics, population and migration patterns, and their role within cultures. Most notably, Archie Carr's work starting in the 1960s serves as the foundation for sea turtle research today (Ehrenfeld, 1987). Carr's works often examined the endangered Green turtles (*Chelonia mydas*). More generally, Carr provided descriptive studies of multiple sea turtle species, including their biological features (Carr and Hirth, 1962; Carr and Goodman, 1970; Carr, 1987) and behavioral patterns (Carr and Hirth, 1961; Ehrenfeld and Carr, 1967; Carr et al., 1974). This

work came at a time when such information about sea turtles was scarce, though threats were already causing a decline in population numbers. His legacy as 'the man who saved sea turtles' lives on in various wildlife reserves, particularly in his famous Tortugero National Park in Costa Rica, and through the Sea Turtle Conservancy.

Almost simultaneously, Bernard Nietschmann was studying sea turtles from a cultural perspective along the Miskito Coast in Nicaragua. Nietschmann's work uncovered the grand scale of turtle collection and the true hunting skills of the Miskito Indians. His studies shed light on the economic importance of sea turtle species (mostly Green and Hawksbill) for subsistence living and for trade amongst the greater Caribbean (Nietschmann, 1972; Nietschmann, 1979; Nietschmann, 1979). While sea turtles only played a part in Nietschmann's overall works, the legacy of his role motivating native people, particularly within the Caribbean, to take control of their own resources reminds geographers of the importance of incorporating cultural immersion and local perspectives into research.

Post Carr and Nietschmann, current research is still understanding the complex ecological and cultural roles of sea turtles. However, as ecological management and threat mitigation has become necessary to prevent sea turtle extinction, newer literature tackles the human-wildlife aspects of the sea turtle landscape. The work of Lisa M. Campbell currently leads in examining the political ecology aspects of turtle conservation, including the importance of scale within geographic studies (Campbell, 2007), the use of citizen science for improved sea turtle knowledge (Campbell and Vainio-Mattila, 2003; Cornwell and Campbell, 2012), and the overall call for an interdisciplinary approach for human-wildlife issues management (Campbell, 2005).

2.1 IMPORTANCE OF NESTS AND CURRENT THREATS

My study focuses on the threats to sea turtle nesting sites as they are arguably the most important and threatened sea turtle habitat. Nesting site selection includes three phases: selection of the beach, female appearance, and nest placement (Wood and Bjordnal, 2000). Studies indicate that abiotic factors, including moisture and temperature, affect nesting site selection (Mortimer 1980; Stoneburner and Richardson, 1981; Cardinal et al., 1998). As these abiotic factors change, the nesting site selection process can also change. The effects of climate change have consequently emerged as an important topic within the greater sea turtle conservation literature (Fish et al., 2005; Fish et al., 2008; Hawkes et al., 2009). Increased air temperatures have been linked to increased sand temperatures in some locations; this local sand warming skews nest sex ratios towards female and also favors species that predominantly nest in cooler months or locations (Pike, 2013; Laloë et al., 2016). Research also indicates that sea level rise, another consequence of climate change, is expected to increase beach erosion rates; this will reduce the availability of critical sea turtle nesting habitat (Baker et al., 2006). In the Caribbean specifically, sea levels have already increased around twenty centimeters within the last century, with an expected ten centimeters more by 2025 (Maul, 1993).

Research documenting anthropogenic threats, such as development, should be considered a priority for conservation along with monitoring abiotic factors (Richardson, 1999). Increased coastal development presents several hazards to sea turtle nesting beaches, including artificial light, various types of pollution, and beach stabilization structures. Within the wider Caribbean, over 80% of nesting sites are affected significantly by artificial lighting and pollution (Dow et al., 2007). Some types of artificial light lead to decreased green and loggerhead turtle activity on the beaches reducing overall nesting activity (Witherington, 1992). Pollution has been listed to

threaten turtles through entanglement, habitat degradation, and ingestion (Nelms et al., 2015). Sea walls, and other beach armoring structures, discourage nesting and lower overall nesting success (Mosier and Witherington, 1998; Witherington et al., 2011). Unfortunately, coastal development is the most geographically ubiquitous threat to sea turtle nesting sites (Dow et al., 2007).

While my study focuses on threats to sea turtle nesting sites, it is important to acknowledge that marine turtle populations are still threatened in the water, mostly from predation and accidental bycatch in gillnets. Though it has declined since the mid-twentieth century, turtle meat consumption and trade is still present in many regions of the world, including the Caribbean, Mediterranean, and Southeast Asia (Mancini and Koch, 2009; Nada and Casale, 2011; Chen et al., 2009). In part, this consumption is a result of turtles as bycatch. Traditionally aimed to catch lower-swimming commercial fish, gill nets can entangle sea turtles by capturing their heads and fins, resulting in the drowning of the turtle or eventual limited use/loss of limb entangled (NOAA). Gill nets, though efficient, also can damage habitats including coral reef structure. Common nicknames for the nets are include “wall of death” or “curtain of death” (Sneed, 1991; Bauer, 2007). Though bans throughout the Caribbean have occurred limiting gillnet use, a recent study discovered that gill net use is still one of the more common tools among the southern Belizean fishermen studied (Mayhew, 2016). While these threats do not directly affect nesting sites, they do target turtles that otherwise might nest in Belize, particularly if they are females just prior to appearance (step two of site selection).

The aforementioned threats occur on both national and international scales. One difficult aspect of managing the widespread threats to sea turtles is that they are highly migratory species. This requires management cooperation between many nations and Institutions (Smith et al.,

1992). Therefore, while localized efforts are very important for species conservation, the need for regional cooperation adds another level of complexity to sea turtle conservation. Gillnet usage in one country could still pose a threat to turtles during their lifecycle despite a localized ban in another; reducing pollution in one country may not reduce in water and on beach pollution concentration to a non-harmful level. This issue particularly important as sea turtles do not return to nest every year. While it varies by species, it has been recorded that sea turtles return to nest every two to four years (Carr, 1980). During that time, turtles are exposed to all of the threats that are present along their travels, regardless of the threat status of their nesting beach.

2.2 BELIZE

Belize is a Central American country located on the Caribbean Sea just south of the eastern edge of Mexico's Yucatan Peninsula and east of Guatemala. Belize is home to 380,010 people, with an 11.1% unemployment rate and 41.3% poverty rate (Statistical Institute of Belize). The country is highly influenced from its past as a British colony, and English remains the main language. However, both Creole and native Mayan influences create a diverse cultural landscape throughout the country.

At 27,700 square kilometers in total area, Belize is only 274 kilometers at its greatest length and 109 km at its greatest width. Though relatively small in area, Belize is rich with biodiversity housed in its various mountainous, wetland, lowland jungle, and coastal landscapes. In addition to the mainland, Belize contains over 200 cayes of various sizes that border the Mesoamerican Reef. These cayes are crucial areas of nesting habitat for the various sea turtle species present in Belize. The Mesoamerican Reef, second to the Great Barrier Reef in Australia, is one of the largest reef systems in the world with almost 1,127 km of critical habitat for various marine species, including the endangered sea turtle populations focused on within my study

(Foster et al., 2012). Belize is sometimes referred to as a leader in marine protection for having nearly 4,000 km² of managed Marine Protected Areas (MPAs) and for their relatively extensive implementation of no-take zones (Dahlgren, 2014).

With ample biodiversity, a relatively low population, and active environmental regulations, it could appear Belize is a haven for marine ecosystems, and particularly sea turtles, relative to human impacts. However, these factors do not exempt Belize from struggles within the human-environmental landscape. Belize has an extensive history of sea turtle extraction for trade and subsistence living. In part, this resource use has resulted in only three of the five species that have been recorded in Belize (hawksbill, loggerhead, and leatherbacks) to be commonly seen in the waters (Dow, 2007). Green sea turtles (*Chelonia mydas*), though recorded to still nest in Belize as of 2016, are rarely sited (TIDE, 2017). Currently, threats of population pressure and development expansion are currently plaguing local marine ecosystems and critical marine turtle habitat (Foster et al., 2011; Mumby, 2012). Anthropogenic threats are expected to continue as tourism and coastline development is increasing at an alarming rate; in 2008 alone, over 840,000 tourists arrived in Belize, and this rate is expected to increase by at least one third by 2020 (Foster et al., 2012). In order to accommodate the increase of tourists, development along highly desirable shorelines will be required. Many of these resorts are funded from international sources. Therefore, the role that foreign development plays in ability to mitigate threats to sea turtles should be at the forefront of sea turtle conservation conversations.

Finally, reports from local community members have also indicated extreme coastal erosion occurring along the southern coast. Some beaches near Monkey River in Southern Belize have completely disappeared within the last few years, and that it is not the only location that this phenomenon is occurring (e-Communication with James Foley, TIDE Director). Because of a

combination of natural forces and anthropogenic climate change, this erosion is negatively impacting coastal areas throughout Belize on both environmental and societal levels (Fuller and Wilson, 2002; Karlsson and Hovelsrud, 2015; Karlsson et al., 2015).

2.3 IMPORTANCE OF LOCAL KNOWLEDGE FOR CONSERVATION

While the biological aspects of sea turtles are well documented, more social science research needs to be done to speak to the human-wildlife conflict component of sea turtle conservation (Campbell, 2003). As several threats to marine turtles and their nesting sites are anthropogenic, an ethnographic study is a crucial part of this study to greater understand the Belize-specific sea turtle landscape. Recognizing the importance of sea turtles as a resource at the local level is critical for the success of a sea turtle conservation plan because of the human-turtle history present throughout many regions. Sea turtle consumption and trade, while illegal, still occurs due to various potentially locale-specific reasons (Rudrud, 2010; Senko et al., 2011). A conservation plan gives guidelines on human actions to improve or maintain environmental conditions; incorporating social sciences to bridge the gap between ecological knowledge and the success of conservation programs therefore is a necessity (Mascia et al., 2003).

CHAPTER 3

LOCAL CONVERSATIONS

The cultural perception survey for this study examined four aspects of local marine reserve stakeholder involvement with sea turtles: 1) the type of benefits (economic or ecological) that are associated with marine turtle populations; 2) the knowledge of the presence and severity of threats to turtles that are affecting their marine reserve; 3) observed changes to turtle populations and nesting activity and where the changes are located; and 4) the perception of the impacts of marine reserves for stakeholders on their daily lives and for turtle protection.

3.1 METHODS

During the summer breeding months in 2017, I conducted semi-structured interviews with stakeholders in both northern and southern Belize to record their knowledge and understanding of the severity of the threats to sea turtle in Belize. Participants were selected after my presence as a researcher and TIDE affiliate was established in the area using the Snowball sampling technique. Using this technique allows to compensate for the uneven interaction of locals with sea turtles and their nesting sites (Steinberg, 2016). I first began interviewing in Southern Belize with TIDE workers and affiliates due to close proximity. One of the captains that works with TIDE is also a part of a well-established tour group in the area. The group is a family of brothers that are fishermen, tour guides, and captains. These brothers served as my next

source of responses. My conversations within this family connected me with their extended family members and other MPA stakeholders. TIDE also invited me to participate at a local fisherman's forum that hosted around 30 PHMR and SCMR stakeholders. During free time during the forum, I attempted to interview as many willing stakeholders as possible. Respondent acquisition in Northern Belize involved me wandering into tour shops and asking if anyone who was knowledgeable about sea turtles had a spare moment to chat. Often, the guide I spoke to would refer me to another dive shop in town. While some efforts were fruitless, my conversations at tour shops ultimately led me to the Hol Chan Marine Reserve main office, where I was able to interview several types of stakeholders, including a marine biologist and a technical worker.

The cultural perception survey consisted of questions that were all optional; respondents were able to pick and choose which questions they could answer, though they were encouraged to complete the survey. Accommodations were made for varying levels of English literacy. For respondents that spoke Spanish, the questions were read aloud to them in Spanish. For respondents that were uncomfortable writing their answers, answers were recorded for them. For respondents that were more interested in having a conversation, notes were recorded relating to the four main questions of the survey. A total of 19 surveys were completed between May 9 and July 11, 2017. See Appendix for survey in full.

3.2 RESULTS

A total of 6 surveys recorded from stakeholders in the north (Ambergris Caye) and 13 from the south (Port Honduras and Sapodilla Cayes Marine Reserve). All surveyed individuals were Belizean males and ranged from 20-68 years in age, with the average age of 35.5 years (Table 3.1). Most respondents indicated that they were primarily fishermen (6 of 19) (Figure

3.1). Professions listed under "Other" include NGO worker, Sustainable Tourism Manager, and Technical Assistant for a Marine Reserve.

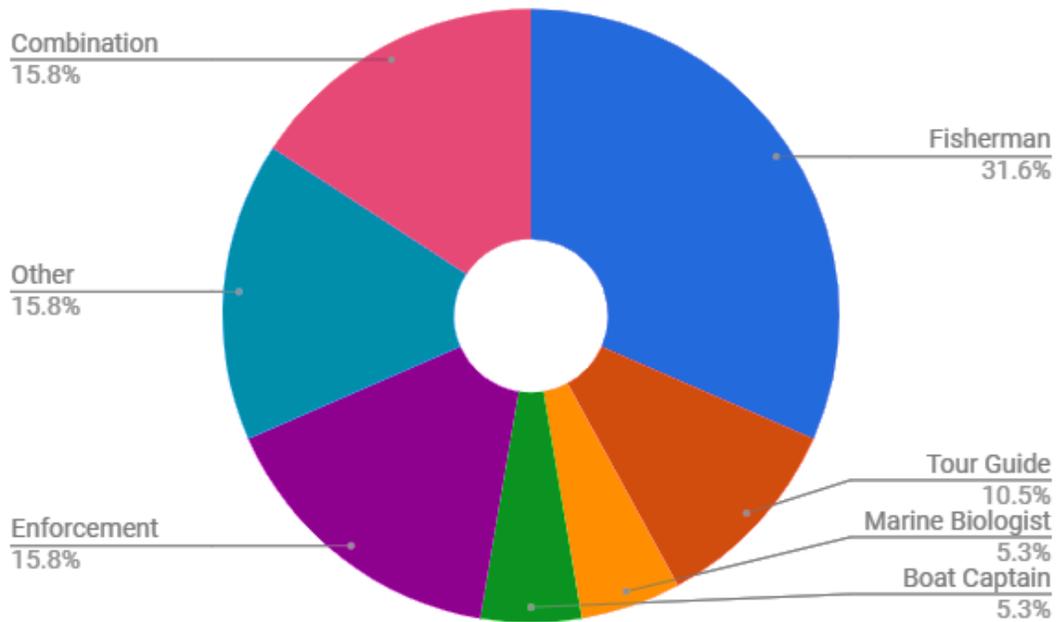


Figure 3.1. Primary source of income identified by respondents of 2017 stakeholder survey in northern and southern Belize (n = 19). ‘Combination’ answers reflect responses where at least two options were selected for primary income source. ‘Other’ answers reflect specific professions that were in between job categories.

Table 3.1. Age of respondents (n = 19) for surveys completed between May – July 2017. Respondents include stakeholders for marine reserves in northern and southern Belize.

Age (years)	Number of Respondents
20-24	3
25-29	6
30-34	1
35-39	3
40-44	2
45-49	0
50-54	1
55-59	1
≥60	2
No Answer	1

PERCEPTION OF SEA TURTLES AND THREATS

A majority of responses indicated that sea turtles have both economic and environmental value (16 and 18 of 19 respectively). About half of responses (9 of 19) indicated that sea turtles are neither over nor under protected with current regulations in Belize. Over half (10 of 19) admitted to having collected sea turtles in their lifetime, though when asked why, the most common answers included for food prior to regulations and for rescue. 11 of 19 responses indicated they had eaten sea turtles in the past, with the most recent date of 12 years ago. Of the threats listed in the survey, the threat that was identified as the greatest concern by the greatest

number of people (11 of 19) was coastal erosion, followed by coastal development (9 of 19). Egg collection is the threat of least concern amongst the respondents (7 of 19), while other threats had varying degrees of concern amongst the respondents (Figure 3.2). When asked what threats to turtles and their nests were not listed, responses indicated threats of boat traffic, other fishing equipment such as long lines, trash pollution, overall climate change, and illegal fishing activity from Guatemala. Generally, these threats did not vary greatly between the Northern and Southern stakeholders (Table 3.2). Values for perceived threats of coastal development, hunting of sea turtles, and use of nets varied by over one categorization. The greatest variation between groups was for perception of sea turtle hunting (1.08), while the lowest differences were egg harvesting and predator disturbance (0.42).

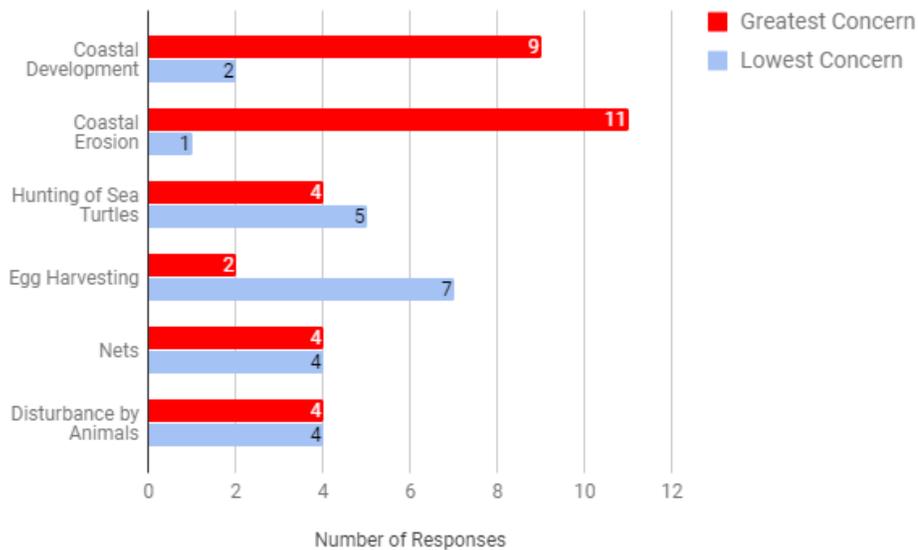


Figure 3.2. A reflection of the number of responses that indicated extreme views (of greatest concern or of lowest concern) for particular threats to sea turtles and their nesting sites from 2017 surveys.

Table 3.2. Difference between Northern and Southern regions on perception of threats to sea turtles. Values are averaged from survey responses indication that 1 = least concern, 5 = greatest concern.

	Northern (n = 6)	Southern (n = 13)
Coastal Development	4.67	3.67
Coastal Erosion	4.5	4.17
Hunting	2.17	3.25
Use of Nets	4.00	3.00
Egg Harvesting	2.33	2.75
Predator Disturbance	2.83	3.25

CHANGES IN TURTLE NUMBERS AND NESTING ACTIVITY

Most survey responses indicated an overall decrease of both turtle presence and nesting activity noticed throughout their lifetime (8 and 7 of 19 respectively, Figure 3). Some respondents left the answer blank because they were unsure of how to distinguish between past and present numbers. Specific locations for these changes ranged throughout the cayes of Belize, with no particular region listed more than another.

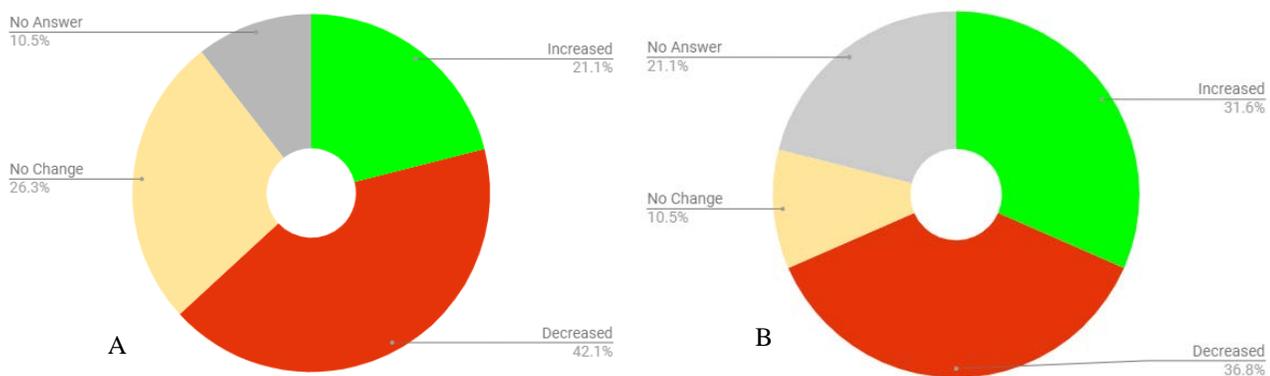


Figure 3.3. Percent of conversations indicating observed changes in turtle presence over the respondent's lifetime for A – turtle numbers; B – turtle nesting activity.

IMPACT OF MARINE PROTECTED AREAS (MPAs)

Overall, MPAs were indicated as positive influences on the daily life of stakeholders and positively affected sea turtle population numbers within Belize (8 of 19 and 10 of 19 respectively, Table 3.3).

Table 3.3. Responses to the impacts of marine reserves from 2017 conversations. (n = 19; '+' indicates positive or beneficial effects, '-' indicates negative or harmful effects, '+/-' indicates mixed beneficial and harmful effects).

	Yes +	Yes -	Yes +/-	No	Unsure	N/A
Daily Life	8	2	2	1	0	6
Turtle Populations	10	1	1	1	2	4

3.3 DISCUSSION

Based on the survey results, perceptions of the status of turtles, their nesting sites, and nesting site threats varied amongst the stakeholders. In general, respondents had favorable views of turtles: they are “something that [they] like to see,” fisherman (age 50); “absolutely [they are important]. I love turtles,” tour guide and sales (age 20). As all stakeholders made a living from marine resources, the high percentage of responses that viewed turtles environmentally and economically important is not surprising. One resort manager (age 59) indicated that “[turtles are] important to all species,” in the marine environment. Locals also mentioned sea turtle's role in and value to Belizean eco-tourism, mostly just because tourists enjoy turtles; “Tourists love turtles. Divers really like sharks while snorkelers like the turtles more,” northern based tour guide (age 20). Primarily tour guides also speculated that tourists are also more likely to go on a tour if there is a high chance that they will see them based on their own observations. An interview with a resort manager, previous tour guide, and marine activist indicated that the sight of a single turtle in his experience adds significantly to the tips from a tour. He explained that for

one tour, a group might tip an extra \$5 US for seeing a sea turtle. While for one tour, this may not seem like much, these tour guides give several tours a week, and sometimes even a day. If a guide are three tours a week for a month, that can lead to an extra \$45 US, or \$90 BZE for no extra work on part of the guide. These numbers seemed to encourage guides to take tourists to turtle spots; one guide mentioned that he and others would feed the turtles consistently at one spot so that they could take their tours out there and almost always see a turtle to improve their tips.

Overall, these responses support statements made by the World Bank indicating that resources inside the Caribbean Sea, including associated biodiversity conservation and tourism, have the potential to be the frontier for the growth of neighboring countries, though little is known about the true economic value of each resource (Pail et al. 2016). Further developing these economic influences, especially on a local level, might influence the creation and resulting success of management efforts, especially for sea turtles. This may indicate that sea turtles still have a role to play within current regulations; they are a critical part of the tourism industry which is expected to increase from 47 to 70 million dollars throughout the Caribbean by 2024 (Pail et al. 2016) and also hold an ecological role that is acknowledged by stakeholders:

Already, “a lot of fishermen (local) know the importance of protecting the turtles,” boat captain (age 42). With only three responses indicating the contrary, marine reserves as well are viewed to positively impact sea turtles and the greater marine environment:

"[If] they are more protected [by MPAs] they would find refuge,"
reserve enforcement (age 27).

"[MPAs] increase the numbers of turtles because of regulations,"
university lecturer/managed access officer (age 28).

"[MPAs] can help the turtles as a landing site for turtle nesting,"

fisherman (age 29).

"MPAs are helping to protect turtles, maybe not 100% because there are still some fishers that still fishing for them,"
reserve enforcement (age 20).

"[MPAs] contribute to the increase of marine turtle numbers"
HCMR technical assistant (age 27).

"In the way of protecting habitat for the marine life,"
tour guide and boat captain (age 36).

"The marine protected areas help in growing the natural habitats [for turtles] in the area. Once properly managed it can support the fish population as well as fishers,"
resort manager (age 59).

In addition to their positive influence on sea turtle numbers, stakeholders generally like marine reserves and even acknowledge that they depend on them for their livelihood:

"[MPAs have] actually has better our daily life,"
HCMR technical assistant (age 27).

"My life depends on it, of the high protection of the resources,"
Southern reserve ranger (age 27).

"[Because of MPAs] there is an abundance in whatever you like,"
fisherman and tour guide (age 23).

"[MPAs] create job opportunities,"
tour guide and captain (age 36).

"[MPAs] had a positive impact in my life as a boat captain. There have been increased turtle sitings and nestings in [Placencia]. Had a positive impact on tourism which created more jobs for us Belizeans,"
boat captain (age 42).

Most complaints regarding managed areas expressed frustration with regulations limiting what fishermen can do out in the waters, including gear use:

"It has stopped our normal fishing practices – like number of hooks we can use and set lines,"
fisherman and farmer (age 37).

"[MPAs] looks good on paper, but in reality only those involved benefit; fishermen get screwed,"
fisherman (age 50).

While this was not the majority, these responses may indicate that fisherman have been struggling recently, and feel like they could make more money in the short term if regulations were loosened.

Based on these general results, implementing sea turtle protection measures through MPAs may be a good method moving forward. However, the issues expressed by the fisherman should be heard and addressed to keep moral and respect for the institution of MPAs high. Some of these interviews were conducted at a Fisherman's Forum meeting held by TIDE. This forum invited stakeholders from both the Port Honduras and Sapodilla Cayes Marine Reserve. At this meeting, fishermen expressed and discussed their concerns with managers. In turn, TIDE workers and managers gave informational presentations regarding the updated regulations and their associated ecological and community benefits. Continuing meetings such as the Fisherman's Forum will help keep stakeholders involved and maintain overall positive perceptions of managed areas, allowing them to be successful in future.

There was great variation of perception of threats to sea turtles and their nesting sites amongst stakeholders. Coastal erosion was generally agreed upon as being a threat of great concern for turtles throughout Belize; "the sand shifts and [the turtles] notice," says a fisherman (age 50). However, many responses mentioned coastal erosion in light of affecting communities, and not just for sea turtles. For Southern Belize, it is likely that this view may be highly impacted by the frequency of coastal erosion in local news. Monkey River, a coastal town in Southern

Belize approximately 45 km from Punta Gorda and a previously listed STRAP nesting site, has been facing extreme rates of coastal erosion. The once thriving town that at one point was in the news for harboring most of the tourism for southern Belize is now being written about as a town that once was, with homes and graveyards falling into the sea. For Northern Belize, coastal erosion is combated by a large concentration of sea walls covering the caye to protect the many resorts; “Sea walls are the biggest change” on south Ambergris Caye according to a Hol Chan Marine Reserve technical assistant (age 27). Only three respondents discussed coastal erosion in the light of recent climate conditions, one tour guide and boat captain (age 36) stating that “global warming is affecting slowly but surely, the rising sea levels are slowly covering nesting areas and washing and eroding the beach areas.” Most other responses did not imply there was a connection between coastal erosion and sea turtles, and instead viewed it as a threat to communities. Either way, it is clear that rising sea levels and associated coastal erosion is occupying the minds of Southern Belizeans.

Coastal development and the associated foot and vehicle traffic is also generally considered a great threat among the stakeholders. Ambergris Caye (Northern Belize) respondents indicated concern regarding the expansion of the road that goes along the coast. "The road makes things easier to start building," according to an Ambergris Caye based marine biologist (age 37). During my time visiting Ambergris Caye, I rode a bike down the main road until it ended; it is true that as of now, passage to the northern tip of the caye is difficult without a vehicle. The further north on the road that you go, the fewer tourist-friendly spots there are. The hotels, restaurants, and bars become scarce, and the roadside vegetation is less kept. I stopped at a hotel bar that was at the end of the part of the road that I could access with my bike. The bar was small, and the two women that were working it were surprised that my friend and I had even

biked that far, as most people who visit them are on golf carts or ATVs. Assuming that we were strictly tourists, a few locals that were also stopped there joked with me that they would take us to Mexico on their ATV if we wanted, for it was just a few miles up the beach. They indicated that the path would be too hard to travel with bikes, for it was bumpy and wild. With the road expansion, more people would be able to visit the end of the island. Perhaps it would increase foot traffic across the Belizean-Mexican border. These presently relatively untouched and less developed areas currently serve as a refuge away from the chaos of tourism for nesting turtles according to reports from locals. Ambergris Caye respondents indicated concern about the increase of golf carts and cars driving on the beaches, disturbing nests and deterring females from nesting.

In southern Belize, development along the coast is at a much lower concentration in comparison to Ambergris Caye, though an increase in tourism is impending. Recent news from the Port Honduras Marine Reserve indicates that a request for a resort was submitted for West Snake Caye early in 2017. While it is understandable why the cayes are alluring to developers, it not only serves as an important social gathering point for locals, but it is also recorded active nesting site for the critically endangered hawksbill turtle. The Environmental Impact Assessment (EIA) for the resort, Caribbean Castaway, neglects to discuss the critical importance as a nesting site. The resort indicated that they plan on using the Punta Gorda town dump for their waste. This dump is far from regulated, and mostly consists of waste haphazardly piled within a semi-clear plot of land within the Rio Grande watershed. Considering that Punta Gorda receives near 4 meters of rain a year, this contributes to high amounts of plastic waste that enters PHMR and washes up on the local cayes. This resort also planned on clearing about 30% of the vegetation, including thinning some of the mangroves that are critical for coast stabilization and storm

protection. Already, coastal erosion is a main threat for turtle nests on West Snake Caye. As well, coastline vegetation plays a critical a role in the nesting site selection for the critically endangered hawksbill turtle (Varela-Acevedo, 2009), therefore reducing the available vegetation will negatively affect the population.

TIDE doesn't apparently have jurisdiction for the shoreline or the caye themselves. Building this resort would have negative impacts to the community as well, as this island is used for a lot of social gatherings. Though the development of the resort has been combated by TIDE, this particular project has not been officially terminated. This resort is only one of the many other requests to come as tourism in Belize continues to increase and spread towards the South. Local stakeholders in southern Belize agree that development is an increasing issue:

“el desarrollo en la costa ha cambiado mucho y es una amenaza / Development on the coast has become very important and is a threat,” fisherman (no age provided).

Based on the responses, stakeholders more greatly connected development to threats to turtles and nesting than coastal erosion. It is interesting to note the slight variations between of responses between Northern and Southern stakeholders. While many stakeholders from the North indicated that they grew up in Southern Belize, their experiences working in the more developed Northern region has impacted their views. For example, the average value associated with coastal development was at 4 of 5 (with 5 being a threat of greatest concern). This varied from Southern stakeholders by one degree.

When asked in particular where the changes of turtle presence or nesting presence occurred, I received a lot of blanket answers: “All over!” “The sea” “The cayes”. These responses came from various types of stakeholders, including NGO workers, tour guides, and fishermen. Though these results may be the most unexpected, they arguably are the most

important as they could shed light on a greater issue of the lack of nesting site awareness. I heard comments from fishermen including “turtles don’t nest on the mainland beaches” and “turtles don’t nest in northern Belize.” Though I only had a few weeks of observations under my belt, I knew at the time that these statements were incorrect. Turtles are highly migratory creatures, but the lack of precision within responses is cause for some concern when implementing spatially regulated turtle conservation efforts. It indicates that awareness regarding the location of important foraging and nesting grounds for sea turtles throughout Belize may not be well known.

Another observation is that Belizeans are concerned with being perceived as a turtle friendly people. Quite often a defensive stance was taken when talking about Belizean’s past of eating now protected turtles. The blame for issues occurring in southern Belize in particular was cast off to Guatemala, their southern bordering country. For example, several fishermen indicated that there are illegal fishers from Guatemala; if turtles were being hunted in the marine reserves than ‘it must be the Guatemalans’:

“Fishermen from neighboring countries are the ones who hunt the turtles to sell in their country. In Belize, the turtles are protected,” boat captain (age 42).

In the eyes of the stakeholders, Belizeans "listen to the lawmakers of the country," fisherman (age 65). While this study focused on examining turtle conflicts in Belize, during my field season I was able to make a quick visit to Guatemala to renew my tourist visa. In Livingston, a port town in Guatemala only forty minutes by boat away from Punta Gorda, Belize and the Port Honduras Marine Reserve, I saw several stands in the Livingston market sold turtle products, including full adult and juvenile hawksbill shells and jewelry crafted of hawksbill shells. As well, I experienced jewelry makers on the beach using the fact that their earrings were made from real hawksbill shell; the jewelers used this fact to try to convince me to purchase them if this made them more valuable to me as a tourist. This trade of hawksbill products is illegal

throughout the Caribbean. Upon return to Belize, I was sharing my pictures of the illegal products with fellow TIDE workers, and they expressed feelings of concern and disgust. While in Belize, I had never seen turtle products being sold on the streets of Punta Gorda as openly as I had in Livingston, so I decided to do some deeper exploration. Tucked away in the back of some shops, I did find turtle shell earrings in Punta Gorda. While the shop owners did not display them as openly as the shops in Guatemala, there slightly tucked away and hidden in some of the shops in Punta Gorda, Belize, hawksbill jewelry is also sold.



Figure 3.4. Photos from a market in Livingston, Guatemala (~31 km from Punta Gorda, Belize). Photos taken in June, 2017.

At the conclusion of the semi-structured interviews, several stakeholders had comments on what should be done moving forward regarding turtle conservation. Some indicated that more research similar to this project needed to be done because it was important to understand the issues from various angles:

“Keep on doing research and take the nest away and place the turtles after they hatch,”
reserve enforcement (age 27).

"Do more patrol when the turtles are nesting and keep watch [on] them while they nest,"
fisherman (age 29).

One fisherman indicated that perhaps Belize is ready to change current sea turtle regulations:

“I believe that sea turtles can now be harvested sustainably. Short open season (3 months) to decrease pressure from other marine products,”
university lecturer and managed access officer (age 28).

Overall, the information learned from these survey responses provided critical information regarding the greater sea turtle landscape within Belize. Belizeans care about sea turtles for both their environmental and economic values. Increasing knowledge about turtle nesting locations and threats may help reduce future nesting loss from erosion and development. One method of doing could include increased monitoring programs that engage locals with sea turtle patterns. Though these responses were only from a limited group of stakeholders, they provide hope for sea turtle population recovery in the future through community efforts and awareness through the avenue of MPAs.

CHAPTER 4

THREAT ASSESSMENT ANALYSIS

This chapter examines the results of the threat assessment conducted throughout Belize in the summer of 2017. Examining threats for sea turtles is notably difficult due to their migratory nature. However, conducting threat assessments to study regional nesting habitat loss may help solve this issue; understanding threats at a smaller scale allows for more manageable solutions to threats. This study examines threats to known nesting locations in three marine reserves in southern Belize: Port Honduras, Sapodilla Cayes, and South Water Caye. Results from this assessment were mapped to identify geographic areas of greatest and lowest concern. Site specific suggestions to mitigate threats are offered per marine reserve (See Appendix 7.3).

4.1 METHODS

STUDY SITES

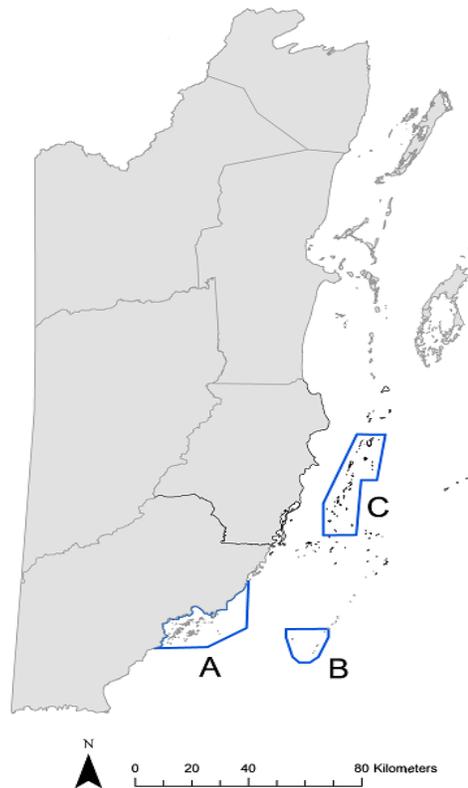


Figure 4.1. Map of threat assessment study areas.

A. PORT HONDURAS MARINE RESERVE

The Port Honduras Marine Reserve (PHMR) protects 41,400 ha along the southern tip of the Mesoamerican Reef. The nearest municipality to PHMR is Punta Gorda, a town with a population close to 5,000 people which is right on the marine reserve edge. The PHMR is primarily managed by the Toledo Institute of Development (TIDE) and the Belize Fisheries Department. The latest management plan (2011 – 2016) for the marine reserve indicates that sea turtles are a conservation target; this listing is to keep with the International Convention for the Protection and Conservation of Sea Turtles for the Western Hemisphere of 1997 that calls for necessary turtle protection. The plan includes a Sea Turtle Monitoring Programme for in-water and nesting sea turtles. From 2009-2015, TIDE managers surveyed nesting activity for four sites

in PHMR: West Snake Caye, South Snake Caye, Punta Ycacos Beach, and Punta Negra. These monitoring efforts were supplemented with dominant vegetation cover, threat appearance, and beach profile data for the years 2013-2015 for the same four sites. Five sites were surveyed in this reserve: Punta Ycacos Beach, Snake Cayes (East, West, and South), and Punta Negra.

B. SAPODILLA CAYES MARINE RESERVE

The Sapodilla Cayes Marine Reserve (SCMR) protects 15,618 ha and is the southernmost marine reserve in Belize lying entirely on the Mesoamerican reef. In 1996, the reserve was listed as a World Heritage Site as an IUCN Category IV (Habitat/Species Management Area). The nearest municipality to SCMR is Punta Gorda 50 km to the east. The close proximity of the cayes to Guatemala and Honduras combined with the increasing tourism industry in Punta Gorda lead to increased foreign visitors to these cayes according to local reports. The PHMR is managed by the SEA (Southern Environmental Association) Belize and the Belize Fisheries Department. According to management plan for the SCMR prepared by Wildtracks for 2011 - 2016, sea turtles are listed as the first potential conservation target species, and are included as a reserve resource in reference to current threats for the reserve as whole. At the time of survey, there were no consistent records for turtle nesting in the marine reserve (Wildtracks, 2010). Ten sites were surveyed in this reserve: Ragged Caye, Lime Caye, Hunting Caye, Nicholas Caye, Frank's Caye, Northeast Caye, Tom Owen's Caye, Redrock Sandbore, CocoSolo, and Ranguana Caye.

C. SOUTH WATER CAYE MARINE RESERVE

The South Water Caye Marine Reserve (SWCMR) is the largest protected area in Belize at 47,703 ha. Along with the SCMR, SWCMR is listed as one of the World Heritage Sites for the Mesoamerican Reef in 1996. The nearest municipality to SWCMR is Dangriga, a town with a

population near 10,000 people 24 km to the east. The SWCMR is managed by the Belize Fisheries Department. Sea turtle nesting data is consistently kept on Carrie Bow Caye by the Smithsonian Research Station, and sea turtle protection is a goal of the marine reserve management plan to keep with the International Convention for the Protection and Conservation of Sea Turtles for the Western Hemisphere of 1997. Turtle nesting areas are listed as a conservation target within the SWCMR Management Plan, meaning it will be used as a metric to evaluate the management plan's success. Data regarding nesting patterns on other cayes is limited besides data collected on Carrie Bow Caye. Four sites were surveyed in this marine reserve: Tobacco Caye, South Water Caye, Twin Cayes, and Carrie Bow Caye

SURVEYS

For this threat survey, I examined a total of 15 locations previously listed as nesting sites in the 1992 STRAP report between May and July, 2018. I adapted the 2006 Sea Turtle Threats Survey from a WIDECAST report (Dow et al, 2007). The survey includes 17 threats, and each site was given a ranking: R = Rare, O = Occasional, F = Frequent, FA = Frequent in a certain Area, U = Unknown. These ranks were translated into a Likert-style scale, where a score of 1 indicated the threat was rare, while 5 indicated that the threat was frequent. See Appendix for survey in full. For some sites, I was able to determine the presence and severity of all 17 threats on my own. However, for some threats on some sites, information regarding their presence and severity was limited. Due to lack of resources or access, I examined locations as much as possible, supplementing my observations with information provided by knowledgeable locals when needed. These locals were affiliated with TIDE or other management agencies who were familiar with the area.

To spatially represent the overall impacts of the threats observed, I calculated an Overall Threat Score (OTS). The OTS is a summation of the aforementioned threat values by location. Locations with a high OTS indicate a nesting site that is considered more threatened than a location with a low OTS. This calculation assumes that threats have the same weighted effect on nesting turtles. As well, this number assumes that unknown threats are considered Rare/1.

4.2 RESULTS

Sea turtle nesting is still active in southern Belize, and threats vary in presence and severity by marine reserve. Of the three marine reserves surveyed, SWCMR appears to be the most threatened, and the SCMR appears to be the least threatened. The most common threats observed throughout all the reserves was pollution from trash and nest lost to abiotic factors (i.e. erosion).

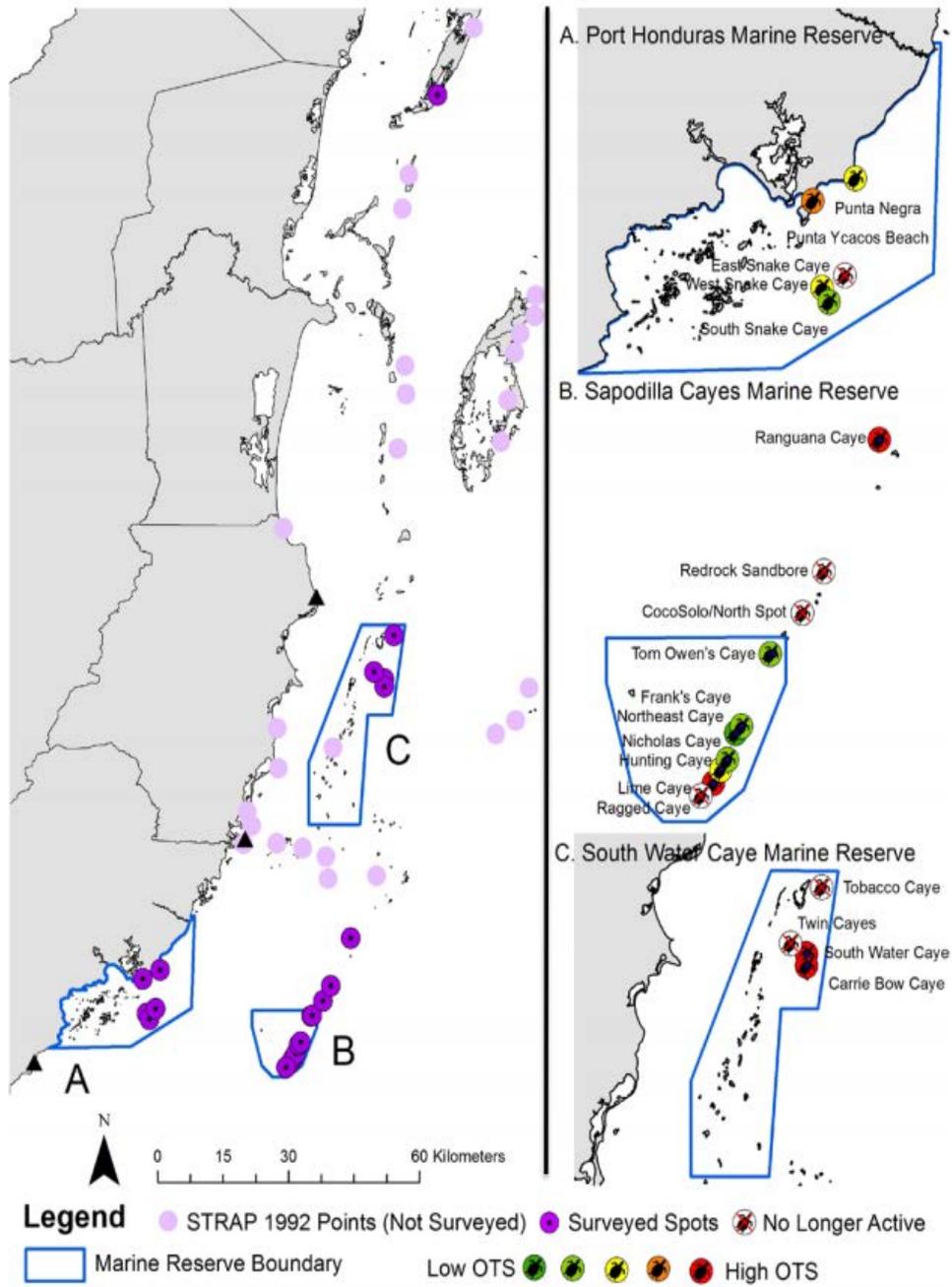


Figure 4.2. Locations of marine reserves studied during the summer of 2017. Results of OTS are mapped. Color scale represents severity of overall threats.

Table 4.1 Frequency of threats listed on the WIDECAS^T 2007 threat survey adapted for this project. By marine reserve, threats are counted based on their presence greater than ‘Rare’. N values reflect total of active sites per reserve.

	PHMR (n = 4)	SCMR (n = 7)	SWCMR (n = 3)
1. Killing of nesting females by humans	0	0	0
2. Killing of nesting females by predators	2	0	3
3. Nest loss to predators	2	0	3
4. Nest loss to abiotic factors	2	2	3
5. Egg Collection (by humans)	0	1	0
6. Harassment due to increased presence of humans	0	1	3
7. Artificial lighting	0	0	3
8. Pollution	1	3	3
9. Beach erosion/accretion	4	2	0
10. Beach armoring/stabilization structures	1	1	3
11. Beach nourishment	0	0	0
12. Recreation beach equipment and/or other obstacles	3	1	1
13. Mechanized beach cleaning	0	0	0
14. Beach vehicular use	0	0	0
15. Sand mining	0	0	0
16. Exotic (or loss of native) vegetation	3	2	2
17. Livestock (presence on the beach)	0	1	0

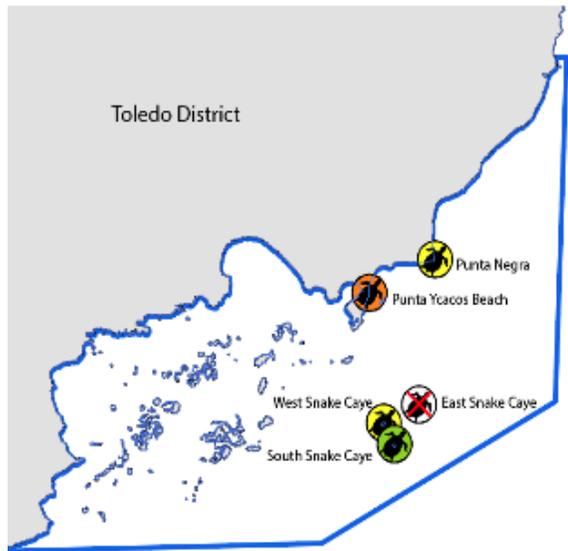


Figure 4.3. Threat assessment results for PHMR (from Figure 4.2)

The most common threats to PHMR nesting sites include beach erosion and native vegetation loss (Table 4.1). The least threatened site is South Snake Caye, while the most threatened is Punta Ycacos Beach. I observed several nests on Punta Ycacos beach that were disturbed by predators, egg shells broken open and eaten. The beach was also littered greatly with trash of all sizes. Only one site, East Snake Caye, was listed as a nesting site in 1992 that is no longer active according to local reports. Data collected by TIDE managers indicates sea turtle nesting trends have overall increased in the Port Honduras Marine Reserve between 2009 – 2015. The most active year for PHMR was 2010 with a total of 21 nests found, all on the Snake Cayes. Of the sites surveyed, Punta Ycacos was the most visited nesting site by turtles, with 15 nests recorded at its peak year in 2014. While nesting species was rarely recorded in the data, if a species was listed it was Hawksbill. In 2012, the lowest number of nests were recorded across all sites in the PHMR (5). Threat analysis indicates that threats are unevenly distributed amongst the marine reserve, but are generally not severe (Figure 4.3). Other data collected by TIDE indicates that they surveyed sites have also seen a change in vegetation cover from 2013 – 2015, primarily

in the loss of sea grape (*Coccoloba uvifera*) trees. This may be due to increased erosion patterns, which were visible during my site surveys.

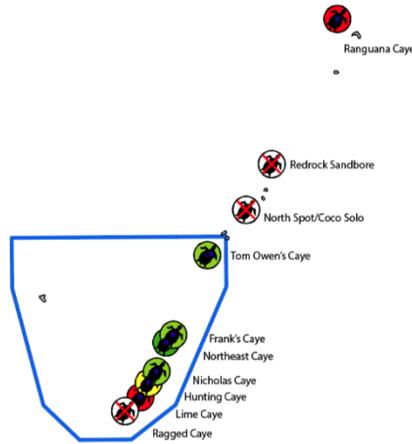


Figure 4.4. Threat assessment results for SCMR (from Figure 4.2)

The most common threats to SCMR include pollution from trash and beach erosion (Table 4.1). For example, Lime Caye has experienced great erosion over at least the past 20 years, with one side of the island very steep with palm trees falling into the sea. Overall, threat results indicate a variety of threat levels for the cays, but mostly the cays are relatively unthreatened. Inside the reserve, one site (Ragged Caye), and two sites outside the reserve (CocoSolo/North Spot and Redrock Sandbore) were listed as a nesting site in 1992 and are no longer active according to local reports. Observations from this study indicate that the Sapodilla Cayes are still active for turtle nesting patterns, particularly on Nicholas and Lime Caye. Nests were recorded on these cays as early as May 9, 2017.

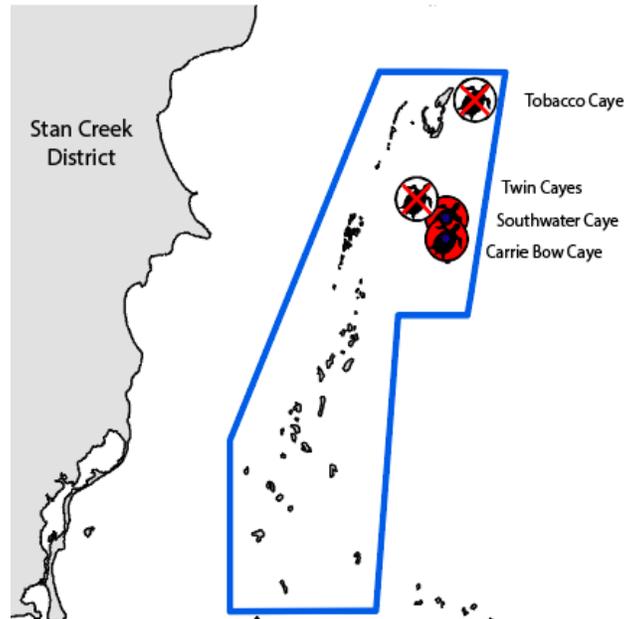


Figure 4.5. Threat assessment results for SWCMR (from Figure 4.2).

SWCMR had the highest presence of threats of the three marine reserves surveyed. The most common threats to SWCMR nesting sites include: artificial lighting, beach erosion, beach armoring/stabilizing structures, pollution, harassment due to increased amount of humans, nest loss to predators, killing of nesting females by predators, and nest loss to abiotic factors (Table 4.1). Two sites, Twin Cayes and Tobacco Caye, were listed as a nesting site in 1992 that are unlikely still active. While in 2008, there was some reports of green turtle nesting (Wildtracks 2009), this is most likely no longer true according to local reports. Carrie Bow Caye Turtle nesting data collected by members of the Smithsonian Tropical Research Institute indicates that as of 2016, both Loggerhead and Hawksbill turtles are still active nesters on the caye.

4.3 DISCUSSION

It is clear that Southern Belize is still active relative to turtle nesting for Hawksbill and Loggerhead turtles, and that southern nesting sites are experiencing multiple threats at various

severities. The Sapodilla Cayes seem to be relatively less threatened compared to nesting sites in the PHMR and SWCMR. As these cayes are remote and little affected by a rapid expansion of tourism, this result is to be expected. Knowledge of active nesting for these cayes is particularly important because a recent report on marine turtles in Belize indicates that the Sapodilla cayes may not be as important as the STRAP 1992 previously indicated (WWF, 2017). Most likely, inconsistent monitoring efforts and a lack of communication about turtle nesting is the cause of this data gap; there has been no official monitoring program established in SCMR like there has been in the PHMR. This reinforces the need for frequent and organized monitoring and reporting. Of the threats that are present in the SCMR, erosion and pollution are clear issues. Erosion has been affecting the Sapodilla Cayes at rapid rates since they were first surveyed in 1960, some cayes experiencing a 70% loss of land cover by 2012 (Houser *et al.*, 2014). Lime Caye for example, has had to move the kitchen for their guest houses 50 feet about seven years ago due to the encroaching sea level. Now, the location of their previous kitchen site is well underwater. On Hunting Caye, the south side of the island is completely covered with trash. Plastics of all sorts are embedded in the shoreline vegetation when you can even see it. Hunting Caye serves as post for the Belizean Coast Guard. While they are aware of the ecological issues of the pollution on the cayes, they indicated that they had tried in the past to clean it, but the sheer volume was too much to keep up with.

During my time in the Sapodilla Cayes, I experienced some of the foreign visitor involvement that had been described by locals during my interviews. On Lime Caye, there was a group of Guatemalan fishermen that kept to themselves. They were seemingly harmless and communicated with the owners of the cayes. However, on an exploration of the Sapodilla Cayes to complete my threat survey, my boat (borrowed from and labelled Belize Fisheries

Department) encountered a group of shark fishermen on Coco Solo Caye. As our boat pulled up to shore, the shallow waters were tinted with blood from the dead shark that was rolling along the rack line. The boat we stopped beside on the beach had at least two dead sharks and pools of shark blood in it. The fishermen seemed confused and were not expecting us. As Coco Solo is technically outside of Marine Reserve Boundaries, possession of sharks was not illegal, though our captain suspected that these fishermen had caught them in illegal zones. Two of the fishermen clearly did not speak English, and stood still as the other approached our boat and asked if we needed help with anything. We did not, so we quickly went on our way. The fishermen did not resume cleaning the sharks until we were almost out of sight. While my experiences do not validate the defensive nature of the Belizeans regarding foreign presence in the MPAs, I did see the presence of foreign fishing in the reserve and sense the tension between nationalities.

Nesting sites in the PHMR (aside from East Snake Caye) are also active, but are more threatened than the Sapodilla Cayes. Unfortunately, the turtle monitoring program conducted by TIDE is no longer active due to a lack of funding. While data is present for the reserve from 2009 – 2015, the records are poor post 2012. This may be a result of Hurricane Ernesto, which made landfall just north of the Belize border with Mexico on the Southern tip of the Yucatan peninsula, followed by the impact of Tropical Storm Helene in 2012. However, it is also likely that all nesting data reported by TIDE is an underestimate of the true nesting activity present, as this program was underfunded during active status and includes data gaps. The West and South Snake Cayes, which are recorded as PHMR as the most active sites, are the least threatened within the reserve. Despite increasing efforts to develop PHMR, these cayes should avoid development, including the Caribbean Castaway Resort, as much as possible moving forward.

Also, data collected by TIDE from 2013 – 2015 indicates that there has been shifts in PHMR nesting sites vegetation composition. As vegetation cover has been linked to nest temperatures, this observed shift could negatively impact local vegetation-seeking hawksbill turtles (Kamel, 2013). While more data is needed, this could present an issue for hawksbill populations that nest in PHMR as air temperatures continue to increase as a result of climate change.

One limitation of this study that unknown data was assumed to be rare/not present for OTS calculations. Because local people were unaware of these threats in the area, the likelihood of them occurring is low. However, more research should be done to verify these claims. As well, more research should be completed to understand the weight of specific threats on turtles. Understanding this information could allow for implementation of environmental modeling techniques to test out possible scenarios for local management efforts. For example, if there was a quantifiable weight associated with the threat impact of erosion versus pollution, models could predict to a more accurate degree how threatened a particular nesting site was relative to other threatened areas experiencing similar threats.

The most ubiquitous threat across all the marine reserves is pollution. For PHMR and SCMR, the dump in Punta Gorda is most likely a large source of the pollution. This dump is not regulated, and during the rainy season, debris along with other waste products run into the Rio Grande river. This directly empties in the Port Honduras Marine Reserve and floats out to the Sapodilla Cayes. For SWCMR, pollution most likely washes up on shore from Dangriga, the nearest town. By 2025, there will be an expected 906-2,417 million metric tons of plastic debris in Belizean waters (Pail et al. 2016). This value is nearly double the concentration estimates for 2010.

Threat survey results indicate that egg harvesting is rarely present throughout visited nesting sites, despite its long standing issue in many sea turtle communities. This practice holds such cultural and economic significance for several communities that current research trends examines how to incorporate these practices into sustainable harvesting practices (Hope, 2002; Campbell et al., 2007). Collection of sea turtle eggs was restricted in the 1990s along with other sea turtle regulations, and has apparently held its taboos status amongst locals. Nest disturbance by predators is another threat that was expected to play a greater role as a threat to nesting sites. While dogs and other predators have played an important role in limiting nesting success in other nesting areas such as Tortugero, this issue was not observed greatly in Southern Belize overall (Fowler, 1979). It is important to note, however, that dogs were present and threatening at some locations in the PHMR and SWCMR, including sites that turtle nesting was found to be no longer active. Therefore, the true effect of dogs on sea turtle nests in Belize should be further studied in order to understand the severity of their effects on a small scale. Some threats (e.g. beach nourishment, sand mining, mechanized beach cleaning) listed on the adapted WIDECAST survey were not considered threats to Belizean sea turtle nesting sites based on survey results and ground-truthing operations. As coastal erosion and development are likely to increase across Belizean coastlines, these threats may play a larger role in the greater sea turtle threat landscape.

Overall, this study may indicate that protected areas protect turtle beaches more than areas not located in a protected area. Of the four sites that were surveyed and listed as no longer active, two laid outside of a marine reserve. Ranguana Caye was the most threatened surveyed site (largest OTS), and it lays outside of a reserve boundary. This may indicate that continuous improvement and expansion of reserves might be beneficial for increasing and stabilizing nesting populations.

CHAPTER 5

CONCLUSIONS AND FUTURE EFFORTS

This study had two main objectives: 1) to understand local perceptions of threats to sea turtles and their nesting sites and 2) to identify threat patterns related to sea turtle nesting for three critical marine reserves in Belize. Results from this study indicate that sea turtle nesting is still active throughout southern Belize. As well, there are misconceptions about the current turtle nesting landscape amongst stakeholders. This is mostly due to an observed lack of efficient monitoring and reporting from management. While stakeholders in these critical reserves are aware that threats to turtles are present, their spatial awareness of the issues is lacking. Therefore, more effort needs to be focused on ensuring adequate sea turtle management that involves sharing turtle specific news with stakeholders.

The results from this study identified several threats, including nest loss from erosion, pollution, and loss of native vegetation, that are present along critical nesting beaches in Belize. Most of the assessed areas are within MPAs, and could benefit from monitoring for threats and nesting activity. However, there are no active sea turtle monitoring programs in Southern Belize. While such a program has existed in the Port Honduras Marine Reserve, as of 2015 the program has lost full funding. This paints a bleak picture for national organizations that are trying to report on sea turtle nesting trends. The most recent report, WWF Belize Marine Turtle Report 2017, suggests that sea turtle nesting activities in most of Belize are only “fairytale.” Such a statement can be dangerously misleading; the lack of recorded on-the-ground knowledge could limit obstacles preventing outside developments, such as the previously mentioned Caribbean

Castaway resort on West Snake Cake, from establishing on critical nesting habitat. It is the lack of monitoring that is the cause of such a data gap for Southern Belize.

There are a variety of mitigation strategies that can be implemented to reduce the effects of some threats that have been identified within this study. For example, one of the most pressing issues for the Sapodilla Caye Marine Reserve is plastic debris pollution. By planning beach cleans during the day at or below the high-tide line is a way to involve locals, conservation groups, and even tourists in a both environmentally and socially beneficial activity (Choi and Eckert, 2009). However, implementing these types of mitigation practices requires money and manpower. Survey results from this study indicate that Belizean people are pro-turtle and pro-MPA; both turtles and MPAs are connected to local livelihoods. As it is most likely not an issue of willing local, mobilization of necessary programs is therefore most likely thwarted by lack of funding. TIDE, for example, one of the larger and well-established environmental non-profit organization, ceased its turtle monitoring program in 2015 due to the lack of funds.

Solving issues of lack of funding is no easy task; one possible solution is to incorporate more citizen science programs throughout known nesting sites in lieu of government funded programs. Local knowledge can have a role in MPAs success by adding to scientific data (Gerhardinger et al, 2008; Ferse et. al, 2010). Allowing reports of sea turtle nests to come to local non-profits on a citizen level could diffuse the organizational manpower efforts needed to complete sea turtle nest monitoring programs. Turtle walks could even be incorporated into local eco-tourism activities, which brings both economic and conservation benefits (Tisdell and Wilson, 2002). While this method will overlook many laid nests, few data is greater than no data when it comes to a region's critical role in an endangered species lifecycle. Even records of some

nesting sites would prevent reports in the future from publishing statements alluding to sea turtle nesting no longer being active throughout Southern Belize.

The goal, however, should be for each reserve should have a sea turtle monitoring program to keep both accurate nesting and threat data. This data is critical for evaluating the overall threatened status for sea turtle populations. These efforts should be evaluated on a regular basis to ensure sea turtle monitoring program success. This would include evaluating such programs based on suggestions listed in Marcovaldi and Thorne (1999) : (1) the number of members involved in the program, (2) how well the programs improve community-level quality of life, (3) an overall decline in the number of turtle nests disturbed by humans and females collected intentionally or accidentally, (4) the implementation of more legislation for the protection of sea turtles, (5) creation of and continued support for protected areas benefiting sea turtles, (6) any profit generated by the program and the portion that is invested in the protection of sea turtles and in local community programs, and (7) an overall increased amount of community members and others familiar with the sea turtle conservation programs. By using these metrics and collecting adequate data, Belize will be able to monitor progress of management efforts. By also increasing management efforts, this would provide data to further evaluate the success of MPAs as an institution for sea turtle and greater marine endangered species conservation.

There is hope for sea turtle populations in Belize, but there is also more work that needs to be done. Results from this study lay the groundwork for future sea turtle nesting threat surveys in Belize, and calls to action greater management efforts with respect to local sea turtle populations.

With only a few of the reserves surveyed in this study, there is more information to be gained from monitoring and researching the other critical turtle nesting areas in Belize, and the greater Caribbean, at site and MPA specific scales.

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APPENDIX

7.1 Threat Assessment

(Adapted from Dow et al., 2007)

Sea Turtle Threats Survey

Location Name: _____

Date/Time: _____

R = Rare, O = Occasional, F = Frequent, FA = Frequent in a certain Area, U = Unknown

1. Killing of nesting females by humans

How often does this occur?

2. Killing of nesting females by predators

Which predator species? Invasive species?

3. Nest loss to predators Which predator species? Invasive species?

4. Nest loss to abiotic factors

What factor? Ex. flood, erosion

5. Egg Collection (by humans)

How often does this occur?

6. Harassment due to increased presence of humans

Ex. tourists discouraging nesting

7. Artificial lighting

How often does this occur?

8. Pollution

What type of pollution – agriculture, petroleum/tar, sewage, industrial runoff, beach litter/debris?

9. Beach erosion/accretion

Where? When? Caused by storm events? How often does this occur?

10. Beach armoring/stabilization structures

Where? How often does this occur?

11. Beach nourishment

Where? How often does this occur?

12. Recreation beach equipment and/or other obstacles

How often does this occur?

13. Mechanized beach cleaning

How often does this occur?

14. Beach vehicular use

How often does this occur?

15. Sand mining

Where? How often does this occur?

16. Exotic (or loss of native) vegetation

How often does this occur?

17. Livestock (presence on the beach)

How often does this occur?

7.2 Basis for local conversations

This survey was used as the backbones of semi-structured interviews.

Section 1: Participant information

1. What do you do for a living? _____
2. What is your age? _____

Section 2: Views on Sea Turtles

3. Do you think sea turtles have **economic** value? Y/N
4. Do you think sea turtles have **environmental** value? Y/N
5. Do you think sea turtles are **over protected**? Y/N
6. Do you think sea turtles are **under protected**? Y/N
7. Have you ever collected sea turtles? Y/N
8. Were you trying to? Y/N
9. Do you ever eat turtles? Y/N
10. If so, how recently? (0-1 year/2-5 years/5+years ago)
11. Do you know of anyone else who has recently (within the last 5 years) hunted for turtles?
Y/N

Section 3: Threats to Sea Turtles

How would you rank the following threats towards sea turtles in Southern Belize? 1 = Lowest Concern, 5 = Greatest Concern

- | | | | | | |
|---|---|---|---|---|---|
| 12. Development: | 1 | 2 | 3 | 4 | 5 |
| 13. Coastal Erosion: | 1 | 2 | 3 | 4 | 5 |
| 14. Sea Turtle Hunting: | 1 | 2 | 3 | 4 | 5 |
| 15. Use of Nets: | 1 | 2 | 3 | 4 | 5 |
| 16. Egg Harvesting: | 1 | 2 | 3 | 4 | 5 |
| 17. Nest Disturbance by Animals: | 1 | 2 | 3 | 4 | 5 |
| 18. Are there threats that you think are missing? If so, please write them below. | | | | | |

19. Where do you most often see turtles now? Circle on map if necessary

20. How have **sea turtle** numbers changed throughout your lifetime?

Increased Decreased No Change

21. How have **sea turtle nest** numbers changed throughout your lifetime?

Increased Decreased No Change

22. If changes have been detected, where have you seen these changes? Use map if necessary.

23. Where do you most often see turtles now?

Section 4: Conservation in Belize

24. Has the creation of the Port Honduras Marine Reserve impacted your daily life? Y/N

If so, how?

25. Do you think the PHMR plays a role in turtle numbers? Y/N

7.3 Site specific summary of threats and management suggestions

The following report lists the main threats to sites by Marine Reserve in Belize. For more detailed methods to mitigate the threats listed below, please reference:

Choi, Ga-Young and Karen L. Eckert. 2009. Manual of Best Practices for Safeguarding Sea Turtle Nesting Beaches. Wider Caribbean Sea Turtle Conservation Network (WIDECAST) Technical Report No. 9. Ballwin, Missouri. 86 pp.

Port Honduras Marine Reserve

Punta Ycacos

Greatest Threats: Pollution; Predators



TIDE indicates this site has lower erosion in comparison to other sites in PHMR. This site has recently seen the construction of a shed on the beach, but is otherwise rather undisturbed by people. Nesting activity is still active according to 2015 nesting data collected by TIDE. One nest found destroyed with egg shells everywhere on May 30, 2017. Monitoring for and protecting nests at the site, along with trash removal, would also be helpful as some pieces of debris were very large. Reports of loss of native vegetation are also present for the caye, though is not listed as an extreme threat at this time.

Snake Cayes

Greatest Threats: Erosion, Nest lost to Abiotic Factors



Of the three Snake cayes, the active nesting sites include South and West. East Snake Caye is not active according to local reports, despite records in the STRAP 1992. The Snake Cayes historically are important for turtle nesting. These beaches are relatively untouched, with only light use from local tourism. There are no apparent predators on the cayes, and trash accumulation is little to none. Of all sites surveyed, Snake Cayes appear to be faced with the lowest amount of threats aside from erosion. For West Snake Caye, erosion is a great issue, with reports of frequent nest loss to the shifting shoreline. While sometimes the eggs are relocated, greater effort should be made on West Snake to prevent loss of nests.

Punta Negra

Greatest Threats: Predators, Erosion, and Development

Punta Negra still has active nesting, though the majority of nesting occurs between Brion Point and Punta Negra due to the presence of people, artificial lighting, and dogs. Erosion has changed the shoreline from a gradual slope to more bank-like. For this area, reduction of lights would be beneficial, and development should be limited for the stretch between Brion Point and Punta Negra. More data regarding the nesting frequency by species should be collected. Information regarding Punta Negra acquired from personal communication with Kenworth Martin (May 2017).

Sapodilla Cayes Marine Reserve

Lime Caye

Greatest Threats: Pollution, Erosion, Artificial Lights



Lime Caye still active for turtle nesting. Early nesting activity reported for May 9th 2017, hatch of at least one nest confirmed in August 2017. Suspected species is Hawksbill. Nesting continued steadily throughout November according to reports from local contacts. This Caye is owned by the Garbutt family, and it is used for family and tourist purposes. Artificial lights are sometimes left on all night. On the island, there are signs indicating that the beach is a turtle nesting site. Erosion has been documented for the Caye, and the Southwest side of the caye has a beach that is consistently increasing in steepness. The kitchen on the island was moved 7 years ago due to encroaching erosion. This island should be managed for erosion, as well as nighttime light usage should be limited even with tourist presence.

Hunting Caye
 Greatest Threats: Erosion and Pollution



Hunting Caye is inhabited by the Belize Coastguard. There is also a relatively unused facility owned by the University of Belize that serves as a dormitory. There is lots of trash on the Southeast side of the island, and this slope is reportedly increasing in steepness. There are posted signs present on the caye indicating that it is a turtle nesting site. While there are dogs present on the caye, they have not been reported to mess with eggs once nest is laid or emerging females. Reports from locals indicate that development has changed dramatically between 2003 and 2017. Managing for pollution and erosion is key for nesting success.

Nicholas Caye
 Greatest Threats: Erosion



While erosion is listed as the greatest threat for this caye, relative to other

cayes surveyed, this caye is the least disturbed. The caye is owned by Belcampo Lodge, and has a caretaker present on the island. As of May 2017, several turtle nests were indicated, species most likely is hawksbill due to nests located in vegetation. Beaches are undisturbed with limited trash and obstacles on 360 degrees of this caye. Native vegetation is also fairly intact.

Frank's Caye
 Greatest Threats: (Possible) Egg Collection



Historically, turtle nesting was active on Frank's Caye. Recent reports indicate turtle may still occur, but it is limited. This caye is relatively uninhabited with no-one guarding it. It is suggested that Guatemalan occupancy may occur, and that there may or may not be egg collection associated with it. Most threats related to Frank's Caye unknown due to the lack of inhabitants and visitation by locals.

South Water Caye Marine Reserve

South Water Caye

Greatest Threats: Artificial Lighting, Stabilizing structures, Loss of vegetation, increased harassment from humans



South Water Caye is inhabited by 4 developments; Blue Marlin Beach Resort, IZE, The Pelican, and private residences. This caye serves mostly as a tourist destination. There are at least 3 dogs on the island, though they were not reported to have impacted nested turtles. Reports of juvenile turtles living near the caye were recorded. Limited knowledge about nesting patterns is recorded. Lights on development structures should be turned off at night, and nests should be identified and protected for tourists to avoid bothering them. This could be an eco-tourism opportunity to be implemented by the resort if nesting numbers are discovered to be frequent enough.

Carrie Bow

Greatest Threats: Trash and Beach Stabilization structures



This caye serves as a research station for the Smithsonian. Nesting records are kept in detail for the caye. Trash is picked up weekly by researchers. Erosion has been a problem for the caye, and several sandbag structures have been implemented to prevent future loss. The shorelines of this island have been indicated to be very flexible, but historically has gotten smaller. The primary species nesting on Carrie Bow is Hawksbill. Correspondence with Scott Jones.

Tobacco Caye

Greatest Threats: Predators, Beach structures



This caye is noticeably covered in conch shells along most of the shore. Many dogs are on the island and have been reported to attack nesting females, preventing them from nesting successfully. One report from a local indicated that turtles don't emerge at all because of the dogs. Not likely an active nesting site.

Non-Protected Cayes

North Spot

Greatest Threats: Presence of humans

Report from shark fisherman on the caye: "Turtles don't come this far north". Likely no longer active due to shrinking in size and conch coverage.



Tom Owen's Caye

Greatest threats: Sea wall, presence of human



Tom Owen's Caye is currently a dive center that has small cabanas for those participating in the dive research. There is a sea wall that is on all edges of the cay. Local sources indicate that Tom Owen's is still an active nesting site, despite this sea wall, though no nests had been laid for the 2017 season as of May 30. A clearing area should be made for turtles to nest successfully, and erosion should be monitored.

Ranguana Caye

Greatest Threats: Structures, Recreational equipment on the beach, increased presence of humans





Ranguana Caye serves as a tour spot for day trips out of Placencia. On the island there is a resort as well as a beach bar and recreation stand for vacationers to relax and enjoy the caye. There is a sign listed on the bar indicating that sea turtles nest on this caye. The back side of the caye is blocked by sandbags to prevent erosion. In 2016, there were a reported 16 nests found, including Hawksbill, Loggerhead, and Leatherback species. Efforts on the caye have been made by those working on it to trap turtles that happen to hatch during the day in order to release them at night to avoid day-time threats present. Efforts have been made to relocate nests that have been made in erosion prone areas. Beach equipment should be put away in order to prevent discouraging emerging females. As well, lights should not be left on at night and nesting surveys should be completed during nesting season to identify nests. If necessary, nests can be moved, but they should be marked in order to prevent possible tourist interference.