

2010 PEARL CAYS HAWKSBILL CONSERVATION PROJECT, NICARAGUA



Day time nesting hawksbill laying a clutch of eggs, Pearl Cays, Nicaragua, 2010. Photo: V. Huertas/WCS

FINAL REPORT

Prepared By

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ABSTRACT

The Wildlife Conservation Society (WCS) monitored the nesting activity of hawksbill turtles, *Eretmochelys imbricata*, during the 2010 nesting season on the Pearl Cays, Nicaragua. The total number of clutches recorded was 299, setting a new record since conservation activities began in 2000. Over the years of applied conservation measures there has been, on average, a 9.4% annual increase in the number of clutches laid. Poaching activities continue to be significantly reduced, decreasing from 12.7% in 2009 to 7.0% in 2010. This is the second lowest poaching rate recorded since initiation of project activities. Poaching occurred on cays primarily used by fishers and where *acopios* (lobster buying stations) are established, however, poaching also occurred on cays permanently inhabited by caretakers, such as on Lime and Wild Cane cays. Hatching and emergence successes for clutches where at least one egg hatched were 72.2% and 70.8%, respectively. We estimated a minimum 28,459 hatchlings were produced during the 2010 season. At least four mature female and 17 juvenile hawksbills were killed since the 2009 Pearl Cays hawksbill report. Alteration and/or destruction of hawksbill nesting and developmental habitats continues in the Pearl Cays, and unregulated coastal development is the principal cause. Removal of dune vegetation, uncontrolled construction, artificial beach lighting during nesting and hatching seasons, presence of domestic or exotic fauna, and pollution resulting from increased human presence on the Pearl Cays are negatively impacting hawksbill reproduction, threatening not only this regionally important hawksbill nesting population but also economically valuable marine resources in the area. In addition, the Italian television production company, Magnolia, produced two sequential survivor type reality shows in the Pearl Cays. The second show was produced for a Spanish audience and occurred during the first months of the nesting season. The large number of people involved in the shows impacted hawksbill nesting habitat, particularly beach vegetation, and interfered with hawksbill monitoring activities. In November 2010, the Nicaragua National Assembly declared the Pearl Cays a wildlife refuge. We are encouraged by this declaration and are hopeful that this newly established protected area will provide meaningful protection to this important ecosystem. We again provide recommendations to minimize human threats, including the regulation of development and construction activities, prohibiting the presence of domestic and exotic animals, prohibiting the destruction of beach and dune habitats, promoting the restoration of native beach vegetation, prohibiting the use of artificial lights on beaches during nesting and hatching seasons, and restricting human activities that may be detrimental to hawksbill nesting and reproductive efforts.

Report Summary

- a) The steep increase in the number of clutches compared to 2009 is likely due to natural fluctuations in remigration intervals rather than an actual increase in population size. Natural fluctuations in nesting activity can be expected on sea turtle nesting beaches, and can be affected by environmental conditions. The long-term nesting trend, however, indicates a consistent increase in nesting activity over the last decade. Continued monitoring of the nesting population is needed in order to better assess population status and causes of fluctuations in nesting levels.
- b) Egg poaching and killing of adults (especially reproductively mature females) and juveniles continue to threaten hawksbill recovery. Due to the high migratory behavior of all sea turtles, conservation efforts need to be conducted along the entire Caribbean coast

of Nicaragua, not just in the Pearl Cays; otherwise, hawksbills protected at the nesting beach will continue to be killed when they migrate to their foraging grounds away from the Pearl Cays.

- c) Use of the Pearl Cays by humans continues to increase resulting in negative impacts to the cays, hawksbill reproductive efforts, and other marine resources. Regulating human activities, such as artificial light use and presence of domestic or exotic animals, are necessary to mitigate these impacts.
- d) Uncontrolled and unregulated coastal development on the cays poses an immediate and serious threat to the Pearl Cays hawksbill nesting colony and the fragile ecosystems of the area by altering and/or destroying crucial nesting and developmental habitats for this species, as well as other species that contribute to the economy of local human populations and biodiversity of the area (e.g., lobster, shrimp, and finfish).
- e) Donations of live turtles to the WCS program to be tagged and released was again very high this year, and is a positive sign of increased interest in conserving sea turtles in the Pearl Cays area; however more work is needed to eliminate all killing of hawksbills on the Caribbean coast of Nicaragua.
- f) Activities to raise awareness should continue to be a priority to strengthen and enhance positive attitudes towards conservation of natural resources and increase collaboration with conservation efforts.

INTRODUCTION

The hawksbill turtle, *Eretmochelys imbricata*, is listed as critically endangered on the IUCN Red List (Mortimer and Donnelly, 2008) and on Appendix I of CITES (UNEP-WCMC, 1 July 2011). On Nicaragua's Caribbean coast, hawksbill turtles nest on the Pearl Cays, at El Cocal, and sporadically along the mainland; and all size classes forage in offshore coastal waters (Lagueux et al., 2003; Lagueux and Campbell, 2005; Lagueux and Campbell, unpubl. data). The Pearl Cays rookery is believed to be the largest remaining nesting population in the west-central Caribbean (Lagueux et al., 2003) and as such, has been identified as an important index site within the greater Caribbean region for long-term population monitoring (see www.cites.org/eng/prog/HBT/dialogue2/E-HT2-8.pdf). The Pearl Cays area also provides important foraging and developmental habitats for hawksbill turtles from the Pearl Cays and from across the wider Caribbean, with 18 genetic haplotypes identified thus far, representing up to seven or more rookeries (Lagueux et al., 2001; Lagueux and Campbell, unpubl. data).

Hawksbill turtles on Nicaragua's Caribbean coast are severely threatened by decades of uncontrolled killing of nesting females and taking of their eggs, and by the opportunistic capture of foraging juveniles and adults (Nietschmann, 1981; Lagueux, 1998; Lagueux et al., 2003; Lagueux and Campbell, 2005). In 1999, the Wildlife Conservation Society (WCS) conducted the first systematic surveys of the Pearl Cays and discovered that nearly 100% of the clutches laid were taken by local fishers for personal consumption, and nesting females were often killed for their meat and scutes (Lagueux et al., 2003). In 2000, a community and government approved project to protect nesting females and their eggs was implemented by WCS. In addition, WCS

implemented a “Donate A Live Turtle” program that provides an incentive to local fishers and inhabitants on the cays to voluntarily donate live turtles to the project to be tagged and released (including males and juveniles, as well as green, *Chelonia mydas*, and loggerhead, *Caretta caretta*, turtles) that otherwise would be killed for their meat and/or scutes. This volunteer program is conducted throughout the year and not only helps save turtles directly but also provides an opportunity to educate local residents and engage them in sea turtle conservation activities.

Both the Donate a Live Turtle Program and the Pearl Cays conservation project have been highly successful at reducing hawksbill mortality in the Pearl Cays area. For example, there has been a steady increase in the number of clutches laid, and although variable, a decrease in the number and percent of clutches poached since initiation of the nesting beach project (Lagueux et al., 2003, 2006, 2009; Campbell et al., 2007, 2008, 2010). In addition to protecting females and eggs, we have increased efforts to collect data on the reproductive ecology of females to better understand nesting ecology and habitat needs of hawksbills in the Pearl Cays. For example, data collected during the 2005 nesting season indicate that hawksbills have a strong preference for nesting among beach vegetation on the Pearl Cays (Lagueux et al., 2006), a behavior commonly observed at other hawksbill nesting sites (e.g., Horrocks and Scott, 1991; National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998; Kamel and Mrosovsky, 2006).

The Pearl Cays hawksbill population is currently facing destruction of its nesting and feeding habitats from increasing human presence in the area. The construction of permanent houses and/or the installation of lobster buying stations, *acopios*, on 11 of 16 cays used by nesting hawksbills are negatively affecting nesting behavior, as well as indirectly affecting reproduction from the destruction and alteration of nesting habitat (e.g., sand mining, clearing of upper beach vegetation, and structures built on nesting areas). Other factors negatively affecting hawksbill reproductive biology and survival include the presence of domestic or exotic animals, and artificial lighting of nesting beaches. In addition, fishing activities in the Pearl Cays such as the lobster, shark and sea cucumber fisheries add to these threats. In addition to the lack of affective management to mitigate negative human affects, these activities increase human presence on the cays and in surrounding waters, which in turn increases pressure on other marine resources. Furthermore, sharks, lobsters, and sea cucumbers play vital roles in marine ecosystems and a reduction in their populations in the Pearl Cays area will undoubtedly have detrimental affects on other resources and habitat quality.

The conservation of hawksbill turtles in the Pearl Cays is important for both the regional and global recovery of hawksbills. In this report we provide results from our conservation and research efforts during the 2010 nesting season, as well as some of the long-term trends.

Objectives

Objectives for the 2010 nesting season were to:

1. quantify nesting activity spatially and temporally on 14 of the Pearl Cays,
2. document human activities daily on the cays during the nesting season,
3. maintain or increase survival of egg clutches and nesting females,
4. determine hatching and emergence success,
5. continue the collection of reproductive and biometric data on nesting females,

6. continue to monitor beach and nest temperatures to assess trends in incubation temperatures,
7. promote conservation through the media and education,
8. build capacity at the local and regional levels,
9. improve local collaboration and increase government involvement in conservation activities, and
10. provide incentives to local fishers to donate live marine turtles of any species for tag and release.

Study Area

The Pearl Cays are located from 3 to 22 km east of the mainland, off the central Caribbean coast of Nicaragua (Figure 1), and encompass an area of approximately 700 km². The study area is comprised of 14 of the 22 Pearl Cays; they are Baboon, Black Mangrove, Bottom Tawira, Buttonwood, Columbilla, Crawl, Grape, Lime, Maroon, Vincent, Water and Wild Cane, and two additional cays that have only recently had nesting activity, Maria Crow Cam (nesting activity first observed in 2009) and Seal (nesting activity first reported in 2007). The cays range in size from 0.04 ha to 18.4 ha; although the size of the cay is not necessarily related to the amount of available nesting habitat (Table 1). Although rare, hawksbill nesting also occurs in the northern Pearl Cays on Askill and Little Savanna; however, these cays were not included in the regularly surveyed area because of their distance from our primary study area and infrequency of nesting, e.g., no nesting activity has been reported on Askill and Little Savanna cays since 2007. No nesting occurs on Top Tawira, Esperanza, Savanna, Walter, and two unnamed cays due to a lack of appropriate nesting habitat. Cays where no nesting occurs are comprised primarily of mangroves and/or coral rubble along their shorelines.

METHODS

Nesting Beach Surveys

During the 2010 nesting season, nesting beach surveys were conducted regularly on 12 of the Pearl Cays where the majority of hawksbill nesting occurs, and periodically on Maria Crow Cam and Seal cays. Surveys were carried out by one of two, four-person WCS field teams who worked alternate weeks from the end of July to mid-December. Field team members received classroom and field training by experienced WCS personnel in sea turtle biology, nesting ecology, and in conducting nesting beach surveys, data collection, and clutch relocation methods. Of 14 candidates who attended the one-day training workshop, eight (five men and three women) were selected to work with the hawksbill project. As in previous years, selection of team members included a mixture of people from as many local communities as possible, some with previous project experience and some without. Team members included Harvey Antonio, Claudia Forbes, Gertrudis Hodgson, José Hodgson, Linda Hodgson, Kensly Martínez, Dorian McCoy, and Alan Morales (Photo 1), representing five local communities of the Pearl Lagoon basin (Haulover, La Fe, Orinoco, Pearl Lagoon, and Set Net Point) and three of the six ethnic groups (Creole, Garifuna, and Miskitu). William McCoy (Field Supervisor) and Victor Huertas (Project Coordinator) supervised and assisted with team activities, data collection and management. In addition, a U.S. undergraduate student from Eckerd College, Aisha Rickli-Rahman, worked with the project as an intern, participating in project start-up activities, assisting

the teams in conducting diurnal nesting beach surveys and nocturnal patrols, and assisting with the WCS Youth Group.

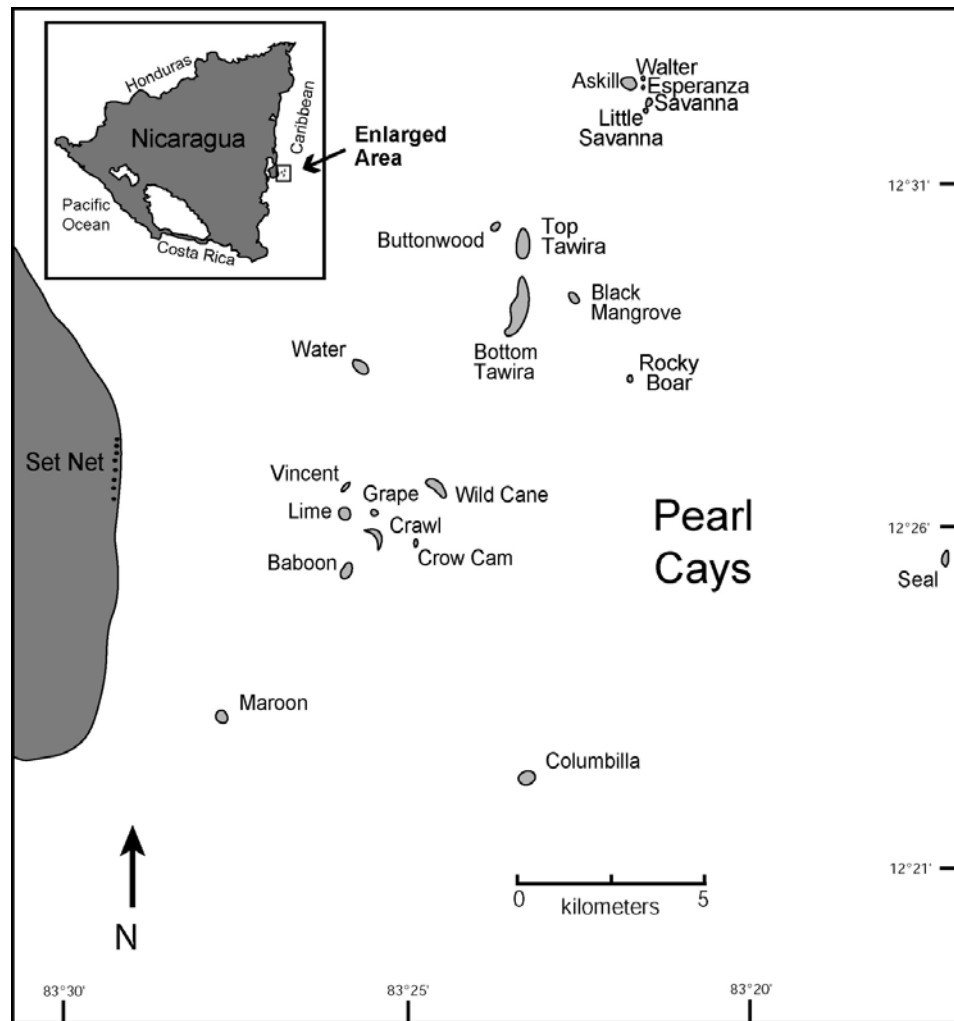


Figure 1. Map of the Pearl Cays, Nicaragua.

Table 1. Area and cumulative nesting beach length of the cays regularly monitored in the study. Data is based on a mapping survey conducted in October 2009, updating previous mapping survey information from September 2004.

Cay	Area (ha)/ Nesting Beach Length (m)	Cay	Area (ha)/ Nesting Beach Length (m)	Cay	Area (ha)/ Nesting Beach Length (m)
Baboon	4.61 / 310	Columbilla	3.02 / 113	Maroon	0.2 / 132
Black Mangrove	0.67 / 7.5 ¹	Crawl	1.80 / 590	Vincent	0.04 / 169
Bottom Tawira	18.4 / 310	Grape	0.46 / 120	Water	4.69 / 460
Buttonwood	0.22 / 226	Lime	3.5 / 393	Wild Cane	7.47 / 517

¹Nesting area was altered due to a build-up of coral in front of the nesting beach due to a storm surge caused by Hurricane Ida, late in the 2009 nesting season (November).

Two Nicaragua National Police accompanied project staff on nesting beach surveys. Two Police from Bluefields were assigned to the project, rotating personnel every two weeks, throughout the survey period. Prior to their trip to the Pearl Cays, each Police received an orientation which included a presentation about basic sea turtle biology, conservation needs of hawksbill turtles and the Pearl Cays, overview of hawksbill project activities and results, and the living conditions in the temporary camp.

To determine the onset of the nesting season and to protect clutches laid early in the season, surveys were initiated on 23 April but the first nests of the season were encountered 17 May. Prior to encountering the first nest, surveys were conducted approximately weekly but once nesting began, surveys were conducted approximately every four to six days until early June, and then every two to three days until a temporary camp was established on 27 July. From 27 July to 16 December surveys were conducted daily, and additional surveys were conducted periodically, between 17 December 2010 and 5 March 2011, when hatched nests were excavated.

During each cay-survey (defined as each time a cay was surveyed), data on nesting and non-nesting emergences were recorded, as well as the status and location (using GPS) of each nest. For the purposes of locating the nest after hatchling emergence, each nest was referenced by marking a nearby object (e.g., a tree) and recording the distance and compass bearing from that object to the nest. Clutches were left *in situ* unless the survey teams deemed it necessary to relocate them to protect them from would-be poachers or due to inadequate environmental conditions that might negatively affect incubation, e.g., located too close to the high tide line or in areas prone to inundation. Relocation involved the excavation of a nest chamber of similar depth, at a site usually within a few meters of the original nest site, careful removal of each egg into a bucket, transport of the bucket to the new site, careful placement of the eggs into the new nest chamber, always maintaining the eggs in their original vertical orientation, and covering the eggs. The new site was minimally disturbed and then camouflaged to hide the eggs from would-be poachers.

Several parameters were measured for each nest. Clutch size was based only on egg counts of relocated clutches because it provides the most precise measurement. Nest depth was measured from the bottom of the nest cavity to the beach surface, either when clutches were relocated or when clutch contents were excavated (for *in situ* clutches). Crawl length was measured along the track from the most recent high tide to the center of the nest chamber, as well as to any incomplete nest chambers excavated during an emergence. Nest location in relation to the water's edge was measured in a straight-line, perpendicular to the shore, from the most recent high tide line to the center of the nest cavity, as well as to any incomplete nest chambers excavated during an emergence. Also recorded, was the location of the nest on the cay (i.e., beach, on the dune, or behind the dune) and the habitat type where the nest was located (i.e., among vegetation, area naturally without vegetation (e.g., open beach or rocky), or area where vegetation has been altered or removed). Means are provided with one standard deviation (SD).

Poaching activity was categorized as completely or partially poached (some eggs removed but the remainder of the clutch was left to incubate) based on evidence found by the survey team at the nest site or during nest excavations. Completely poached clutches were those nests where all eggs were removed from the nest chamber, and often broken eggshell(s) were present in or around the nest chamber. Partially poached were those clutches where evidence of disturbance to

the nest chamber was observed, such as the appearance of eggs missing at the top of the clutch combined with obvious signs of human presence at the nest site, e.g., human footprints in the sand or evidence of poking in the sand with a stick; or when there was a difference of more than 20 eggs between clutch count at excavation and the original clutch count by the teams at relocation. We did not assume that small clutch sizes were partially poached nests; rather we included nests as partially poached only if there was evidence of human disturbance and/or apparently missing eggs from the clutch.

Nest Excavations

After 70 days of incubation, or sooner, if evidence of hatchling emergence was observed, nests were excavated to determine hatching and emergence successes. Once the nest cavity was relocated, clutch contents were removed, separated into categories, and counted, by the same individual (CJL) for consistency in categorizing and counting nest contents. Nest content categories were modified from Miller (1999) and include: shells (S, empty shells greater than 50%), undeveloped (UD, unhatched eggs with no obvious embryo), unhatched (UH, unhatched eggs with obvious embryo smaller than full-term), unhatched term (UHT, unhatched eggs with an apparently full-term embryo or pipped hatchling), unhatched with unknown stage of embryo (ENS, unhatched eggs with embryo, but stage could not be determined due to excessive decomposition), unknown state (UNK, it could not be determined whether or not their was an embryo present), live hatchlings in the nest (L, encountered in the nest cavity), and dead hatchlings (D, completely pipped hatchlings encountered in the nest cavity). Clutches that had not hatched when checked were left to complete incubation. If hatchlings were active and already emerging, however, they were counted and released. If the number of hatchlings found in the nest cavity was greater than the shell count at excavation, we used the hatchling count in the hatching and emergence success calculations since it provided a more precise estimate of hatched eggs. Clutches that had been partially poached were not included in the calculations of hatching or emergence success because we did not know the extent to which the clutch was disturbed when eggs were removed by poachers.

Night Surveys

To collect reproductive and biometric data on individual females, night surveys were conducted frequently during most of the nesting season (from 21 July to 11 November). Although the WCS teams initiated night surveys on 21 July; local collaborators inhabiting some of the cays assisted the project by capturing nesting females beginning on 28 May. Night surveys consisted of patrolling the beach at least every hour from approximately 1900 h to sunrise in search of nesting females. Field staff was trained by experienced WCS personnel to conduct night patrols and in methods for locating, observing and capturing nesting females. During encounters with nesting females, care was taken not to disturb the female or the nesting process. Once the female began laying eggs or once the nesting attempt was abandoned, a field staff member approached the turtle to check for flipper tags and determine whether or not biometric data needed to be collected. Individual females were measured only once during the nesting season; therefore, females that had already been encountered in 2010 by field staff could be released immediately after being identified. Turtles that were encountered for the first time in 2010 were kept on their backs on the upper beach platform until early morning when project supervisors could collect the appropriate data on each individual. Females not bearing tags were tagged with Inconel #681

metal tags (National Band & Tag Co., Newport, Kentucky, U.S.A.) on the trailing edge of each front flipper, proximal to the first scute. In addition, passive integrated transponder (PIT) tags (12mm, 125kHz) were inserted into the left front flipper of each turtle not previously tagged to minimize loss of data on individuals from metal flipper tag loss. Biometric data were collected from each turtle on her first encounter for the season, and a small tissue sample, for genetic analysis, was obtained from a rear flipper of females not previously sampled.

Incentive Program - Donation of Live Turtles

Throughout the 2010 nesting season, we continued our incentive program which encourages fishers and other people on the cays to donate live marine turtles to the project for tag and release (Photo 2A) by providing them with a specially designed T-shirt for each turtle donated. Each T-shirt bears the message, “I’m a Volunteer in the Caribbean Nicaragua Tagging Program”, “I’m Helping Our Turtles, Are You?” in Spanish, English, and Miskitu. To further encourage donations of live turtles we offer a lifejacket for every 15th live turtle donated by an individual. Each lifejacket is painted on the back with a turtle silhouette and the slogan, “Donating Turtles Saves Lives, Protect Our Resources, Nicaragua Sea Turtle Conservation Program, Wildlife Conservation Society” (Photo 2B).

RESULTS

Nesting Beach Surveys

From 23 April 2010 to 5 March 2011, a total of 1,908 cay-surveys were conducted on 14 of the Pearl Cays. We recorded 152 non-nesting emergences and 299 egg clutches, resulting in a ratio of non-nesting to nesting emergences of 0.51:1. Of the 279 clutches where month laid was known, 51.1% were laid in July (26.4%) and August (24.7%) (Figure 2).

Most nesting activity occurred on Water Cay with 69 clutches laid (23.1%), followed by Wild Cane Cay with 62 clutches (20.7%), Columbilla with 40 clutches (13.4%), and Crawl with 28 clutches (9.4%) (Figure 3). These four cays represented 66.6% of all clutches laid throughout the season. No clutches were recorded on Black Mangrove, Maria Crow Cam, or Seal cays during the 2010 nesting season. Of the 299 clutches laid, 59.9% (179 clutches) were left *in situ* and 38.8% (116 clutches) were relocated to a site near the original nest location. The remaining four clutches were poached either completely or partially prior to encounter by a survey team.

Hawksbill nest parameters for 2010 are summarized in Table 2. Mean clutch size, based only on relocated clutches, was 155.1 ± 35.0 eggs ($n=115$). Thirty-five yolkless eggs were observed in 22 clutches, ranging from 1 to 5 yolkless eggs in a clutch. Due to the inexperience of some survey team members, however, it is possible that the number of yolkless eggs was underreported. Overall mean crawl length (from the high tide line to the center of the nest cavity) for females that successfully nested was 13.05 ± 10.65 m (range=2.30-76.57, $n=217$); however, on at least 33 occasions (15.2%) females crawled more than 20 m before laying their clutch. Overall mean straight-line distance from the most recent high tide line to the center of the nest was 5.80 ± 3.55 m (range=0.85-25.30, $n=269$), however, some clutches were laid as much as 25 m from the high tide line.

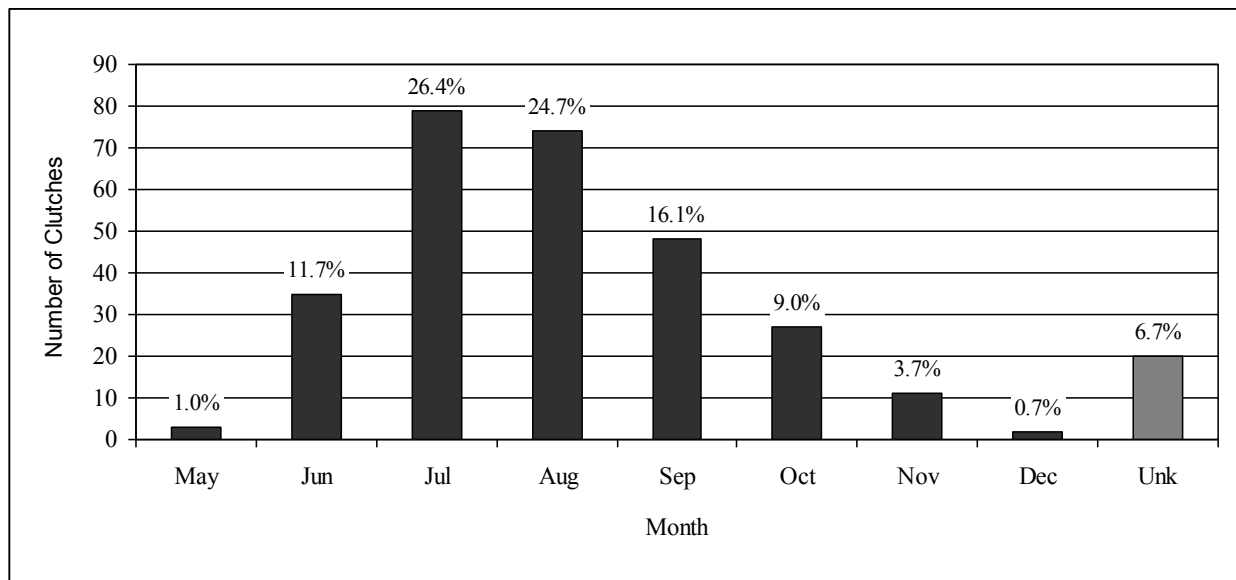


Figure 2. Temporal distribution of hawksbill clutches laid on 14 of the Pearl Cays, from May to December 2010 (n=299). Gray bar includes nests where month laid is unknown.

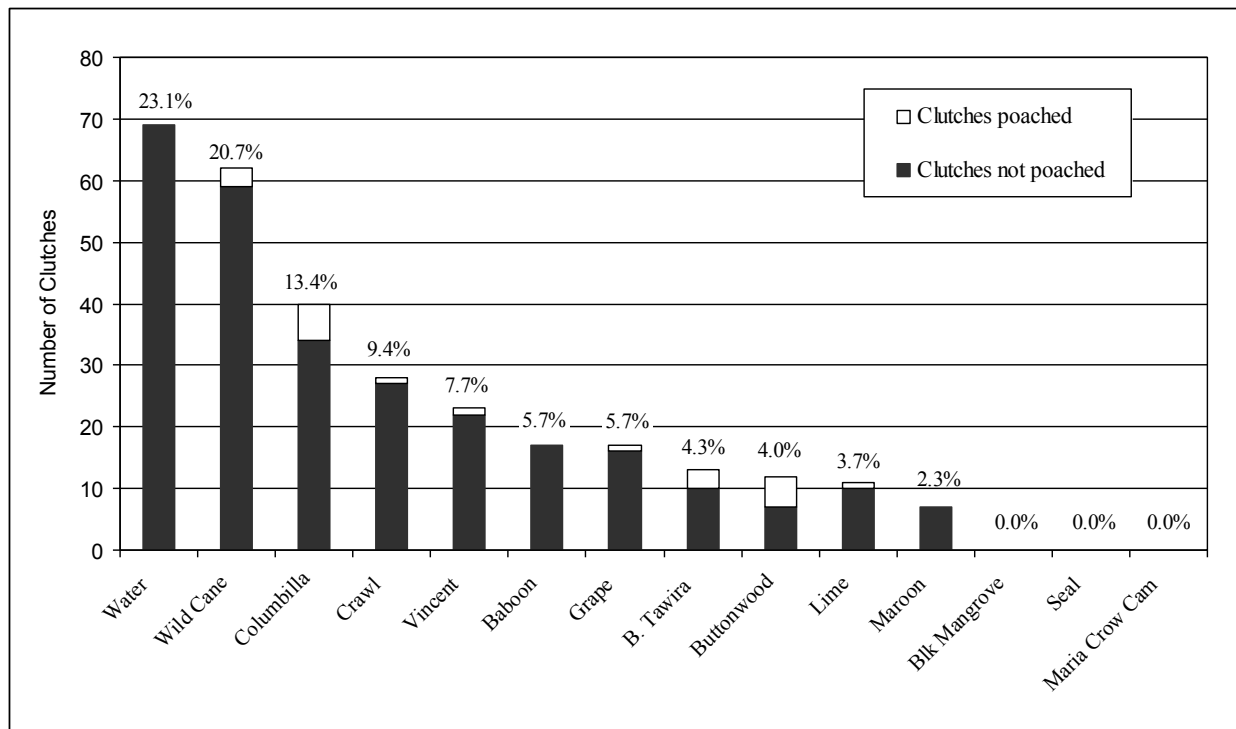


Figure 3. Spatial distribution of hawksbill nests on 14 of the Pearl Cays during the 2010 nesting season. Bars show total number of clutches laid by cay separated into clutches not poached and clutches affected by poaching (partially or completely). Numbers above bars indicate percent of total clutches laid on each cay.

Table 2. Hawksbill nest parameters, Pearl Cays. Crawl length and straight-line distance from the high tide line (HTL), respectively, to the center of clutches laid in non-altered or removed vegetation (4a and 5a), vegetation altered or removed (4b and 5b), a naturally non-vegetated area (4c and 5c), or on the open beach (4d and 5d). Only 4a and 4b, and 5a and 5b were tested for differences between means. Means with the same superscript are significantly different.

Nest Parameters	Mean	Standard Deviation	Range	n
1. Clutch size	155.1	35.0	60-266	115
2. Nest depth – <i>in situ</i> clutches (cm)	38.5	4.5	26.0-50.0	114
3. Nest depth – relocated clutches (cm)	38.4	5.3	21.0-51.0	109
4. Crawl length (m) - for all nests combined	13.05	10.65	2.30-76.57	217
a) Non-altered/removed vegetation	11.76 ¹	9.44	2.95-62.00	138
b) Vegetation altered/removed	18.55 ¹	13.89	4.90-76.57	38
c) No Vegetation (naturally clear)	18.75	20.86	4.00-33.50	2
d) Open Beach	11.96	9.2	2.30-47.30	39
5. HTL to nest (m) - for all nests combined	5.80	3.55	0.85-25.30	269
a) Non-altered/removed vegetation	5.54 ²	3.01	0.85-19.00	170
b) Vegetation altered/removed	7.77 ²	4.95	1.05-25.30	52
c) No Vegetation (naturally clear)	4.95	3.11	2.75-7.15	2
d) Open Beach	4.55	2.58	1.00-11.00	45

Crawl lengths (CL) for clutches laid in areas where ground vegetation had been removed (Table 2, 4b) were significantly longer than clutches that were laid in areas with ground vegetation present (Table 2, 4a) (t-test, $t_{(54)}=3.80$, $p=0.0004$). Similarly, straight-line distances from the most recent high tide lines (HTL) to the center of nests laid in areas where vegetation had been removed (Table 2, 5b) were significantly longer than in areas where ground vegetation was present (Table 2, 5a) (t-test, $t_{(57)}=3.88$, $p=0.0003$). CL and HTL data were skewed and thus, data for both were transformed ($\log_{10} + 0.5$ to each data point) for analysis. Because individual females nest more than once during a nesting season and we were not able to identify every nest to individual turtles, there is a possibility of lack of independence of either the CL or HTL data, however, the p-values are sufficiently small to suggest that a significant difference would still exist between the groups even if possible lack of independence were accounted for.

A correlation analysis was conducted to evaluate the overall trend in nesting. We found a significant positive relationship between the number of clutches recorded on the Pearl Cays and the number of years since initiation of the hawksbill project in 2000 ($r = 0.894$, $p < 0.001$, Figure 4). Since 2000, there has been an overall 94.2% increase in nesting levels, with an annual average increase of 9.4% from 2000 to 2010. Data prior to 2000 are not available for the entire nesting season.

Temperature Loggers

We continued to monitor sand and nest temperatures at mid-clutch depth in the Pearl Cays. Sixteen temperature data loggers were inserted in clutches and as a control an accompanying

temperature logger was placed in the sand one meter from the center of the nest at a depth of 35 cm. In addition, 30 temperature data loggers were buried 35 cm deep in the sand, in known nesting areas on a variety of cays. Loggers in nests were placed approximately in the center of the clutch after temporarily removing 60-75 eggs. Once the logger was in place the removed eggs were returned immediately to the nest chamber and covered. At all times vertical orientation of the eggs was maintained. Loggers in nests were only inserted in clutches left to incubate *in situ* and were retrieved from clutches post-hatching, along with the accompanying control logger. The 30 temperature loggers were retrieved in December, near the end of the hatching season.

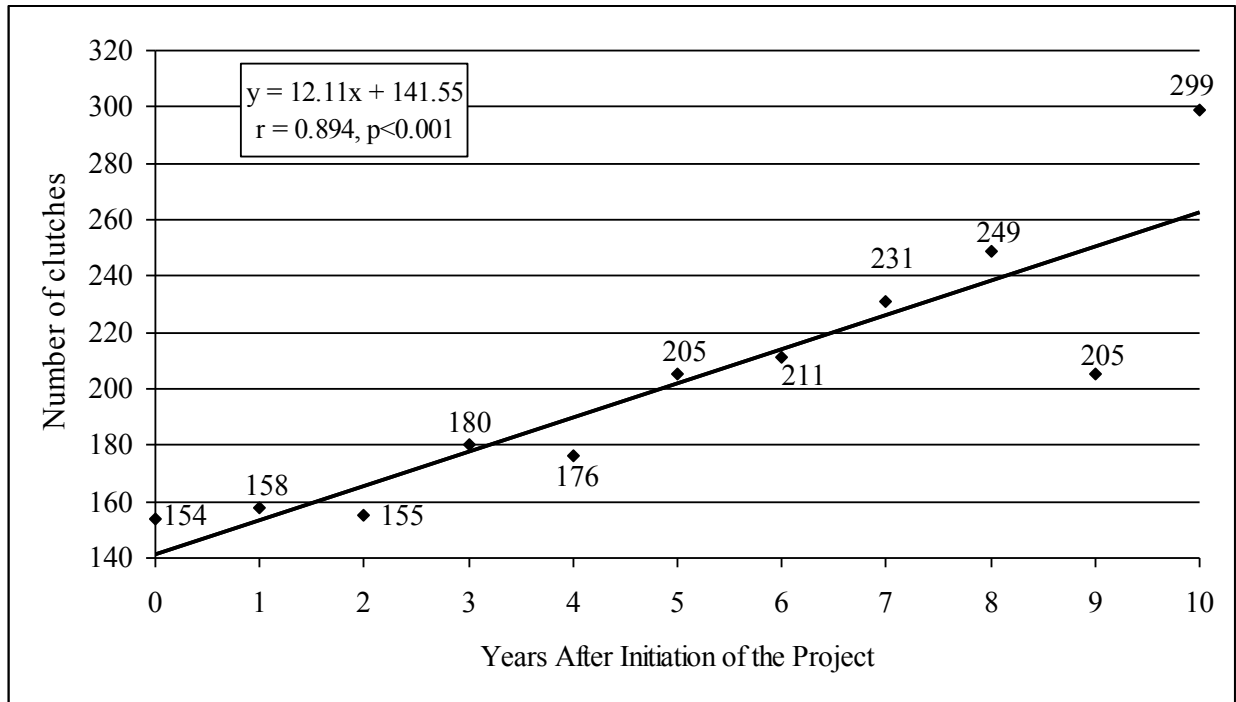


Figure 4. Trend in hawksbill nesting since project initiation in 2000 (year 0) to 2010 (year 10), Pearl Cays.

Nest Excavations

Of the 295 clutches left to incubate, 17 were affected by poaching activities (four clutches were completely poached and 13 were partially poached). Ten of the 13 partially poached clutches had at least one egg hatch. Of the remaining 278 clutches, 251 hatched, 16 had no eggs hatch, three were affected by high tides and/or water inundation, six were washed-out, one was partially destroyed, and one clutch was not found post-hatching. It was not possible to determine what caused the partially destroyed clutch, but it appeared that multiple predation events by crabs and birds had occurred. No clutches were affected by dog predation during the 2010 nesting season. In total, 265 clutches had at least one egg hatch (includes the three clutches that were partially poached prior to the team's survey).

The overall poaching rate, regardless of when or if an entire clutch was poached, was 7.0% (five completely poached and 16 partially poached) and occurred on 8 of the 11 cays where nesting

occurred in 2010 (Table 3, Figure 3). Of the 21 clutches affected by poaching, the largest proportion (71.4%) occurred on cays used periodically by fishers or where *acopios* were permanently established (Table 3). In addition, poaching activities also occurred on Crawl, Grape, Lime and Wild Cane cays, which were inhabited permanently by caretakers, foreigners, or temporarily by a large number of foreign and local staff filming a television reality show during the first two months of the nesting season (see Human Activities section below). Just over 50% of poaching events occurred on Buttonwood and Columbilla cays, and when combined with Bottom Tawira and Wild Cane cays represent 84.6% of all poaching events. For 10 of the 13 partially poached clutches, however, we observed no other signs of poaching other than a discrepancy of greater than 20 eggs between the original clutch count and the count at excavation, and thus, it is possible some of these clutches weren't partially poached but that field staff miscounted during the original clutch counts.

Table 3. Number and percent of clutches affected by poaching in 2010, Pearl Cays. No poaching events were observed on Baboon, Maroon, or Water cays.

Cay	Type & Duration of Human Presence	Total Clutches Laid	Number and (%) Poached (partially or completely)
Buttonwood	<i>Acopio</i> (fishers), Permanent	12	5 (41.7)
Columbilla	Fishers, Occasional	40	6 (15.0)
Bottom Tawira	<i>Acopio</i> (fishers), Permanent	13	3 (23.1)
Wild Cane	Caretakers, Permanent	62	3 (4.8)
Lime	Caretakers ¹ , Permanent	11	1 (9.1)
Grape	Expatriates and local staff, Permanent	17	1 (5.9)
Vincent	TV show staff, Frequently ²	23	1 (4.3)
Crawl	Caretakers, Permanent	28	1 (3.6)

¹ Lime Cay was also occupied from prior to the nesting season until 27 July by a large number of foreign and local staff filming a television reality show.

² Helicopters and/or reality show staff were observed from 23 April to 27 July (last date reality show personnel observed in the Pearl Cays). No people were observed on Vincent during the remainder of the nesting season.

For all clutches where clutch contents could be evaluated, hatching (HS) and emergence (ES) success were 68.1% and 66.7% (n=261), respectively. For those clutches where at least one egg hatched, HS and ES were 72.2% and 70.8% (n=246), respectively. For clutches left *in situ*, HS and ES were 69.8% and 69.1% (n=152), respectively; and for relocated clutches HS and ES were 64.6% and 62.2% (n=94), respectively. HS and ES for *in situ* clutches were not significantly different from relocated clutches (Mann-Whitney U, Z=1.81, p=0.0696 and Z=1.83, p=0.068 respectively). Although data for HS and ES were skewed, transformations did not reduce skewness, thus, a non-parametric test was used that does not assume normality. Because individual females nest more than once during a nesting season and we did not identify every nest to individual turtles, there is a possibility of lack of independence of either the HS or ES data. However, since we have no information at this time to determine if each nesting event is independent of any other nesting events, the test results indicated no significant difference between *in situ* and relocated clutches for both HS and ES and there is considerable similarity in their distributions, the conclusion of lack of a significant difference is justified. Additionally, HS

and ES for nests with temperature loggers inserted was 72.7% and 72.3% (n=15 clutches), respectively. Based on shell counts, we estimated a minimum 28,459 hatchlings were produced. The exact number of hatchlings cannot be determined because i) one nest was not located at excavation, ii) a few clutches washed out post-hatching but prior to excavation, or iii) in some cases, eggshells were too fragmented to count. Mean time to emergence for *in situ* clutches was 65.2 days \pm 4.4 days (range=61-72, n=5).

Night Surveys

From 21 July through 12 November, a total of 468 cay-night surveys (defined as each night a cay was patrolled) were conducted on 11 cays to encounter nesting females. Cays selected for monitoring each night were based on our assessment of the likelihood of encountering a returning nesting female or on cays that had consistently high nesting activity, e.g., Water and Wild Cane. We encountered nesting females on 156 occasions of which 99 (63.5%) successfully nested and 57 (36.5%) were non-nesting emergences. Of the 156 encounters, we sighted 59 individual females and the remaining 97 encounters were resightings of those same females. Of the 59 individual females encountered, 22 showed no evidence of having been previously tagged (referred to as “recruit”), thus all 22 of these females were tagged and measured for the first time. The remaining 37 females (referred to as “remigrant”) were tagged in the Pearl Cays during previous nesting seasons by project staff (Table 4).

Table 4. Number of female hawksbills newly tagged and number of remigrants observed each nesting season by year when they were originally tagged in the Pearl Cays, Nicaragua.

Year Tagged	Number of Females Tagged	Number of Remigrants by Year								
		2002	2003	2004	2005	2006	2007	2008	2009	2010
1999	1 ^a		1						1	
2000	4	1	2		1		2		1	
2001	1		1		1		1		1	
2002	17			9		2	2	5	3	2
2003	34				10	2	8	5	4	6
2004	14					1	5	3	2	7
2005	13						3	3	3	2
2006	5							2	1	2
2007	20								3	10
2008	29									8
2009	20									
2010	22									
Total	180	1	4	9	12	5	21	18	19	37

^a Female was originally captured in-water and tagged, and was encountered nesting in the Pearl Cays four years later.

Of the 59 individuals encountered, 22 females (37.3%) were observed nesting once, 16 (27.1%) were observed nesting twice, 6 (10.2%) were observed nesting three times, 5 (8.5%) were

observed nesting four times, and 1 (1.7%) was observed nesting six times. The remaining 9 females (15.3%) were observed only during a non-nesting emergence. Of 28 females encountered nesting more than once, 18 (64.3%) used the same cay for each nesting event, 9 (32.1%) used two different cays, and 1 (3.6%) used three cays. Females had an average renesting interval of 15.6 ± 1.8 days (range=12-21, n=35). Twelve females were observed renesting after 25 days or more; however, these observations were not included in the calculations since it is likely that nesting events for these females were missed due to incomplete coverage of nesting beaches.

Remigration intervals (defined as the # of years prior to 2010 a previously tagged female was last seen in the Pearl Cays) ranged from two to seven years with a mean of 2.5 ± 1.2 yr, (n=37). Due to varied and incomplete coverage of the nesting beaches, some of the intervals most likely represent missed two or three year remigrations. In fact, at least 86.5% of returning turtles exhibited either a two or three year remigration interval. As in previous years, shifts in remigration intervals by individual females were also observed in 2010. For example, two females switched from three-year to two-year intervals, and two other females switched from two-year to three-year intervals; however, five females did not shift their remigration interval whether it had previously been a two or three year interval. Since we began a concerted effort to tag nesting females in 2002, the ratio of remigrants to recruits over the past nine years has changed considerably (Table 5), and thus far appears to be related to night patrol effort. In 2010, however, we observed a much greater proportion of remigrants than in any previous season.

Table 5. Proportion of remigrants (tagged during a previous nesting season by project staff) to recruits (no evidence of having been previously tagged) encountered each year on the Pearl Cays.

Year	Recruits Tagged	Remigrants Encountered	Ratio of Remigrants:Recruits	Effort (cay-night surveys)
2002	17	1	0.06:1	73
2003	34	4	0.12:1	93
2004	14	9	0.64:1	165
2005	13	12	0.92:1	169
2006	5	5	1:1	65
2007	20	21	1.1:1	284
2008	29	18	0.62:1	369
2009	20	19	0.95:1	407
2010	22	37	1.68:1	468

Human Activities and Habitat Alteration/Destruction

Human presence on the cays was monitored throughout the nesting season in order to identify and better understand the impacts of human activities on hawksbill nesting, and foraging and nesting habitats in the Pearl Cays (Table 6). Nine of the fourteen cays monitored during the season were permanently inhabited during the 2010 nesting season. Columbilla and Maroon cays were inhabited only occasionally, and Maria Crow Cam Cay remained uninhabited throughout the nesting season. Although Vincent Cay remained uninhabited, the cay was used frequently during the day from April through July by the crew filming a reality show (see following

paragraph). Seal Cay was surveyed only twice during the nesting season, but was uninhabited from November 2009 through the 2010 nesting and hatching seasons (until May 2011). The WCS survey team established a temporary camp on Crawl Cay on 27 July and inhabited the camp until 16 December, when the camp was dismantled and all materials removed.

One of the greatest human disturbances prior and during the 2010 nesting season occurred from January through July, when the Italian television production company Magnolia and its Spanish subsidiary filmed two separate, survivor-type reality shows consecutively, entitled “L’Isola dei Famosi” and “Supervivientes”, respectively, in the Pearl Cays. The reality show’s activities affected fragile dune vegetation and occupied critical nesting habitat for hawksbill turtles on Buttonwood, Lime, Maroon, Vincent, and Wild Cane cays. Although the temporary main headquarters of the production company was located on Corn Island, Magnolia’s technical, logistical and local staff was based on Lime Cay. Based on our surveys, Lime Cay had the single largest number of inhabitants with 65 people, but it was reported that as many as 100 reality show personnel were occupying the cay at one time. From 23 April to 29 July we conducted 32 surveys of Lime Cay in which a mean 26.5 ± 13.3 people/day (range=5-65) were observed on the cay. Once the reality show staff completed their filming and left the area, however, Lime Cay had a mean 3.4 ± 1.6 people/day (range=0-10, n=140 observations) on the cay. Five cabins were built on the south side of the cay to house staff and local workers. In addition, a large enclosure was constructed in the center of the cay and used as a stage for the show (Photo 3A). In January 2011, the large enclosure was found burned down and the charred remains left on the cay (Photo 3B). Although not occupied, Vincent Cay was used almost daily throughout filming to land a large military helicopter, multiple times per day, and a smaller private helicopter, to transport staff and participants between the Pearl Cays and Corn Island. From 23 April to 29 July (last day reality show personnel were observed in the Pearl Cays), helicopters and/or reality show staff were observed on Vincent Cay during 29.0% of the surveys. Rotation of the helicopter blades promoted erosion of the cay by displacing beach sand. No people were observed on Vincent Cay during the remainder of the nesting season. Participants in the show occupied, although not simultaneously, Buttonwood Cay and a large portion of the south beach of Wild Cane Cay, however, both staff and participants moved regularly between these cays. Filming of the Reality Show interfered with periodic beach monitoring of hawksbill nesting prior to establishment of our camp on 27 July by denying the survey team access to two cays, Buttonwood and Wild Cane. During two one-week periods (21 to 25 May and 16 to 22 July) when they were filming on Buttonwood Cay, all access was denied (n=6 times). During a six-week period (29 May to 14 July) while they were filming on Wild Cane Cay, we were denied access to the southeast section (an important nesting area) seven times and the entire cay on one occasion (n=18 survey attempts), resulting in being denied access to monitor hawksbill nesting activity on the southeast section of the cay 44.4% of the time during the period.

Of the remaining inhabited cays, Bottom Tawira had >10 people/day on the cay 49.1% of the time (mean= 10.6 ± 5.7 people/day, range=2-31, n=171 observations) throughout the nesting season. Crawl Cay, location of project temporary camp, had a mean 8.4 ± 4.3 people/day during the reproductive season (range=1-31, n=175 observations). The remaining inhabited cays had means less than 4.3 people/day.

Vegetation on the upper beach platform was altered, removed, or maintained cleared on several cays during the nesting season (Table 6). Cutting or clearing of mangrove trees, and/or ground

vegetation, or raking was observed on Baboon, Bottom Tawira, Buttonwood, Crawl, Grape, Lime, Maroon, Water and Wild Cane cays. Large areas on Baboon (north, west, and center), Crawl (east, west, and center), Grape, Lime (center and south) and Wild Cane (north and northwest) were periodically raked, maintaining areas devoid of vegetation and preventing the regeneration of native plants. On Bottom Tawira, additional cutting of mangrove forest continued on the west and north sides of the cay, in violation of Law #585 (Ley de Veda para el Corte, Aprovechamiento y Comercialización del Recurso Forestal) that prohibits the cutting of mangroves (Art. 1).

The use of artificial lights at night on the cays was monitored from 22 July to 16 December 2010 and was observed on Bottom Tawira, Grape, Lime, and Water cays (Table 6). Lights were observed most frequently on Grape Cay with 138 nights illuminated (94.5%, of 146 nights monitored), and lights were on as late as 0400 h. Of the 146 nights monitored, 75.3% of the time lights on Grape Cay were on until 2300 h ($n=110$ nights), representing approximately 50% of the nocturnal period, and were prominent on all sides of the cay. Due to the persistent use of artificial lights in the center and around the perimeter of Grape Cay (Photo 4), and the report of hatchlings found disorientated on the cay we decided to move all subsequent clutches laid on the cay to an area farthest from the lights. To shield emerging hatchlings from the negative affect of artificial illumination on the cay a temporary screen was constructed from bamboo and black plastic (Photo 5). At the time of excavation, almost all the nests were full of biting ants and nest contents were hot from decomposition processes. Many of the nests were full of dead hatchlings that died prior to emerging. Overall mean hatching rate on Grape Cay was 44.8% (range=0-98.4%, $n=13$). On Bottom Tawira, lights were observed 30.8% (44 nights) of the time, of which 88.6% of the time lights were turned off by 2200 h. On Lime Cay, lights were observed on 39 nights (27.1%) on the south side of the cay, and were turned off by 2200 h 66.7% of the time. On Water Cay, lights were observed 14 nights (9.8%) on the west and central portions of the cay, and 92.9% of the time were turned off by 2200 h.

Domestic and/or exotic animals were present during the nesting season on 10 of the 14 cays monitored, e.g., dogs, cats, pigs, chickens, and rats (Table 6). Dogs were observed on 9 of the 14 cays where hawksbill nesting occurs, with as many as 14 dogs present at one time on Bottom Tawira, and as many as 4 dogs present at one time on Black Mangrove. Dogs were also brought occasionally to Columbilla Cay by green turtle fishers, and to Buttonwood Cay by lobster fishers. One domestic pig was observed on Bottom Tawira, however, it was confined to a corral. In addition, one domestic cat resides on Crawl Cay, one feral cat was observed on Lime Cay, and a wild cat (species unknown, but probably a margay, *Leopardus wiedii*, or an ocelot, *L. pardalis*) was observed on Wild Cane Cay. The wild cat was reportedly captured in a mainland forest and brought to the cay in approximately 2005 (Campbell et al., 2008). Rats were observed only on Water Cay.

There was very little new construction on the cays during the 2010 nesting season but that may be in large part due to the number of permanent structures already present. For example, by the end of 2009, Grape Cay (less than 0.5 ha in size) was almost entirely covered with six buildings, a cement dock, and a retaining wall that blocked access of adult females to nesting habitat on the north side (Campbell et al., 2010). In 2010, hawksbills attempted to nest underneath buildings on Crawl and Wild Cane cays, and inside a fishermen's hut on Columbilla Cay. On some cays, sections of the nesting beaches continue to be used to store lobster fishing materials and/or dead

vegetation was piled-up, such as coconut husks, fallen branches and driftwood, and later burned. Small nesting areas on Bottom Tawira and Buttonwood cays were, on occasion, covered with lobster traps during the nesting season, rendering the areas unusable by nesting hawksbills. The extraction of sand, or sand mining, was observed on the west side of Grape Cay on three occasions, Maroon (north and west sides), and Water (west side).

Adult and Juvenile Hawksbills Killed

We estimated that since the 2009 Pearl Cays hawksbill final report (Campbell et al., 2010) at least four reproductively mature female hawksbills from the Pearl Cays rookery and 17 juveniles were killed. Of the four adult females, one was captured by local fishers in the RAAN (Región Autónoma Atlántico Norte) and three by fishers in the RAAS (Región Autónoma Atlántico Sur). All 17 juveniles were captured and killed by fishers in the RAAS.

We believe that hawksbill mortality is highly underrepresented because our data is based almost entirely on tag recoveries and because of information received that fishers inhabiting the northern Pearl Cays continue killing juvenile hawksbills. In 2010, our project field staff visited the northern cays (Askill, Esperanza, Little Savanna, Savanna, and Walter) regularly on 30 occasions (on average one visit per week) during the nesting and hatching seasons to discourage the killing of juvenile hawksbills by lobster divers, to talk with *acopio* residents about the need for hawksbill conservation, and to provide an incentive to donate live turtles for tag and release (see Incentive Program).

Table 6. Summary of human activities and habitat alteration/destruction observed during the 2010 hawksbill nesting season, Pearl Cays. N/A = Not Applicable. Maria Crow Cam and Seal cays are not included in the table due to the lack of human activity.

Cay	Side of Cay Where Most Disturbance Occurred	Human Habitation	Domestic and/or Exotic Animals Present	Use of Artificial Lights	Sand Mining	Erosion of Coastline Observed	Construction Activities &/or Obstruction of Nesting Area	Vegetation Alteration
Baboon	North & West	Permanent	Dog and chickens	No	No	Northeast, North, Northwest, West	Repairing house.	Periodically raked north & west sides of cay to maintain large area denude of all vegetation (dune & inland), including nesting area. Remaining patches of grass cut on north side.
Black Mangrove	Entire cay	Permanent	Dogs	No	No	No	None observed.	None observed.
Bottom Tawira	West & South	Permanent	Dogs, pig and chickens	Yes	No	No	Repairing <i>acopio</i> .	Vegetation cut on west side (dune & inland), and south side (dune). Herbicide sprayed on upper beach of west side to kill grass. Burned piles of dead vegetation on south side. Mangroves cut on west side of cay.
Buttonwood	Entire cay	Permanent	Dogs (sporadically)	No	No	North and South Pt.	Walls made of palms placed on north side of cay for several weeks by Reality Show, houses were repaired, one house was removed from north side and placed in center of cay	Cleared dune vegetation on north, cut vegetation on south (inland), and burned piles of dead vegetation on north & west (dune) sides of cay.
Columbilla	North & West	Occasional	Dogs (sporadically)	No	No	No	Thatched fisher camp built.	None observed.
Crawl	West	Permanent	Dogs (sporadically), cat and chickens	No	No	North and East	Construction of cement building continued for a short period at the onset of the nesting season.	Vegetation routinely cleared, cut or burned on the west, southwest, south, east, and center of cay. Large area in center of cay frequently raked to maintain area denude of all vegetation.
Grape	Entire cay	Permanent	Dogs	Yes	Yes, West	All	One small open beach cabana under construction on west side.	Almost entire cay routinely raked to maintain most of the cay denude of vegetation. Ground vegetation cleared and piles of dead vegetation burned on west and south sides. Grass cut on north side (inland).
Lime	South & Center	Permanent	Dogs, cat, and chickens	Yes	No	All	5 cabins and 1 large thatch-roof building constructed in center of cay at the beginning of nesting season for Reality Show. Houses dismantled and large building burned down in January 2011.	Occasionally burned piles of dead vegetation on west and south sides, and inland on south side and center of cay. Periodically raked south side of cay to maintain area denude of vegetation, including nesting area. Large area of grass cut in center of cay.
Maroon	N/A	Occasional	None observed	No	Yes, North	All	None observed.	Ground vegetation cut on north and south sides, and in center of cay. Vegetation cleared on east side (dune & inland).
Vincent	East	Uninhabited	None observed	No	No	All	None observed.	None observed, very little vegetation remaining.
Water	West & Center	Permanent	Dogs, chickens and rats	Yes	Yes, West	North, West, and South	Constructed new cabin next to existing ranch on west side. In January 2011, an additional cabin was initiated in the same area.	Occasionally cleared and/or cut vegetation on west side and in center of cay.
Wild Cane	North & South	Permanent	Small wild cat (probably a margay or ocelot)	No	No	North, West, South, Southeast Pt.	Repaired large house on north beach.	Burned piles of dead vegetation on north, west and south sides, particularly from April through July. Vegetation either cut or cleared on the west and south sides (dune & inland), having particular impact on the south side. Periodically raked north & west sides of cay to maintain large area denude of all vegetation (dune & inland), including nesting area.

Incentive Program - Donation of Live Turtles

We continue to encourage fishers to donate live turtles (in exchange for a specially designed T-shirt, or a life-jacket for every 15th donation by the same individual (Photo 2B) to be tagged and released. Although some fishers continue killing hawksbills of all sizes, we believe the Incentive Program has resulted in an overall decrease in juvenile hawksbill mortality in the Pearl Cays. To date, more than 700 T-shirts and 18 lifejackets have been awarded. During the 2010 hawksbill nesting season (June to December) there were 175 live sea turtle donations, of which three were loggerheads, 13 were green turtles, and 159 were hawksbills. The three loggerheads were captured in nets by green turtle fishers and were large juvenile to adult in size, ranging from 54.3 cm to 71.5 cm minimum straight carapace length (SCLmin) (mean 61.4 cm \pm 9.0, n=3). Green turtles were small to large juveniles ranging in size from 28.7 cm to 53.0 cm SCLmin (mean 38.0 cm \pm 8.8, n=12). Of the hawksbills donated to the project, 13 were nesting females captured on a cay by fishers, watchmen, or other people residing on the cays. The remaining 145 hawksbills were captured in the water (40.8 cm \pm 9.1, n=144), of these, 137 were small or large juveniles (range=20.2-61.5 cm, SCLmin) captured by divers, and the remaining eight (range=40.7-78.0 cm, SCLmin) were incidentally captured in nets set for green turtles.

Awareness and Outreach

Throughout the nesting season, five progress reports on project activities and preliminary results were distributed to 22 Nicaraguan authorities, including: the Ministry of the Environment (Ministerio del Ambiente y los Recursos Naturales, MARENA), National Police, Attorney General for the Environment, Navy, the south autonomous regional government (Consejo Regional, RAAS), Bluefields Indian & Caribbean University (BICU), the Pearl Lagoon municipality, two territorial authorities representing the 12 communities who use the Pearl Cays, and the U.S. Embassy. Twenty weekly updates were compiled and broadcast on three radio stations, Radio Caribbean Pearl (from Pearl Lagoon in Creole English), Radio Zinica (from Bluefields in Spanish) and Radio Rhythm (from Bluefields in Creole English). In Pearl Lagoon, the radio updates were broadcast by local WCS project staff and local high school students from the WCS Youth Group.

The WCS Youth Group (Photo 6) was reactivated in 2010 and continues to work towards the following objectives: a) to provide an opportunity for local teenagers to learn about sea turtle biology and conservation needs, b) to engage them in outreach activities by encouraging them and providing opportunities for them to promote sea turtle conservation, c) to build capacity at a local level, and d) to provide a link between sea turtle conservation activities and community members. The WCS Youth Group is comprised of 12 high school students from the Instituto Las Perlas in Pearl Lagoon, and meets almost weekly throughout the school year. The Youth Group activities are focused primarily on sea turtle biology and conservation but members also learn about marine and environmental issues which they do through presentations, videos, and other activities. In addition to broadcasting radio updates on the local radio station, they have carried out a number of other activities. In October 2010, we launched a blog where the Youth Group shares their activities to a worldwide audience. Together, they write posts and answer messages collectively, in Spanish or English. The website has already received more than 1,000 visits from around the world and can be visited at <http://wcsyouthgroup.wordpress.com>. They also created a poster to raise awareness on coastal and ocean pollution, which we hope to have printed and distributed in 2011.

More than 20 people were hosted by the project and accompanied project staff on trips to the cays to learn about hawksbill turtles, their conservation needs, and project activities. Whenever possible, local authorities, teachers or older students were invited to accompany project staff on nesting beach surveys or night patrols. In addition, Saúl Reyes, from the MARENA delegation in Bluefields, and Jessie Aristhomene, each spent a week with our team on the Pearl Cays and became directly involved in the monitoring and conservation activities, learning about sea turtle biology and the threats hawksbills face on the Pearl Cays. They also learned about the origin of the Hawksbill Project, its development, and the progress made since its initiation. Furthermore, both were able to observe hawksbill females nesting and received training on data collection methods. The project was also visited by Josué Isaías, from the Instituto del Desarrollo Rural in Bilwi (Puerto Cabezas), RAAN. Mr. Isaías is an occasional collaborator with WCS in the northern Caribbean coast of Nicaragua and was given hands-on training by WCS Field Supervisor William McCoy.

Our educational efforts also included assisting local high school students in completing their senior project and other school work. During the 2010 season, the following students from the Instituto Las Perlas in Pearl Lagoon and its annex in Haulover received guidance from WCS staff and used the office library resources: Shorvin Benard, Deyson Burton, Lillieth Desouza, Shaver Downs, Ivania Garth, Darlet Hebbert, Deon Hayman, Nearlene Humphreys, Kesther Lewis, Milda Martínez, Keffrey McCoy, Patrick Patterson, Elia Pineer and Clayvon Sambola. Several of these students joined the WCS excavation team on 4 October to learn about the examination of post-hatched clutch contents and hawksbill reproductive biology.

Progress reports, radio broadcasts, and visitors to the project provided opportunities to inform community members as well as government officials of project activities and threats occurring during the hawksbill nesting season. Furthermore, training workshops and hands-on experiences provided to community members and government officials through the WCS Pearl Cays Project contribute towards the conservation of hawksbill turtles and their eggs. At the end of the nesting season, presentations on the results of the season, hawksbill biology, and hawksbill conservation needs were given to the WCS field staff, local and regional authorities, and to members of the Nicaragua National Police.

DISCUSSION AND CONCLUSIONS

In 2010, a record 299 clutches were laid and more than 28,400 hatchlings were produced. This was the sixth consecutive year with more than 200 clutches recorded. We believe the high number of clutches laid in 2010 is probably a result of variable remigration intervals because annual fluctuations in hawksbill nesting levels are not uncommon and have been reported for many sea turtle nesting populations (e.g., Tortuguero, Costa Rica, Bjorndal et al., 1999). These fluctuations are likely due, in large part, to changes in environmental factors, which can influence food quality and availability, and remigration intervals of individual females. In addition, it's possible that there has been a decrease in female and large juvenile mortality rates, and, thus females are returning to nest in subsequent years and subadult females are recruiting into the reproductive population. Continued long-term monitoring is necessary to more accurately assess population trends and management actions.

Hatching success for all clutches was similar to previous years but hatching rate for relocated clutches improved from 60.0% in 2009 (Campbell et al., 2010) to 64.6% in 2010, although it was lower than the 2007 and 2008 nesting seasons at 68.0% (Campbell et al., 2008) and 71.3% (Lagueux et al., 2009), respectively. The reason for this comparatively low hatch rate for relocated clutches is unclear but could be the result of poor handling of eggs when clutches were relocated. A contributing factor may also be the delay in conducting daily surveys, which did not begin until late July, resulting in more clutches than usual being relocated many hours post nesting. Nevertheless, we will increase oversight of field staff during future nesting seasons in an effort to ensure a greater hatching success for relocated clutches.

Poaching activity, although comparatively low at 7.0% in the 2010 season, is still of concern. Of particular concern is the poaching that persists on Bottom Tawira, Buttonwood, and Columbilla cays. These cays are inhabited regularly by local fishers who are involved in either the lobster, green turtle, or shark fisheries. These cays are particularly problematic with respect to improving nest protection due to a lack of cooperation by a few fishers and lack of enforcement of existing regulations by local authorities; nevertheless, we continue to work with local fishers to increase their cooperation. This season we also recorded poaching activity on Lime and Wild Cane cays during the filming of a Spanish television reality show. Not only did filming activities negatively affect the fragile ecosystem of the Pearl Cays (e.g., alteration and/or destruction of dune vegetation, increased waste and pollution) but it also interfered with beach surveys and protection of hawksbills and their eggs, and increased the number of people on Lime and Wild Cane cays from 12 to 50 times higher than levels reported in recent years, and increased boat traffic around the cays. The fact that poaching activity occurred on these two cays during a period in which a team of Police accompanying foreign and local staff of the television company highlights the need for awareness and capacity building of law enforcement when it comes to the protection of hawksbills in the Pearl Cays area.

Nesting females continue to exhibit similar patterns of inter- and intra- nesting intervals (primarily 2- or 3-yr and 16 d, respectively), and are consistent with other hawksbill nesting populations in the region (Bjorndal et al., 1985; Hillis and Mackay, 1989; Richardson et al., 1999). In 2010, the ratio of remigrants to recruits was 1.68:1, the first time this ratio has been skewed towards remigrants, possibly indicating that a large proportion of the nesting females in this population are not first time nesters. Identifying individuals allows us to monitor mortality and recruitment into the reproductive population, evaluate population status, and to identify and mitigate threats.

Killing of hawksbills continues to threaten hawksbill recovery, not only for the Pearl Cays rookery but also for hawksbills that migrate to Nicaragua's coastal waters from throughout the Caribbean. Hawksbills, like other sea turtles, have naturally high mortality rates at earlier stages of their life cycle and lower mortality rates as they grow and reach maturity. A study conducted on Caribbean hawksbills found that annual survival of large juveniles and adults were the most important factor for population maintenance (Heppell et al., 1995). In Caribbean Nicaragua, hawksbills are generally not targeted by fishers, however, both large juveniles and adults are often captured intentionally by lobster divers, or incidentally in gill and green turtle nets. Since killing of hawksbills is illegal most mortality is likely not reported; thus, our results on hawksbill mortality in Caribbean Nicaragua are the minimum number killed.

The Pearl Cays is an important nesting site for hawksbills in the Caribbean, but this area also includes reefs that provide developmental habitat for foraging hawksbills from both the Pearl Cays rookery and throughout the Caribbean (e.g., Barbados, Costa Rica, U.S. Virgin Islands). International tag recoveries, satellite tracking, and genetic analysis highlight the importance of the Pearl Cays at a regional scale. Thus, actions of Nicaragua's fishers towards hawksbill conservation not only affect Nicaragua's resource, but those of many nations around the region. Unfortunately, the ability of enforcement authorities in Nicaragua to take appropriate actions when needed is inadequate, and thus the illegal killing of hawksbills will only decrease if local fishers are willing to cooperate with conservation efforts. Thus, outreach activities to raise awareness and increase collaboration among fishers along the Caribbean coast of Nicaragua are a vital component of hawksbill recovery efforts for the region.

Use of artificial lights on or near nesting beaches in the Pearl Cays continues to be problematic. Of particular concern is the frequent use of lights until very late at night on Grape Cay. It is well documented that females are deterred from nesting on beaches illuminated with artificial lights, but hatchlings are attracted to lights visible from the beach (Witherington and Martin, 2000). When females are deterred from nesting it can result in them nesting in suboptimal habitat or releasing their eggs at sea, reducing their reproductive success and population recovery. In addition, the orientation of hatchlings towards artificial light sources compromises their ability to respond to natural orientation cues, usually resulting in their death by dehydration or depredation. For these reasons, artificial lights visible from nesting beaches should be prohibited during the nesting and hatching season (May through December, from 7:00 pm to 5:00 am), unless using approved "turtle friendly" lighting. In addition, campfires visible on nesting beaches should be prohibited during the same period. Guidelines for "turtle friendly" lighting have been well established and should be used to help resolve artificial lighting problems in the Pearl Cays (see Witherington and Martin, 2000). These guidelines include considerations for positioning and shading of lights, and types of lights that are less detrimental near turtle nesting beaches.

Hawksbills prefer to nest within the upper beach vegetation (Horrocks and Scott, 1991; National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998; Kamel and Mrosovsky, 2006), with at least one study indicating that nest sites with vegetation were less compacted than non-vegetated sites (Horrocks and Scott, 1991). Our data indicates that females crawl significantly longer distances and farther from the high tide line when clutches are laid in areas where vegetation has been altered and/or removed, suggesting that vegetated areas on the dune are the preferred nesting site for nesting hawksbills. Ground vegetation plays an important role in reducing coastal erosion, however, removal of ground vegetation and sand from nesting beaches continues to occur in the Pearl Cays. Furthermore, large areas on Baboon, Crawl, Grape, Lime and Wild Cane are periodically raked to maintain those areas devoid of vegetation (Photo 7). Continued raking has an ever increasing impact on these small islands by destabilizing beaches, compacting the sand, and increasing erosion, as well as reducing quality nesting habitat for hawksbills.

The impact of vegetation removal from the dune and interior of the cays extends beyond the boundaries of the cays themselves by impacting reefs and seagrass beds in the surrounding waters from increased sedimentation. From our observations, beach erosion is indeed a major conservation issue on the Pearl Cays (Photo 8). As sand-binding vegetation is altered or removed wind may erode nesting beaches and dunes, in addition, waves and currents may erode an entire cay if protection from fringing reefs is reduced (Salm et al., 2000). Thus, the effect of beach

erosion on marine resources in the Pearl Cays has far more implications than reducing of critical hawksbill nesting habitat. For example, seagrass beds are important nursery grounds for economically valuable species and biodiversity is greater in seagrass beds than in adjacent unvegetated areas (Hemminga and Duarte, 2000). Seagrasses have extremely high light requirements which means they are negatively affected by decreases in water clarity (Dennison et al., 1993). Uncontrolled human activities that alter or destroy the Pearl Cays ecosystems is probably the greatest threat to the Pearl Cays hawksbill population. An example of a cay that clearly exemplifies the consequences of removing ground vegetation is Vincent Cay (Photos 9 and 10). This cay has suffered major erosion in recent years due to the removal of ground vegetation, sand-mining and unpermitted construction. Furthermore, in 2010, helicopters transporting staff and provisions for a reality show landed frequently on Vincent Cay (Photo 11), exacerbating beach erosion on this cay. To date, no mitigation measures have been taken to reduce coastal erosion of the Pearl Cays.

Habitat destruction related to human activities on the Pearl Cays has caused the loss of important nesting areas. Since 2003, there has been little to no nesting activity on the north side of Wild Cane Cay (Lagueux and Campbell, unpubl. data). Prior to 2003, when the upper beach and forest was cleared and construction began on a large house and pool, this area accounted for 23% of the nesting activity on this cay (Lagueux and Campbell, unpubl. data). Since 2003, the north side of Wild Cane Cay has been completely devoid of vegetation and no longer provides appropriate conditions for nesting hawksbills. Nesting on the north side of Grape Cay has been eliminated as a result of the construction of a breakwater wall to prevent beach erosion. In early 2007, a wall was constructed on the north side of Baboon Cay to reduce beach erosion (Campbell et al. 2007). Both these breakwater walls were constructed after native ground vegetation was removed and severe erosion ensued. Native plants on the dune reduce erosion and their removal needs to be strictly prohibited. Furthermore, measures to restore native vegetation should be implemented immediately.

Encounters with individual nesting females demonstrate that the majority exhibit a strong fidelity to a certain cay. However, since we pre-select cays where hawksbills are expected to come ashore to lay, we are likely biasing our results somewhat towards females that do not change cays when they re-nest. It is important to understand that there is variability in nest beach selection resulting in movements by some turtles between cays within and between nesting seasons, and thus, all potential nesting areas need protection in order to provide the greatest possibility for reproductive success and population recovery.

WCS strongly supports the economic and development benefits that can be provided to the government and local communities through the expansion of new and/or existing activities. Not all human activities, however, are appropriate or ideal for all sites. The Pearl Cays ecosystem is unique and the cays, seagrass beds, coral reefs, and mangrove forests are highly fragile and not resilient to medium to high human densities and/or impacts. The hawksbill is a critically endangered species and requires specific conditions to successfully reproduce. If nesting sites in the Pearl Cays are lost or degraded so they no longer provide adequate habitat for nesting, egg incubation, or hatching then this important resource will diminish. Due to fidelity to their natal beaches, hawksbill turtles, like other sea turtles, can not move to another location to lay their eggs. If hawksbills hatched in the Pearl Cays can not reproduce successfully then the hatch rate will decrease, reducing recruitment into the Pearl Cays rookery and eventually reducing the population overtime. It is essential that experts and knowledgeable institutions (including NGOs,

local governments and communities) be consulted regarding potential projects or activities being considered in the Pearl Cays. A standard operating procedure should be developed that incorporates the type of activities to be conducted, anticipated direct and indirect impacts that will occur to the ecosystem, time of year in which activities will occur, supervision and oversight of the activities throughout the project period, periodic evaluations, and a mechanism to deny continuation of activities if the impacts exceed allowable limits and/or activities change. Conducting survival type reality shows in the Pearl Cays is not an appropriate activity for this location, particularly during the hawksbill nesting and hatching seasons, and when careful control and strict supervision of human activities does not occur. The short-term benefits realized from the reality show do not outweigh the loss and/or degradation of habitats which undermines the long-term viability of the ecosystem and the dependence of local communities on the resources for food and income.

In total, the Incentive Program has received 763 donations of live turtles since it was initiated in 2000. More than one-third (42.1%) of the turtle donations occurred during the two most recent nesting seasons with 126 turtles donated in 2009 and 195 donated in 2010. The increase in turtle donations is a result of increased presence and effort by project field staff to raise awareness of local fishers in the more northern Pearl Cays about hawksbill conservation needs. In 2010, cooperation of fishers improved with some of them bringing donated turtles to our temporary camp in the lower cays instead of holding turtles on the more northern Pearl Cays for our team to retrieve. Even though these are positive indicators of increased awareness and cooperation, some individuals continue to kill hawksbills, and thus, it is necessary to continue our efforts to raise awareness of fishers in the upper cays. Likewise, a concerted effort to reduce the killing of hawksbill turtles by fishers in the Región Autónoma Atlántico Norte (RAAN) should be implemented and laws protecting hawksbills and their products should be enforced at markets, fairs, tourist destinations, and at airports to reduce the demand for hawksbill jewelry.

Sea turtle nesting sites require special protection. On 30 November 2010, the Nicaragua National Assembly declared the Pearl Cays a wildlife refuge (Ley #738, Refugio de Vida Silvestre Cayos Perlas). As a protected area, the Pearl Cays Wildlife Refuge should provide a framework within which protection of hawksbills, their eggs and critical habitats is ensured through strict enforcement of regulations of human activities on the cays and surrounding waters, and the promotion of local awareness and participation in natural resource management. This community-approved protected area originated because of a widespread concern among stakeholders of the status of the fragile ecosystems and the wildlife found in the area. The new status for the Pearl Cays provides an excellent opportunity to protect and restore degraded areas in order to ensure the long-term viability of the rich biodiversity in the Pearl Cays.

While the 2010 hawksbill nesting season was successful, a number of threats continue to jeopardize the recovery of this important hawksbill rookery. It is evident that more work needs to be focused on educating fishers and local community members about the current and potential benefits from using hawksbill turtles in a sustainable, non-consumptive manner, e.g., through ecotourism, as well as the benefits that a healthy hawksbill population provides to marine and terrestrial habitats. Increased protection of nesting females and clutches have aided in the significant increase in nesting activity observed on the Pearl Cays in recent years, however, human alteration of the cays and surrounding waters is damaging and reducing critical nesting and foraging habitat; hampering conservation efforts and disrupting the ecological balance of the fragile ecosystems in the Pearl Cays area. Nevertheless, we remain optimistic that as we continue

to increase participation in conservation activities, increase awareness and continue educating local inhabitants, and as local communities observe first-hand the advantages of managing use of their natural resources sustainably, positive changes will continue and the Pearl Cays hawksbill population will gradually move towards recovery.

Recommendations for the Pearl Cays

Recommendations continue to be similar as in previous years because the needed measures have not yet been put into place. The cays themselves are rapidly decreasing in area, at least in part due to unsustainable practices, thus, for local communities to continue to benefit from the resources found in the Pearl Cays area it is imperative that a set of regulations be approved by local and regional authorities, and enforced.

- a) Regulations drafted with local community and government authorities to mitigate human impacts on the Pearl Cays, particularly hawksbills, should be legally enacted as soon as possible, and mechanisms for enforcement put into practice.
- b) Buildings should not be constructed on or near hawksbill nesting areas; setbacks of at least 20 m from the upper beach (possibly farther depending on the circumstance) for approved structures should be imposed and enforced.
- c) Breakwater walls, cement docks, and other hard structures should not be permitted in the nearshore waters of the cays.
- d) Upper beach areas should be allowed to revegetate with native vegetation (see Photo 12) and should not be cut or cleared. Non-native plant species such as coconut trees should be removed from the upper beach platform to facilitate the restoration of native vegetation and improve the quality of nesting habitat, and decrease susceptibility of the coastline to erosion.
- e) Artificial lights (including electric lights, campfires, or flashlights without red filters) should be prohibited from illuminating nesting beaches during nesting and hatching seasons, 7:00 pm to 5:00 am from May through February.
- f) Use of generators during the night should be limited during nesting and hatching seasons, and until the potential impact of substrate vibrations produced by generators on nesting hawksbills can be evaluated.
- g) Domestic or exotic animals should not be permitted on the cays at any time.
- h) Human activity on nesting beaches during nesting and hatching seasons should be controlled. People should only be permitted to observe nesting turtles under the supervision of experienced, trained, and permitted guides or permitted sea turtle biologists.
- i) Proper sewage systems and waste disposal should be installed on cays where humans are permitted to reside.

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Photographs



Photo 1. 2010 Hawksbill Project Team. From left (kneeling): Alan Morales, William McCoy (Field Supervisor), Kensly Martínez; from left (standing): Victor Huertas (Project Coordinator), Dorian McCoy, José Hodgson, Claudia Forbes, Gertrudis Hodgson, Aisha Rickli-Rahman, Linda Hodgson, Harvey Antonio. Not pictured: Telia Narcisso, Cathi Campbell, and Cynthia Lagueux.



Photo 2. A) Juvenile hawksbills and green turtle donated to the WCS Donate a Live Turtle Incentive Program during a visit to the northern Pearl Cays, and B) Mr. Arquilius Thomas receiving his third life-jacket for his 45th donation to the WCS Incentive Program.



Photo 3. A) Large hut constructed on Lime Cay for the filming of a TV reality show (July 2010), and B) status of the same area after hut was burned down (January 2011).



Photo 4. Light fixture on a severely impacted upper beach on Grape Cay. Sources of artificial illumination originate from internal building lights, lights mounted on the outside of buildings, and lights located on the upper beach around most of the cay. Ground vegetation has been completely removed around much of the cay and affects of erosion are evident. This area had no nesting activity in 2010.



Photo 5. Temporary screen constructed from bamboo and black plastic to shield emerging hatchlings from artificial lights on Grape Cay.



Photo 6. 2010 WCS Youth Group and project staff, from left: Víctor Huertas (Project Coordinator), Lillieth Desouza, Suling Forbes, Kent Rigby, Yasira Navas, Shelaine Hooker, Tashira Taylor, Kevin Martínez, Shanelly Maradiaga, Telia Narcisso (Project Assistant), Cynthia Lagueux (Program Director), Najelly Jiménez, Charleen Evans, and Ryan Moxley. Not pictured: Kensor McCoy.



Photo 7. Area completely devoid of vegetation on Crawl Cay. This area is frequently raked to prevent regeneration of vegetation.



Photo 8. The west and north sides of Wild Cane Cay have been maintained devoid of vegetation by continued clearing and raking, contributing to severe erosion and resulting in loss of valuable hawksbill nesting habitat.



Photo 9. Although not the original state of Vincent Cay this photograph was taken prior to recent severe beach loss, and thus can be used to compare degradation of this cay to more recent years, 31 January 2007, (see Photo 10 for comparison).



Photo 10. Vincent Cay, 25 January 2011.



Photo 11. Helicopters used by Magnolia Production Co. during filming of the reality show “Supervivientes”. Both helicopters landed repeatedly on Vincent Cay, often multiple times a day aggravating the already severe erosion on this small cay.



Photo 12. Area successfully regenerated by native beach vine on the south side of Wild Cane Cay. This sand-binding vegetation not only offers ideal nesting habitat for hawksbills, but also helps to reduce erosion.