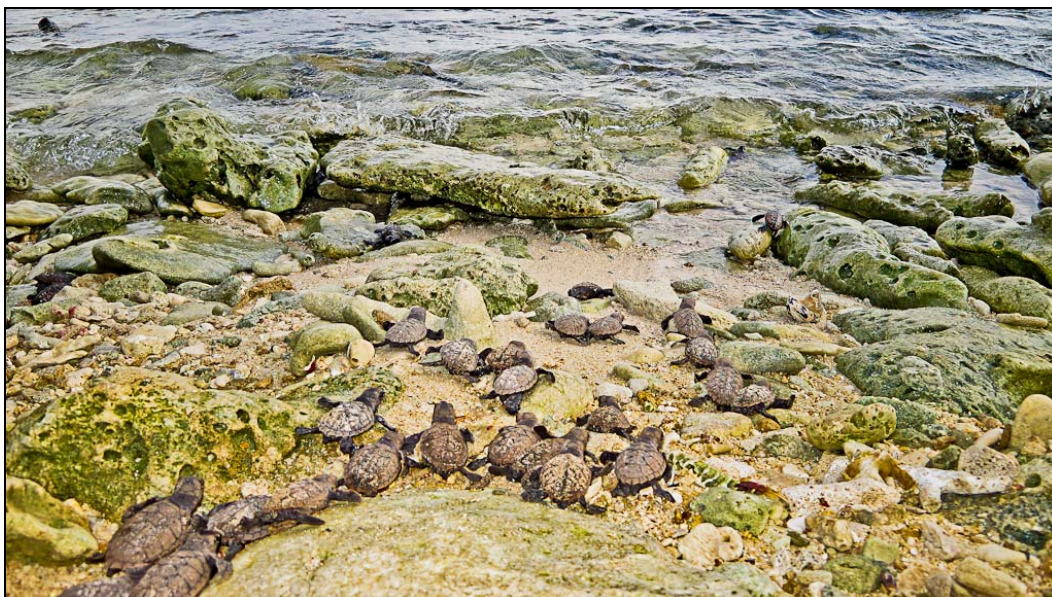




2011 PEARL CAYS HAWKSBILL CONSERVATION PROJECT, NICARAGUA



Hawksbill hatchlings crawling towards the sea, Pearl Cays, Nicaragua, 2011. Photo: V. Huertas/WCS

FINAL REPORT

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ABSTRACT

The Wildlife Conservation Society (WCS) monitored the nesting activity of hawksbill turtles, *Eretmochelys imbricata*, during the 2011 nesting season in the Pearl Cays Wildlife Refuge (PCWR), Nicaragua. We recorded a total of 232 clutches, the third highest number of clutches since conservation activities began in 2000. Over the 12 years of applied conservation measures there has been an average annual increase of 5.2% in the number of clutches laid. Poaching activities continue to be a reason for concern, and increased from 7.0% in 2010 to 15.1% in 2011. 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 Baboon, Crawl, Lime, Water and Wild Cane. In 2011, there has been an increase of unregulated sea cucumber diving activities within the Refuge, and these fishers primarily inhabited cays with caretakers. Although this fishing activity has been observed in previous years, the increased presence of sea cucumber divers in 2011 could be related to the increased poaching activity on some cays. Hatching and emergence success for clutches where at least one egg hatched were 68.8% and 68.7%, respectively. We estimated that at least 20,041 hatchlings were produced during the 2011 season. Between May 2011 and February 2012, fishers along Nicaragua's Caribbean coast killed at least five adults (including two reproductively mature females) and four juvenile hawksbills. Alteration and/or destruction of hawksbill nesting and developmental habitats continued within the boundaries of the PCWR, and unregulated and uncontrolled coastal development was 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 in the Refuge are negatively impacting hawksbill reproduction, threatening not only this regionally important hawksbill nesting population but also economically valuable marine resources in the area. To date, little institutional regulation of human activities or law enforcement has been enacted against environmental law violators in the area. More than a year after the declaration of the protected area, protection remains very low. We provide recommendations to reduce 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, restricting the use of artificial lights during nesting and hatching seasons, and restricting human activities that may be detrimental to hawksbill nesting and reproductive efforts.

REPORT SUMMARY

- a) Annual fluctuations in numbers of nests are common in sea turtle populations and are likely related to varied and/or changing remigration intervals rather than a decrease in population size. Remigration intervals (the number of years between nesting seasons for an individual female) are affected by the quality and quantity of foraging habitat, which in turn is affected by environmental conditions. The long-term nesting trend, however, continues to indicate an overall increase in nesting activity over the last 12 years. Due to these natural fluctuations long-term monitoring is necessary to detect real changes in this segment of a sea turtle population.

- b) Egg poaching increased, extending to cays permanently inhabited by caretakers; and killing of adults (especially reproductively mature females) and juveniles, although reduced, continues to inhibit population recovery. Due to the high migratory behavior of all sea turtles, enforcement of existing laws and conservation efforts need to be conducted along the entire Caribbean coast of Nicaragua, not just in the PCWR; otherwise, hawksbills protected at the nesting beach will continue to be killed when they migrate to their foraging grounds away from the Pearl Cays and are captured by local divers and fishers, which has been proven repeatedly by our tag recovery efforts.
- c) Unregulated human activities on the cays continue to challenge conservation efforts and are resulting in negative impacts to the cays, hawksbill reproductive efforts and other marine resources. Restricting artificial light use and presence of domestic or exotic animals, among others, 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 along the entire coast to attain 100% compliance with existing laws protecting all species of sea turtles.
- 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, 22 January 2012). On Nicaragua's Caribbean coast, hawksbill turtles nest in the Pearl Cays Wildlife Refuge (PCWR), 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 PCWR also provides important foraging and developmental habitats for hawksbill turtles from the Pearl Cays and from across the wider Caribbean, with 20 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 PCWR. 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, 2011; 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 (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 PCWR is important for both the regional and global recovery of hawksbills. In this 12th year of monitoring, conservation and research efforts, the WCS program has made great strides towards the recovery of this important hawksbill nesting and feeding ground, and engaging local stakeholders in better natural resource use management practices. In this report we provide results from our conservation and research efforts during the 2011 nesting season, as well as some of the long-term trends.

Objectives

Objectives for the 2011 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). 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 either cay 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 2011 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 June to the end of October. 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 10 candidates (selected out of 20 applicants) who attended the one-day training workshop, eight (four men and four 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 Alex Allen, Lavonie Cuthbert, Yeldon Desouza, Claudia Forbes, Steve López, Dorian McCoy, Lorelee Murray and Marisa Simión (Photo 1), representing three local communities of the Pearl Lagoon basin (Brown Bank, Haulover, and Pearl Lagoon). In addition, Ruben Julio, from the community of Raitipura, assisted intermittently with field work. William McCoy (Field Supervisor) and Víctor Huertas (Project Coordinator) supervised and assisted with team activities, data collection, and management.

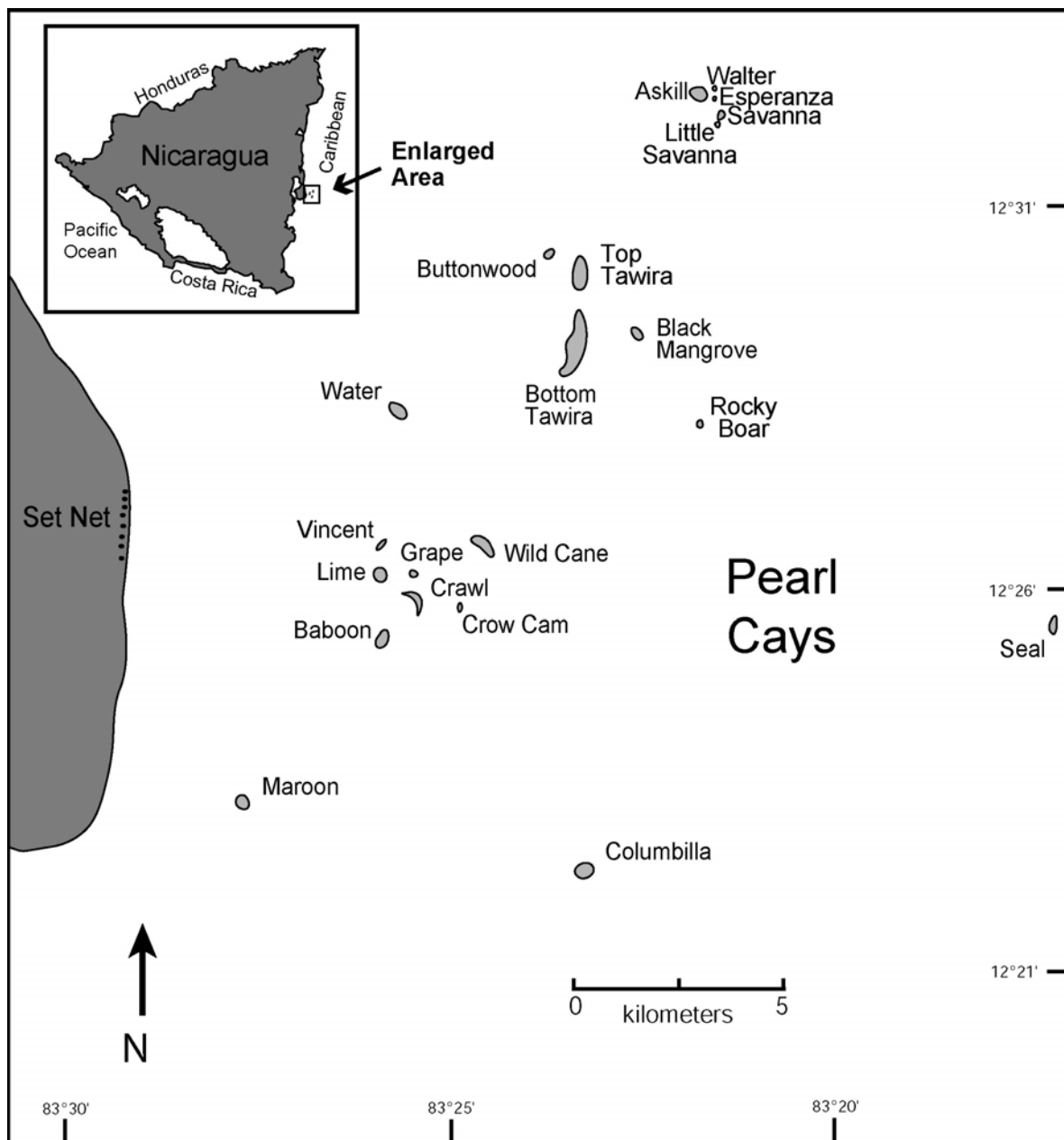


Figure 1. Map of the Pearl Cays, Nicaragua.

Table 1. Area and cumulative nesting beach length for each of the cays regularly monitored in the study. Data is based on a mapping survey conducted in October 2009.

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	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

Two Nicaragua National Police accompanied project staff on nesting beach surveys. Police from the Bluefields station 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 base camp.

To determine the onset of the nesting season and to protect clutches laid early in the season, nesting beach surveys were initiated on 1 May, when the first two nests of the season were encountered. Following the encounter of the first two nests, surveys were conducted approximately every two to three days until 23 June when surveys were conducted daily until 25 October. Our temporary base camp was established on 28 June. Additional surveys were conducted periodically, between 27 October 2011 and 25 January 2012, 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 if nest site conditions were inadequate for 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 clutch from would-be poachers.

Several parameters were measured for each nest. Clutch size was based only on egg counts of relocated clutches because it is more precise than egg shell counts. Nest depth was measured from the bottom of the nest cavity to the beach surface, either when clutches were relocated or when nests 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 general habitat type where the nest was located (i.e., among vegetation, area naturally without vegetation (e.g., open beach or rocky), area where vegetation has been altered or removed, or transition area between beach and vegetation (“border”)).

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.

Temperature Loggers

We continued to monitor sand and nest temperatures at mid-clutch depth. Twenty 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 at 35 cm depth in known nesting areas on several 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 the original 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-emergence, along with the accompanying control logger. The 30 separate temperature loggers were retrieved in December, near the end of the hatching season.

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 were 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 15 June to 16 October). Although the WCS teams initiated night surveys on 15 June; local collaborators inhabiting some of the cays assisted the project by capturing nesting females beginning on 27 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 were 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 by field staff in 2011 could be released immediately after being identified. Turtles that were encountered for the first time in 2011 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 was obtained for genetic analysis from a rear flipper of females not previously sampled.

Incentive Program - Donation of Live Turtles

Throughout the 2011 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 2), 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”.

Data Analysis

A Mann-Whitney U test was used to compare crawl length (CL) and straight-line distance from the high tide line (HTL) in relation to habitat type where clutches were located, and also to compare hatch (HS) and emergence (ES) success for clutches left *in situ* vs. relocated clutches.

After completing a preliminary analysis we found that data were skewed and transformations were unsuccessful at reducing skewness in both cases. Hence, we used a non-parametric test that does not assume normality. Data were analyzed using StatPlus (AnalystSoft, 2009). One standard deviation (SD) is provided with means.

RESULTS

Nesting Beach Surveys

From 1 May 2011 to 25 January 2012, a total of 1,623 cay-surveys were conducted on 14 of the Pearl Cays. We recorded 108 non-nesting emergences and 232 egg clutches, resulting in a ratio of non-nesting to nesting emergences of 0.47:1. Of the 227 clutches where month laid was known, 74.5% were laid during three months, i.e., June (23.3%), July (22.8%) and August (28.4%) (Figure 2).

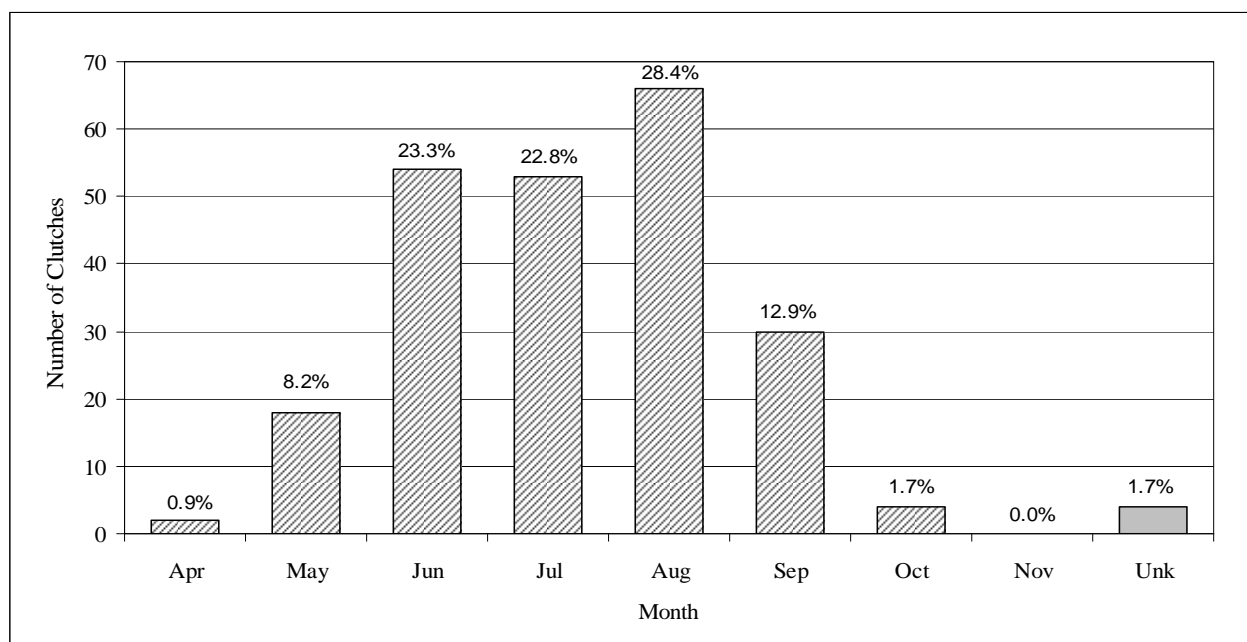


Figure 2. Temporal distribution of hawksbill clutches laid on the Pearl Cays, from April to October 2011 (n=232). Unk = nests where month laid is unknown.

Wild Cane Cay had the greatest number of clutches with 51 (22.0%) followed by Water Cay with 35 clutches (15.1%), Crawl with 32 clutches (13.8%), and Columbilla with 25 clutches (10.8%) (Figure 3). These four cays represented 61.6% of all clutches laid throughout the season. No clutches were recorded on Black Mangrove, Maria Crow Cam, or Seal cays during the 2011 nesting season. Of the 232 clutches laid, 55.6% (129 clutches) were left *in situ*, 8.6% (20 clutches) were left *in situ* but eggs were temporarily removed to insert a temperature logger (see Methods section), and 33.6% (78 clutches) were relocated to a site near the original nest location. The remaining five clutches were poached either completely or partially prior to encounter by a survey team.

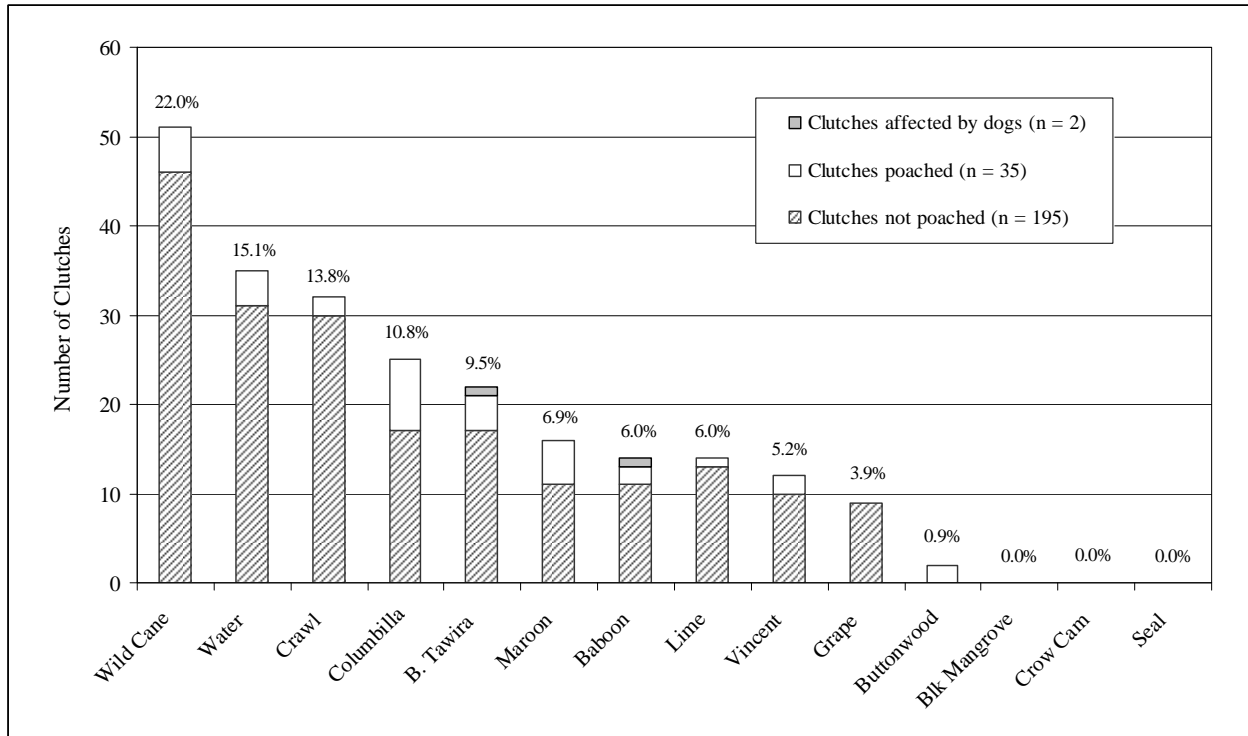


Figure 3. Spatial distribution of hawksbill nests on the Pearl Cays during the 2011 nesting season. Bars show total number of clutches laid by cay separated into clutches not poached, clutches affected by poaching (partially or completely), and clutches dug up by dogs (most likely post-hatching). Numbers above bars indicate percent of total clutches laid for each cay.

Hawksbill nest parameters for 2011 are summarized in Table 2. Mean clutch size, based only on relocated clutches, was 157.0 eggs ($SD=27.4$, $n=78$). Twenty-four yolkless eggs were observed in 14 clutches, ranging from 1 to 6 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 for females that successfully nested was 8.32 m ($SD=6.59$, $range=0.50-63.30$, $n=175$); however, on at least five occasions (2.9%) 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 4.56 m ($SD=2.75$, $range=-0.80-20.00$, $n=213$).

Table 2. Hawksbill nest parameters in the Pearl Cays for 2011. CL = crawl length measured along the crawl from high tide to the center of the nest, HTL = distance of the nest to the high tide measured perpendicular to the coast. Only 4a and 4b, and 5a and 5b were tested for differences between their distributions. Parameters with the same superscript are significantly different.

Nest Parameters	Mean	Standard Deviation	Range	n
1. Clutch size	157.0	27.4	90-210	78
2. Nest depth – original nest cavity (cm)	40.5	3.5	35.0-53.0	77
3. Nest depth – artificial nest cavity post-emergence (cm)	35.9	5.8	23.0-48.0	61
4. CL to nest (m) - for all nests combined	8.31	6.59	0.50-63.30	175
<i>a) Non-altered/removed vegetation¹</i>	7.68	4.98	2.10-39.20	129
<i>b) Vegetation altered/removed¹</i>	12.36	13.22	3.25-63.30	19
<i>c) No Vegetation (naturally clear)</i>	8.34	5.88	2.30-28.07	20
<i>d) Open Beach</i>	7.22	4.35	0.50-16.75	24
5. HTL to nest (m) - for all nests combined	4.56	2.75	-0.80-20.00	213
<i>a) Non-altered/removed vegetation²</i>	4.49	2.62	0.25-20.00	149
<i>b) Vegetation altered/removed²</i>	6.37	3.01	2.10-14.00	25
<i>c) No Vegetation (naturally clear)</i>	3.65	2.75	-0.80-10.35	29
<i>d) Open Beach</i>	3.40	2.46	-0.80-10.35	31

Crawl lengths (CL) for clutches laid in areas where ground vegetation had been removed (Table 2, 4b) were longer than for clutches that were laid in areas with ground vegetation present (Table 2, 4a) (Mann-Whitney $U=1592.5$, $Z=2.10$, $p=0.04$). Similarly, straight-line distances from the most recent high tide lines (HTL) to the center of nests laid in areas where vegetation was removed (Table 2, 5b) were also significantly longer than in areas where ground vegetation was present (Table 2, 5a) (Mann-Whitney $U=2624$, $Z=3.27$, $p=0.001$). 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 the data, however, the p-value for the HTL data is 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. As in previous years, 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 ($r = 0.864$, $p < 0.001$, Figure 4). In spite of the decrease in nesting activity in 2011, there has been an overall 46.0% increase in nesting levels since 2000, with an annual average increase of 5.2% from 2000 to 2011. Data prior to 2000 are not available for the entire nesting season.

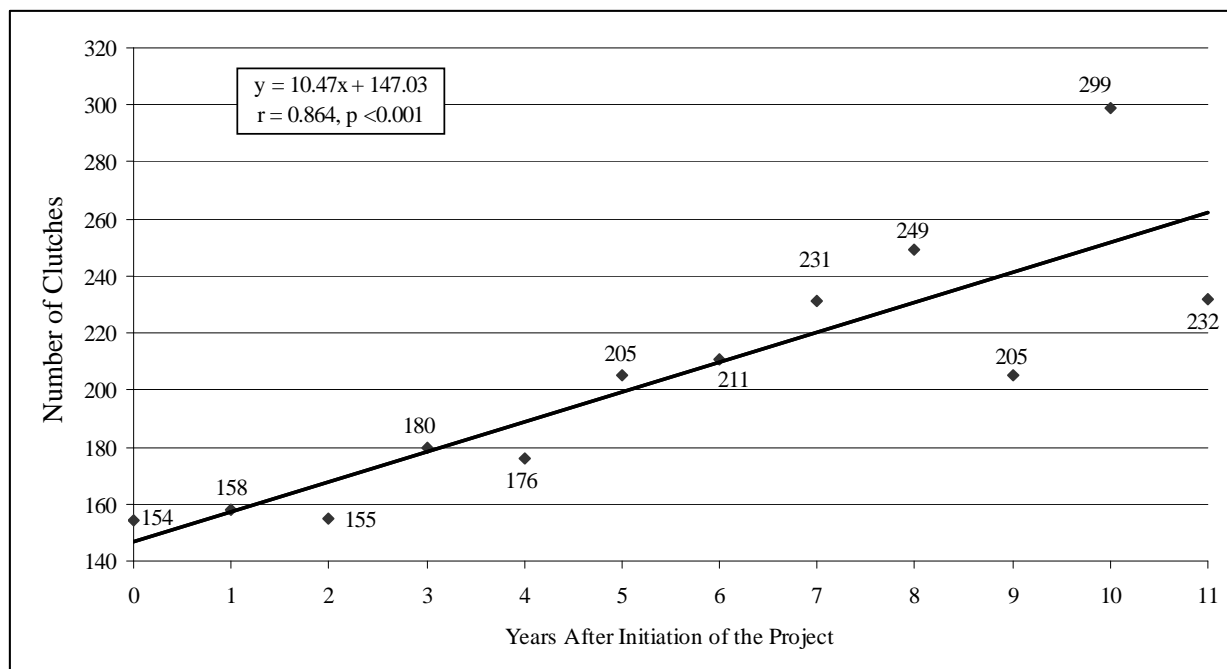


Figure 4. Trend in hawksbill nesting on the Pearl Cays since project initiation in 2000 (year 0) to 2011 (year 11).

Nest Excavations

Of the 232 clutches laid, 227 were left to incubate either *in situ* or at a nearby relocation site after our surveys, the remaining 5 were either completely (n=4) or partially (n=1) poached prior to being encountered. Of the 227 clutches left to incubate, an additional 30 were affected by poaching activities (6 clutches were completely poached and 24 were partially poached). Twenty-three of the 24 partially poached clutches had at least one egg hatch. Of the remaining 197 clutches not affected by poaching, 184 hatched, 4 had no eggs hatch, 3 were washed-out, 4 were partially destroyed (two were dug into by dogs, one was partially destroyed by crabs, and one by a nesting female), and 2 clutches could not be located post-emergence. In total, 212 clutches had at least one egg hatch.

The overall estimated poaching rate, regardless of when or if an entire clutch was poached, was 15.1% and occurred on 10 of the 11 cays where nests were found (Table 3, Figure 3). Of the 35 clutches affected by poaching, the largest proportion (60.0%, n=21) occurred on cays used periodically by fishers or where *acopios* were permanently established (Table 3). In addition, poaching activities also occurred on Baboon, Crawl, Lime, Water and Wild Cane cays, which were inhabited permanently by caretakers, and some of them were also temporarily inhabited by sea cucumber divers (see Human Activities section below). Poaching activity was highest on Columbilla, and when combined with Maroon and Wild Cane cays, represents more than 50% of all poaching events.

Table 3. Number and percent of clutches affected by poaching in 2011, Pearl Cays. No poaching events were observed on Grape Cay.

Cay	Type & Duration of Human Occupants	Total Clutches Laid	Number and (%) Poached (partially or completely)
Columbilla	Fishers, Frequent	25	8 (32.0)
Maroon	Fishers, Occasional	16	5 (31.3)
Wild Cane	Caretaker, Permanent ¹	51	5 (9.8)
Bottom Tawira	<i>Acopio</i> (fishers), Permanent	22	4 (18.2)
Water	Caretakers, Permanent	35	4 (11.4)
Buttonwood	<i>Acopio</i> (fishers), Permanent ¹	2	2 (100.0)
Vincent	Fishers, Occasional	12	2 (16.7)
Baboon	Caretakers, Permanent ¹	14	2 (14.3)
Crawl	Caretakers/WCS team ² , Permanent	32	2 (6.3)
Lime	Caretakers, Permanent ¹	14	1 (7.1)

¹ Also inhabited periodically by sea cucumber divers.

² WCS field staff were not present permanently, but occupied the cay from 28 June to 25 October.

For all clutches where clutch contents could be evaluated, both hatching (HS) and emergence (ES) successes were 67.0% (n=177). For those clutches where at least one egg hatched, HS and ES were 68.8% and 68.7% (n=173), respectively. For clutches left *in situ*, both HS and ES were 71.7% (n=113); and for relocated clutches both HS and ES were 55.4% (n=45). Additionally, both HS and ES for nests with temperature loggers inserted were 72.1% (n=19 clutches). HS and ES for relocated clutches were significantly lower than clutches left *in situ* (Mann-Whitney $U=1520.5$, $Z=3.94$, $p=0.00008$ in both cases); however, no significant difference was found between clutches left *in situ* and clutches with temperature loggers (Mann-Whitney $U=966.5$, $Z=0.69$, $p=0.49$, and $U=967.5$, $Z=0.69$, $p=0.49$, respectively). As previously stated, because individual females nest more than once during a nesting season and our teams were not able to identify every nest to individual turtles, there is a possibility of lack of independence of the data, however, the distributions for HS and ES were similar and the p-values for differences between relocated and *in situ* clutches for HS and ES were low, thus, the conclusion of differences between groups is justified.

Based on shell counts, we estimated a minimum 20,041 hatchlings were produced. The exact number of hatchlings cannot be determined because i) two nests were not located at excavation, ii) clutches washed out post-hatching but prior to excavation, or iii) in some cases, eggshells were too fragmented to count. Average time from deposition to emergence for *in situ* clutches was 63.8 days (SD=5.0, range=57-68, n=4), however, this is based on a small sample size.

Night Surveys

From 15 June through 16 October, a total of 509 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 103 occasions of which 70 (68.0%) successfully

nested and 33 (32.0%) were non-nesting emergences. Of the 103 encounters, we sighted 47 individual females and the remaining 56 encounters were resightings of those same females. Of the 47 individual females encountered, 20 showed no evidence of having been previously tagged (referred to as “recruit”), and hence, all 20 were tagged and measured for the first time. The remaining 27 females (referred to as “remigrant”) were previously tagged in the Pearl Cays prior to 2011 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	2011
1999	1 ^a		1						1		1
2000	4	1	2		1		2		1		1
2001	1		1		1		1		1		1
2002	17			9		2	2	5	3	2	
2003	34				10	2	8	5	4	6	2
2004	14					1	5	3	2	7	3
2005	13						3	3	3	2	3
2006	5							2	1	2	1
2007	20								3	10	7
2008	29									8	6
2009	20										2
2010	22										
2011	20										
Total	200	1	4	9	12	5	21	18	19	37	27

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

Of the 47 individuals encountered, 14 females (29.8%) were observed nesting once, 17 (36.2%) were observed nesting twice, 6 (12.8%) were observed nesting three times, and 1 (2.1%) was observed nesting four times. The remaining nine females (19.1%) were observed only during non-nesting emergences. Of 24 females encountered nesting more than once, 12 (50.0%) used the same cay for each nesting event, and the remaining 12 (50.0%) used two different cays. Females had an average renesting interval of 15.4 days (SD=1.6, range=12-19, n=22). Ten females were observed renesting after 24 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 2011 a previously tagged female was last seen in the Pearl Cays) ranged from two to four years with a mean interval of 2.9 yr (SD=0.8, n=27), with 40.7% exhibiting a 2-yr interval and 29.6% a 3-yr interval. Due to varied and incomplete coverage of the nesting beaches, some of the intervals most likely represent missed two or three year remigrations. As in previous years, changes in remigration intervals by individual females were also observed in 2011. For example, one female switched from a three-

year to a two-year interval, and another female switched from a two-year to a three-year interval; however, 16 females did not change 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 ten years has varied (Table 5), and is related to both night patrol effort and the number of turtles in the population that have been previously tagged, and thus increasing the probability of encountering a “remigrant” turtle. As in 2010, we observed a higher proportion of remigrants during the 2011 season than prior to 2010 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 nesting beaches in the Pearl Cays Wildlife Refuge.

Year	Recruits Tagged	Remigrants Encountered	Ratio of Remigrants:Recruits	Effort (cay-night surveys)
2002	17	1	0.1:1	73
2003	34	4	0.1:1	93
2004	14	9	0.6:1	165
2005	13	12	0.9:1	169
2006	5	5	1.0:1	65
2007	20	21	1.1:1	284
2008	29	18	0.6:1	369
2009	20	19	1.0:1	407
2010	22	37	1.7:1	468
2011	19	27	1.4:1	512

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 their foraging and nesting habitats in the Pearl Cays (Tables 6 and 7). Nine of the fourteen cays monitored were permanently inhabited during the 2011 nesting season. Bottom Tawira had the highest density with a mean 12.8 (SD=6.3) people/day on the cay during the nesting season. Approximately 60% of the time Bottom Tawira was occupied by > 10 people/day. Crawl Cay followed with a mean of 8.8 (SD=5.9) people/day (including caretakers, tourists, and WCS personnel), however, due to diurnal visits by tourists, as many as 61 people were observed on Crawl Cay at one time. In addition, six different groups of tourists spent the night (not consecutively) on Crawl Cay, averaging 6 (SD=1.4, range=4-8) people/overnight trip. The WCS survey team (6-8 people) inhabited Crawl Cay from 28 June to 25 October, when the camp was dismantled and all materials removed. Despite its smaller size, Buttonwood had a similar mean number of inhabitants as Crawl Cay with 8.1 (SD=4.9) people/day, but as many as 22 people at one time (primarily lobster trap and dive fishers). Columbilla was inhabited by green turtle fishers during 67.5% of the nesting season. Sea cucumber divers were observed camping on Maria Crow Cam Cay once at the beginning of the nesting season, and several times on Baboon, Lime and Wild Cane cays during the remainder of the season. In mid-May 2011, a lobster *acopio* resumed activities on Seal Cay, which was surveyed only once during the season, however, fishers using the cay were consulted throughout the season regarding the occurrence of nesting activity but none was reported.

Table 6. Summary of human presence by cay in the Pearl Cays Wildlife Refuge where hawksbill nesting occurs. SCD=sea cucumber divers.

Cay ¹	Occupants	Mean # People (SD)	Range	# Observations
Bottom Tawira	Fishers	12.8 (6.3)	1-27	149
Crawl	Caretakers/WCS team/Tourists	8.8 (5.9)	1-61	150
Buttonwood	Fishers	8.1 (4.9)	0-22	121
Columbilla	Fishers	6.1 (5.6)	0-21	120
Lime	Caretakers/SCD	3.5 (1.8)	0-10	151
Water	Caretakers	2.6 (1.4)	0-8	151
Baboon	Caretakers/SCD	2.3 (1.2)	1-5	150
Grape	Residents/Caretaker/Tourists	2.1 (2.3)	0-22	150
Wild Cane	Caretaker/SCD	1.2 (1.0)	0-8	151
Maroon	Fishers (occasionally)	0.1 (0.7)	0-5	109
Vincent	Fishers (occasionally)	0.0 (0.2)	0-2	151

¹Black Mangrove, Maria Crow Cam and Seal cays are not included because nesting and/or human presence was occasional and/or sporadic.

Vegetation on the upper beach platform was altered, removed, or maintained cleared on several cays during the nesting season (Table 7). Cutting or clearing mangrove trees and/or ground vegetation, or raking was observed on 10 cays (Baboon, Bottom Tawira, Buttonwood, Crawl, Grape, Lime, Maroon, Maria Crow Cam, Water and Wild Cane cays). Large areas on Baboon, Crawl, Grape, Lime and Wild Cane continue to be periodically raked (Photo 3), maintaining areas devoid of vegetation and preventing the regeneration of native plants that help secure the substrate.

The use of artificial lights at night on the cays was monitored from 15 June to 25 October 2011 and was observed on three cays (Bottom Tawira, Grape, and Water) (Table 7). Lights were observed most frequently on Grape Cay with 52 nights (39.7%) illuminated throughout the nesting and hatching seasons. The majority (73%) of the time lights were visible until at least 2300 h (representing approximately 50% of the nocturnal period) but as late as 0400 h, and were visible from all sides of the cay. On Bottom Tawira, lights were observed 4.7% (n=6 nights) of the time, of which 83.3% of the time they were turned off by 2100 h. On Water Cay, lights were observed 41 nights (31.3%) in the central portion of the cay, and 90.2% of the time were turned off by 2100 h. On two occasions during the nesting season, however, the west side of Water Cay was illuminated until 0400 h.

Domestic and/or exotic animals were present during the nesting season on 10 of the 14 cays monitored, e.g., dogs, cats, chickens, and rats (*Rattus* sp.) (Table 7). Dogs were observed on 9 of the 14 cays where hawksbill nesting occurs. As many as 7 dogs were present at the same time on Bottom Tawira, where a female hawksbill was scared back into the water by dogs prior to nesting and a clutch was partially destroyed. Another clutch was also found partially destroyed by a dog on Baboon Cay. Dogs were brought occasionally to Columbilla Cay by green turtle fishers. In addition, one domestic cat resides on Crawl Cay, one feral cat was observed on Lime Cay, and as in previous years, a wild cat (probably a margay, *Leopardus wiedii*, or ocelot, *L.*

pardalis) was observed on Wild Cane Cay. Rats were observed on Crawl and Water cays. No domestic pigs were observed on the Pearl Cays in 2011.

There was very little new construction on the cays during the 2011 nesting season (Table 7), but that may be in large part due to the number of permanent structures already present. Seal Cay is an exception with five new buildings constructed in June 2011 when the lobster *acopio* was reestablished on this cay. On some cays, sections of the nesting beaches continue to be used to store lobster traps and/or 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, on nesting beaches was observed on Maroon Cay on two occasions at the beginning of the nesting season.

Adult and Juvenile Hawksbills Killed

We estimated that at least five reproductively mature hawksbills from the Pearl Cays rookery and four juveniles were killed from 1 May 2011 to 29 February 2012. Of the five adults, two were females, two were males, and one could not be sexed due to its advanced stage of decomposition. All five adults and four 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 reports that some fishers inhabiting the northern Pearl Cays continue killing juvenile hawksbills. In 2011, our project field staff visited the northern cays (Askill, Esperanza, Little Savanna, Savanna, and Walter) on 20 occasions (on average one visit every six days) 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 continue providing an incentive to donate live turtles for tag and release (see Incentive Program).

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 2). Donated turtles are then 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 880 T-shirts and 18 lifejackets have been awarded. During the 2011 hawksbill nesting season (June to December) there were 129 live sea turtle donations, of which 11 were green turtles, 21 were loggerheads, and 97 were hawksbills. Green turtles were small to large juveniles ranging in size from 19.6 cm to 63.2 cm minimum straight carapace length (SCLmin) (mean=43.7 cm, SD=13.9, n=11). Loggerheads were captured in nets by green turtle fishers and were large juvenile to adult in size, ranging from 51.2 cm to 93.5 cm SCLmin (mean=70.1 cm, SD=9.9, n=19). Of the hawksbills donated to the project, 11 were nesting females captured on a cay by fishers, watchmen, or others residing on the cays. The remaining 86 hawksbills were captured in the water, ranging from 20.1-76.4 cm SCLmin (mean=43.5 cm, SD=12.2, n=85). Of these, 74 were captured by lobster and/or sea cucumber divers, and the remaining 12 were incidentally captured in green turtle or gill nets.

Table 7. Summary of human activities and habitat alteration/destruction observed during the 2011 hawksbill nesting season, Pearl Cays.

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	Permanent	Dog and chickens	No	No	Northeast, North, Northwest, West	Repairing a ranch.	Periodically raked north & west sides of cay to maintain large area denude of all vegetation (dune & inland), including nesting area. Burned piles of dead vegetation inland.
Black Mangrove	Entire cay	Periodic	Dogs	No	No	No	None observed.	None observed.
Bottom Tawira	West & South	Permanent	Dogs and chickens	Yes	No	No	None observed.	Herbaceous vegetation cut on west side (dune).
Buttonwood	Entire cay	Permanent	Dogs	No	No	North and South Pt.	Lobster traps piled up and occupying a large portion of the cay.	Cleared vegetation on north (inland), cut grass on north (dune), and burned piles of garbage and dead vegetation on east, south and west (dune & inland) sides of cay.
Cumbilla	North & West	Frequent	Dogs (sporadically)	No	No	Northwest	None observed.	None observed.
Crawl	West, Center and East	Permanent	Dogs (sporadically), cat, chickens, and rats	No	No	North and East	Minor construction work on large cement building continued for a short period during the nesting season.	Vegetation routinely cleared and/or cut on the east, southeast, south, west and center of cay. Piles of dead vegetation were burned inland on north and northwest sides of cay, and on the dune on west side. Large area in east, center, and west sides of cay frequently raked to maintain area denude of all vegetation.
Grape	Entire cay	Permanent	Dogs, white-faced capuchin monkey and parrot	Yes	No	All	One small open beach cabana was finished on northwest side. Same cabana was lost to coastal erosion in the latter part of nesting season.	Vegetation cut on east side (dune & inland). Almost entire cay routinely raked to maintain most of the cay denude of vegetation.
Lime	South	Permanent	Dogs, cat, and chickens	No	No	All	None observed.	Burned piles of dead vegetation inland on south side of cay. Periodically raked south side and center of cay to maintain area denude of vegetation.
Maria Crow Cam	East	Sporadic	None observed	No	No	No	Temporary camp built without a permit in early June by sea cucumber fishers.	Sporadic clearing of dune vegetation on east side of cay.
Maroon	North & South	Occasional	None observed	No	North and West	All	None observed.	Ground vegetation cut on north and south (dune) sides of cay.
Seal	Entire cay	Permanent	None observed	Unknown	No	No	Five new houses built, including an <i>acopio</i> .	None observed.
Vincent	None	Sporadic	None observed	No	No	All (Severe)	None observed.	None observed, very little vegetation remaining.
Water	West & Center	Permanent	Dogs, chickens and rats	Yes	No	North, West, and South	Cabin on the south side initiated in January 2011 was completed by start of 2011 nesting season. Large ranch was repaired.	Occasionally cleared and/or cut grass & native dune vegetation on west side of cay.
Wild Cane	North	Permanent	Small wild cat (probably a margay or ocelot)	No	No	North, West, South, Southeast Pt.	None observed.	Dune vegetation cut on the north and south sides. Periodically raked north & west sides of cay to maintain large area denude of all vegetation (dune & inland), including nesting area.

National Police Collaboration

In total, 20 Police and/or Police volunteers collaborated with the project during the 2011 nesting season (Photo 4). The Police were effective in acting as deterrents to egg poaching and killing of all sizes of hawksbill turtles. In addition, they provided an authoritative presence on the cays when the WCS team was conducting surveys and intervened to confiscate eggs or hawksbill and loggerhead turtles that would otherwise have been killed.

Awareness and Outreach

Throughout the nesting season, four progress reports on project activities and preliminary results were distributed to 26 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), Pearl Lagoon municipality, Territorial Authority representing 10 indigenous and ethnic communities that use the Pearl Cays, and the U.S. Embassy. Seventeen 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.

Our educational efforts also included mentoring local high school students in completing their senior project and other schoolwork. In order to meet the requirements to graduate the students are required to complete a senior project featuring a topic of their choice. Five WCS Youth Group members and many other students from the Instituto Las Perlas in Pearl Lagoon chose marine turtles as the topic for their project, and other students used our library resources for their class work. The students were: Delryn Anderson, Reggyel Bebarford, Sharleen Calistro, Sashy Dávila, Lillieth Desouza, Stevon Dixon, Charleen Evans, Shelly Fox, Tania Hammond, Terrence Hebbberth, Debral Hodgson, Yelva Hodgson, Shelaine Hooker, Kevin Martínez, Milda Martínez, Shakira Martínez, Kensor McCoy, Sheidy McCoy, Shanex Ramírez, Kent Rigby, Shenía Rigby, Ángela Taylor, Tashira Taylor, Liana Tinkham and Shara Williams. Lillieth Desouza and Yasira Navas, students from the Instituto Las Perlas and both members of the WCS Youth Group, joined the WCS team on a survey to learn about our field work and observed first hand the detrimental effects of unregulated human activities in the PCWR. Also, two US undergraduate students participated in a field trip to learn about nest excavations and hawksbill reproductive biology.

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. In addition, on 20 February we hosted a group of 27 students enrolled in a Master of Science in Natural Resource Management and the Environment offered through a consortium between the Universidad Nacional Autónoma de Nicaragua (UNAN) in León (Nicaragua), Bluefields Indian & Caribbean University (BICU, Nicaragua), and the Universitat Autònoma de Barcelona (UAB, Spain). We gave a presentation on the Pearl Cays Hawksbill Project activities and discussed with the students ecological processes and local conservation topics related to our program.

DISCUSSION AND CONCLUSIONS

In 2011, 232 clutches were laid and more than 20,041 hatchlings were produced in the Pearl Cays Wildlife Refuge (PCWR). Most of the nesting activity occurred in June, July and August; and for the first time since 2003 no nesting was recorded in November. Although nesting activity was lower than in 2010, the long-term monitoring shows a positive trend in hawksbill nesting in the Pearl Cays area. In fact, this was the seventh consecutive year that more than 200 clutches were recorded. The stronger fluctuations observed since 2008 are 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, in turn affecting reproductive condition of females and ultimately remigration intervals. Continued long-term monitoring is necessary to more accurately assess population trends and effects of management actions.

In 2011, hatching success for all clutches was slightly lower than in previous years and was due to the low hatch rate for relocated clutches. In fact, the hatching rate observed for relocated clutches this season was lower than any of the previous 11 years of the project. Several factors may have contributed to this relatively low hatch rate, however, poor handling of eggs when clutches were relocated was likely the principal cause. In future nesting seasons, we will increase emphasis on the need for proper egg handling during training and increase oversight of field teams in an effort to ensure a greater hatching success for relocated clutches. Hatching and emergence successes were almost identical in the 2011 season and suggests very low mortality of hatchlings in nest cavities; however, delayed excavation of a large proportion of nests may have resulted in reduced detection of dead hatchlings during excavations due to decomposition and/or removal by predators (e.g., crabs, rats, ants).

Poaching activity in 2011 increased from the previous year, however, it may be lower than reported due to possible clutch count errors made by field staff since 88.0% (n=22) of the clutches found “partially” poached had no other sign of poaching other than a discrepancy of greater than 20 eggs between clutch count during relocation and at excavation. Furthermore, since some excavation trips this season were unavoidably delayed, and field teams reported seeing egg shells on the ground during the hatching season, it is possible that in some cases this discrepancy originated as a result of animals (e.g. crabs, rats) pulling egg shells out of some nest cavities, altering clutch counts at excavations. Nonetheless, during previous seasons poaching on cays inhabited by caretakers would only occur on rare occasions. Since 2006, when diving for sea cucumbers was first observed in the Pearl Cays (Campbell et al., 2007), the fishery has occurred sporadically; however, it appears that demand increased during the 2011 nesting season because several groups of fishers were observed operating in the area, in some cases working together with caretakers on several of the cays. The presence of sea cucumber fishers in the area may be contributing to the increased poaching observed in 2011, highlighting the need for increased vigilance. Additionally, poaching still persists on Bottom Tawira, Buttonwood, Columbilla and Maroon cays. These cays are inhabited either permanently or temporarily by local fishers who are involved in 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 small number of fishers and lack of enforcement of existing regulations by local authorities; nevertheless, we continue to work with all local fishers to increase their cooperation.

Nesting females continue to exhibit similar patterns of inter- and intra- nesting intervals (primarily 2- or 3-yr and approximately 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 2011, the ratio of remigrants to recruits was 1.4:1, and is similarly biased as in 2010, suggesting we have tagged more than 50% of the reproductive females in this population. 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 higher survival 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). Although in Caribbean Nicaragua hawksbills are not targeted by set net fishers, both large juveniles and adults are often captured intentionally by lobster divers, or incidentally in gill and green turtle nets. Since killing hawksbills is illegal and surveillance is low, most mortality is likely not reported; thus, our report of hawksbill mortality in Caribbean Nicaragua is the minimum number killed, and is likely a serious threat to already depleted populations in the region.

The PCWR is a key nesting site for hawksbills in the western Caribbean, but this area also includes reefs that provide important developmental habitat for foraging juvenile 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 on a regional scale. Thus, actions of Nicaragua's fishers towards hawksbill conservation not only affect Nicaragua's resource, but those of many other nations. Despite declaration of the PCWR in November 2010 enforcement remains inadequate and thus continuing outreach activities to raise awareness and increase collaboration of fishers (including incentives) with conservation activities along the Caribbean coast of Nicaragua will remain a priority of the Pearl Cays Hawksbill Project to aid in the recovery of hawksbills in the region.

Use of artificial lights on or near nesting beaches in the Pearl Cays decreased temporarily due to reduced human presence on Grape Cay during part of the reproductive season; however, artificial lighting continues to be problematic. It is well documented that females are deterred from nesting on beaches illuminated with artificial lights (although it does occur), and that 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 January, from 1900 h to 0500 h), 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, many commercial options are now available). 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), and a study by Horrocks and Scott (1991) showed that nest sites with vegetation were less compacted than non-vegetated sites. 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, and reduced crawling requires less vital energy stores needed for reproduction. Ground vegetation also 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. Continued raking has an ever increasing impact on these small islands by destabilizing beaches, compacting of 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 turbidity and sedimentation. From our observations, beach erosion is a significant threat to the cays (Photo 5), as is the resulting sedimentation in the surrounding waters to seagrass beds and coral reefs, as discussed in a previous report (Lagueux et al., 2011). Reefs in the PCWR continue to show signs of stress derived from increased human-induced beach erosion (Photo 6). Uncontrolled human activities that alter or destroy the Pearl Cays ecosystem is one of the greatest threats to hawksbills in the area. To date, no mitigation measures have been taken to reduce coastal erosion on the cays or nearby coastal areas.

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 were cleared and construction began on a large house and swimming 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 hawksbill nesting. Nesting on the north side of Grape Cay has been eliminated as a result of the construction of a breakwater wall to reduce beach erosion (Photo 7). 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, and measures to restore native vegetation should be implemented immediately.

Encounters with individual nesting females indicate that many turtles exhibit a strong fidelity to a particular cay. However, since we do not have complete coverage of cays for night patrols and 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 renest. It is important to know that a segment of the population does not have high site fidelity to a particular cay, and this variability in beach selection emphasizes the need for all potential nesting areas to be

protected in order to provide the greatest possibility for reproductive success and population recovery.

In 2011, we observed an increase in overnight tourist trips to the Pearl Cays. As we have stated in previous reports, WCS strongly supports the economic and development benefits that can be provided to local communities and local government through the expansion of new and/or existing activities. Tourism can offer a range of opportunities that provide local employment and improve livelihoods at a local scale. However, if tourism activities are not properly regulated, they have the potential to add pressure to the fragile habitats and natural resources in the area. The Pearl Cays ecosystem is unique and the cays, seagrass beds, coral reefs, and mangrove forests are highly susceptible to stressors from anthropogenic impacts. Development of any kind in this fragile system should only be done at a level that is ecologically sustainable and does not over burden the natural resources within it.

Since 1999 our incentive program has received a total of 902 donations of live turtles. More than half (52.3%) of these donations occurred during the three most recent nesting seasons. 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. Even though these are positive indicators of increased awareness and cooperation, some fishers continue to kill hawksbills, and thus, in addition to continuing our efforts to raise awareness of all fishers, it is also important that the authorities increase their vigilance in order to prevent the ongoing killing of hawksbills, and other protected species. 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.

Quality nesting habitat is vital to providing appropriate conditions for critically endangered hawksbills to reproduce and their populations to recover, ensuring their long-term survival and allowing them to fulfill their ecological role in the marine ecosystems of the Caribbean. Without quality nesting habitat their reproductive success will diminish, followed by population size, and then the ecosystems in which they play a vital role will also diminish. Furthermore, as a result of strong site fidelity to their natal beaches hawksbills, like most sea turtles, will not simply relocate to a different nesting location, and the use of degraded habitat will decrease hatch rates and reduce recruitment into the population, eventually resulting in the loss of individual populations such as the Pearl Cays hawksbill rookery. Thus, restoring and protecting nesting habitat in the PCWR is vital to the survival and recovery of this important rookery, and will improve conditions for other species as well.

More than a year after the official establishment of the PCWR no management plan or regulations have yet been put into place, and no vigilance or institutional oversight is being conducted to enforce existing environmental laws and prosecute violators. The result of this lack of action is counter to the purpose of the protected area and will ensure that the cays and surrounding marine habitat will continue to be degraded, resulting in ecological and economic consequences that are certain to be experienced by local communities and local governments in loss of natural resources and revenues now and in the future. Immediate steps are needed to improve the future outlook of the PCWR and its valuable natural resources, such as the critically endangered hawksbill.

Education and outreach continue to be a priority in our program (Photo 8). Progress reports, radio broadcasts, and visitors to the project provide 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 Hawksbill Project contribute towards the conservation of hawksbill turtles and their eggs.

While the 2011 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 resulted 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 habitats; 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 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. Although the following recommendations are not exhaustive, if implemented, they would substantially reduce negative human impacts to the fragile Pearl Cays ecosystem.

- a) Regulations already drafted with local community and government authorities to mitigate human impacts on the Pearl Cays, particularly on 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 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, 1900 h to 0500 h from May through January. Lights certified as “turtle friendly” may be used with the appropriate positioning and shields based on accepted guidelines and approval.

- 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. 2011 Hawksbill Project Team. From left: Ruben Julio, Dorian McCoy, Claudia Forbes, Víctor Huertas (Project Coordinator), Lavonie Cuthbert, Cynthia Lagueux (Program Director), Lorelee Murray, William McCoy (Field Supervisor), Marisa Simión, and Rodolfo Chang (Facilitator). Not pictured: Alex Allen, Yeldon Desouza, Steve López, Telia Narcisso (Logistics Assistant), and Cathi Campbell (Scientific Director).



Photo 2. A) Lobster diver Mr. Nildo Abraham donating a juvenile green turtle to the WCS Donate a Live Turtle Incentive Program, and B) Mr. Zaires Méndez receiving his first life-jacket for his 15th donation to the WCS Incentive Program.



Photo 3. Area routinely raked on the east side of Crawl Cay. Native dune vegetation had previously been completely removed.



A



B

Photo 4. A) Police Rucner Valle releasing a juvenile hawksbill donated to the Project in the Pearl Cays, and B) Police Juan Pablo Salinas observing a nesting hawksbill returning to the sea after laying a clutch of eggs.



Photo 5. Severe erosion continues on Vincent Cay. Note concrete remains of the foundation of one of the four buildings built in 2002 on what was then nesting beach habitat.



Photo 6. Juvenile hawksbill turtle shown in degraded coral reef habitat near Crawl Cay.



Photo 7. Breakwater wall on north side of Grape Cay has eliminated all nesting on this side of the cay.



Photo 8. Lillieth Desouza and Yasira Navas, members of the WCS Youth Group, learning how to collect field data in the Pearl Cays.