



Adult female hawksbill post-nesting, Pearl Cays, Nicaragua, 2009. Photo: CL Campbell/WCS.

FINAL REPORT

Prepared By

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ABSTRACT

The Wildlife Conservation Society (WCS) monitored the nesting activity of the largest remaining hawksbill, *Eretmochelys imbricata*, rookery in the central-western Caribbean during the 2009 nesting season on the Pearl Cays, Nicaragua. The total number of clutches recorded was 205, and while lower than recent years continues an overall increasing trend since the early years of conservation activities when there were on average 155 clutches laid each season. Over the ten years of applied conservation measures there has been, on average, a 3.7% annual increase in the number of clutches laid. Poaching activities decreased from 17.3% in 2008 to 12.7% in 2009 on the cays monitored throughout the nesting season. Although poaching decreased from 2008, it was still higher than the lowest poaching rate of 5.8% observed in 2007. Poaching occurred on cays primarily visited by fishers and where *acopios* (lobster buying stations) are established, however, poaching also occurred on cays permanently inhabited by caretakers, such as on Wild Cane Cay. Hatching and emergence successes for clutches where at least one egg hatched were 71.6% and 70.3%, respectively. We estimated that a minimum 18,102 hatchlings were produced during the 2009 season. At least eight mature and 13 juvenile hawksbills were killed during the 2009 season. Furthermore, alteration and/or destruction of hawksbill nesting and developmental habitats continue in the Pearl Cays, particularly on Grape Cay, 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. We again provide recommendations to minimize these 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 the beaches during nesting and hatching seasons, and restricting human activities that may be detrimental to hawksbill nesting and reproductive efforts.

Report Summary

- a) Natural fluctuations in nesting can be expected on sea turtle nesting beaches, such as the decrease from 249 clutches in 2008 to 205 in 2009, and may be the result of changes in remigration intervals, which can be affected by environmental conditions. 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; 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, will be 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) Donation of live turtles to be tagged and released increased considerably 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 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 (IUCN, 2008) and on Appendix I of CITES (UNEP-WCMC, 10 April 2009). 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 <http://www.cites.org/fra/prog/HBT/dialogue2/E-HT2-8.doc>). 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).

The Pearl Cays hawksbill population is 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). 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 volunteer program that provides an incentive to local fishers and inhabitants on the cays to protect nesting females and 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). This volunteer project 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 volunteer program and Pearl Cays conservation project have been highly successful at reducing hawksbill mortality in the Pearl Cays area. For example, there has been a steady decrease in the number and percent of clutches poached and an increase in the number of clutches laid since initiation of the nesting beach project (Lagueux et al., 2003, 2006; Campbell et al., 2007, 2008). 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).

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 the installation of lobster buying stations, *acopios*, on 13 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), presence of domestic or exotic animals, and artificial lighting of nesting beaches. In addition, fishing activities in the Pearl Cays such as the recent extraction of sea cucumbers beginning in 2006 (possibly *Actinopygia agassizii*, *Holothuria mexicana*, and *Isostichopus badionotus*) and ongoing lobster and shark fisheries have likely added 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, sea cucumbers, and lobsters play vital roles in marine ecosystems and a reduction in their populations in the Pearl Cays area could have detrimental affects on other resources and habitat quality. Since 2005, WCS has monitored human activities and habitat alteration/destruction on the Pearl Cays to evaluate their influence on hawksbill nesting.

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 2009 nesting season, as well as present some of the long-term trends.

Objectives

Objectives for the 2009 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. promote conservation through the media and education,
7. build capacity at the local and regional levels,
8. improve local collaboration and increase government involvement in conservation activities, and
9. 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 comprised 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 (first observed in 2009) and Seal (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. No nesting has been reported on Askill Cay in the past few years. 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.

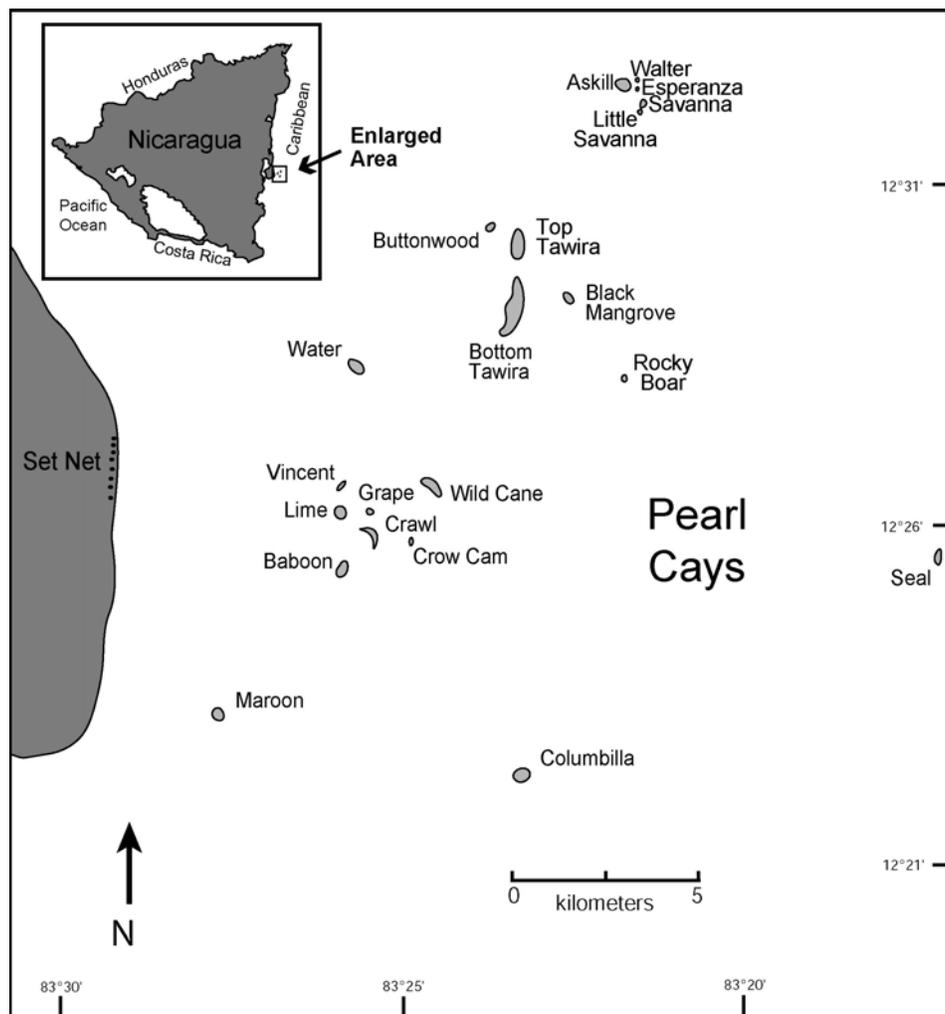


Figure 1. Map of the Pearl Cays, Nicaragua.

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, Pearl Cays.

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*

*Note: Previous field reports listed the cumulative length of Wild Cane Cay nesting beaches as 467 m, this was a typographical error, correct length based on the 2004 mapping survey was 667m.

METHODS

Nesting Beach Surveys

During the 2009 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 two, four-person WCS field teams who worked alternate weeks from June to November. 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 invited to attend the one-day training workshop, nine (seven men and two 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, Harvey Antonio, Dina Chang, Carson Garth, Gertrudis Hodgson, Dorian McCoy, Rafael McCoy, Humberto Patterson, and James Woods (Photo 1), representing four local communities of the Pearl Lagoon basin (Haulover, Marshall Point, Pearl Lagoon, and Set Net Point) and three of the six ethnic groups (Creole, Garifuna, and Miskitu). In addition, William McCoy (Field Supervisor) and Jonathan Willans (Project Coordinator) supervised and assisted with team activities, data collection and management. Nicaragua National Police accompanied project staff throughout the survey period.

To determine the onset of the nesting season and to protect clutches laid early in the season, surveys were initiated on 28 April when the first nest of the season was encountered. From early May to mid-June, surveys were conducted approximately every four to six days, and then every two to three days until the team camp was established on 25 June. From 25 June to 10 November surveys were conducted daily, and additional surveys were conducted periodically between 11 November 2009 and 13 February 2010 when post-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 clutch. For the purposes of locating the clutch 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 due to inadequate environmental conditions that might negatively affect incubation, e.g., located too close to the high tide line, in areas prone to inundation; or to protect them from would-be poachers. 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 of 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). Also recorded, was the location of the nest on the beach, on the dune or behind the dune, as well as whether or not the nest was located among vegetation or in a cleared area. 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. Means are provided with standard deviation (SD).

Poaching activity was categorized as completely poached 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 were those nests where all eggs were removed from the nest chamber, and broken egg shells were also often 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 upon arrival of the survey team, 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 approximate 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 missing eggs.

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), killed by the excavation team (KT, unhatched eggs that were accidentally destroyed by the excavation team when attempting to locate the clutch), 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 23 May to 20 October) by field staff, visitors, fishers, and project supervisors. 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 completed nesting (or the nesting attempt) and began to return to the sea, 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 2009 by field staff could be released immediately after being identified. Turtles that were encountered for the first time in 2009 were kept on their backs in a cool area of the upper beach platform until early morning when the 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 due to loss of metal flipper tags. Biometric data were collected from each turtle upon 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

We promoted saving turtles by providing a specially designed T-shirt to anyone donating a live turtle to the project for tag and release. Due to the popularity of the volunteer tag and release program we now 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 2).

RESULTS

Nesting Beach Surveys

From 28 April 2009 to 13 February 2010, a total of 1,573 cay-surveys were conducted on 14 of the Pearl Cays. We recorded 84 non-nesting emergences and 205 egg clutches (0.41:1 non-nesting emergences to nesting emergences). Of the 203 clutches where month laid was known, 57.0% of nesting activity occurred in July (26.8%) and August (30.2%), combined. Nesting activity in June and September were similar with 14.6% and 13.7%, respectively (Figure 2).

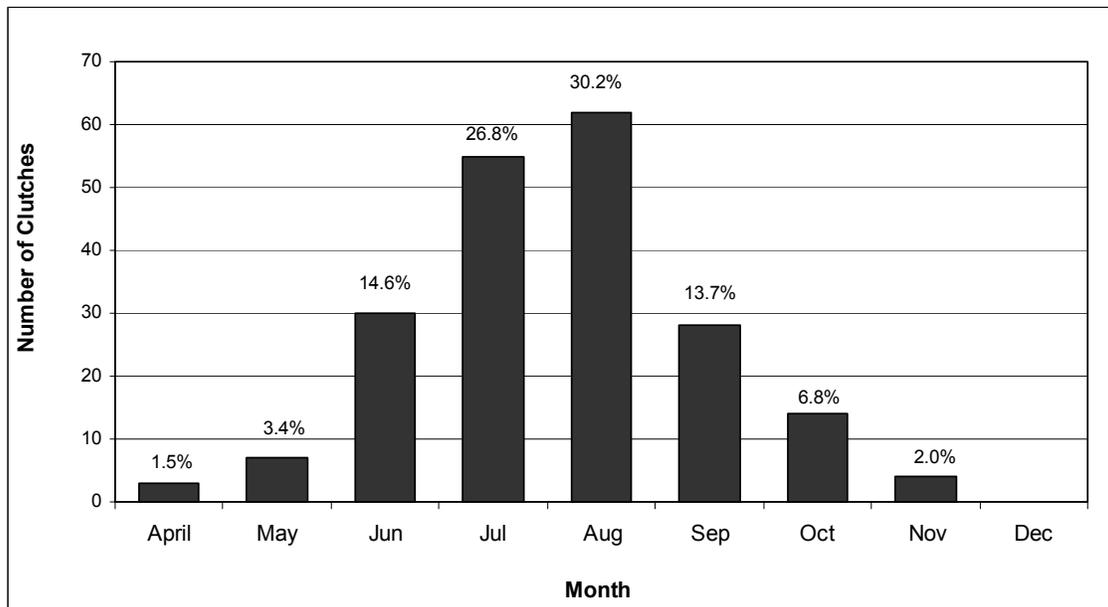


Figure 2. Temporal distribution of hawksbill clutches laid on 14 of the Pearl Cays, Nicaragua from April to December 2009 (n=203). Two clutches are not included because month laid is not known.

Wild Cane Cay had the most nesting activity with 57 clutches (27.8%), followed by Crawl with 27 clutches (13.2%), Water with 25 clutches (12.2%), and Lime with 23 clutches (11.2%) (Figure 3). These four cays represent 64.4% of all the clutches laid throughout the season. No clutches were recorded on Black Mangrove Cay. Of the 205 clutches laid on the 14 cays monitored during the nesting season, 63.9% (131 clutches) were left *in situ* and 31.7% (65 clutches) were relocated to a site near the original nest location. The remaining nine clutches were poached prior to encounter by a survey team.

Hawksbill nest parameters for 2009 are summarized in Table 2. Mean clutch size, based on relocated clutches, was 154.3 ± 29.0 eggs (n=64). Sixteen yolkless eggs were observed in 9 clutches, ranging from 1 to 6 yolkless eggs in a clutch. However, due to the inexperience of some survey team members, it is possible that the number of yolkless eggs was underreported. Mean crawl length from the high tide line to the nest cavity for females that successfully nested was 10.7 ± 10.7 m (n=166); however, on at least 24 occasions (14.5%) females crawled more than 20 m before laying their clutch.

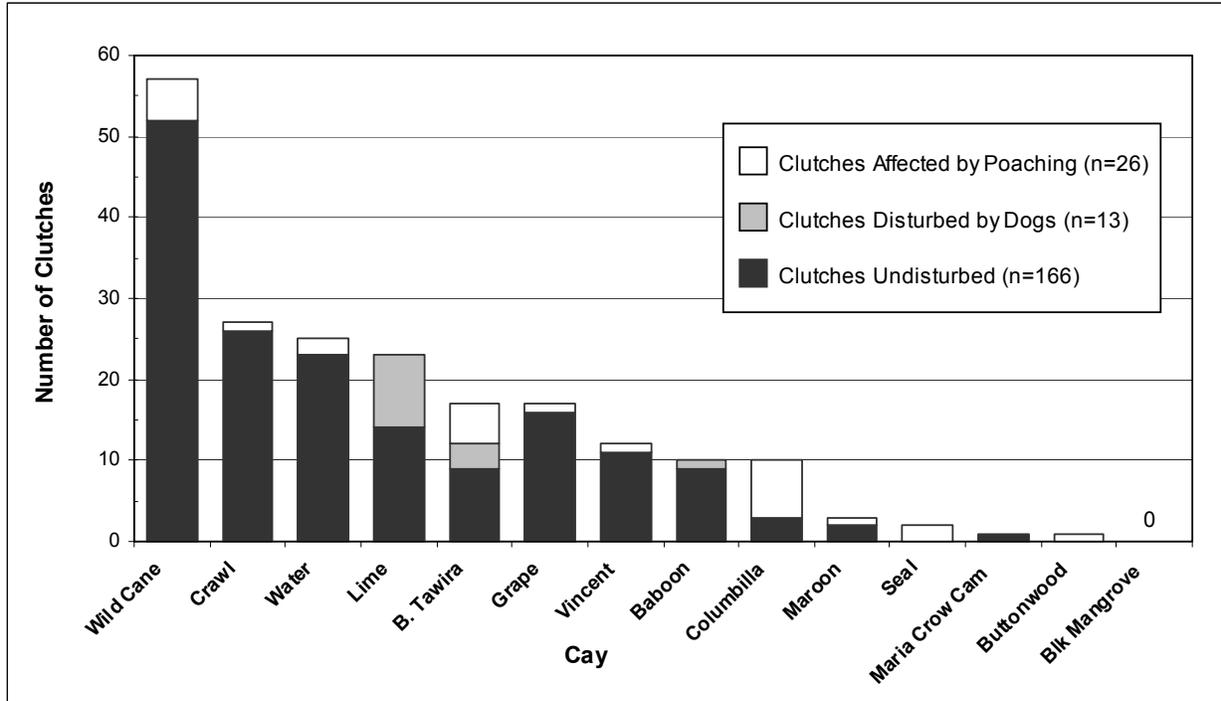


Figure 3. Spatial distribution of hawksbill nests on 14 of the Pearl Cays, Nicaragua during the 2009 nesting season. Bars show total number of clutches laid by cay separated into clutches affected by poaching (partially or completely), clutches disturbed or destroyed by dogs, and clutches undisturbed.

Table 2. Hawksbill nest parameters for 2009, Pearl Cays, Nicaragua. HTL = high tide line.

	Mean	Standard Deviation	Range	n
Clutch size	154.3	29.0	85-247	64
Nest depth - <i>in situ</i> clutches (cm)	39.6	2.4	28.0-45.0	65
Nest depth - relocated clutches (cm)	35.9	4.8	22.0-46.0	57
Crawl length (m)	10.7	10.7	1.1-71.3	166
HTL distance to nest (m)	5.1	4.2	0.8-33.3	196

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 ($r=0.887$, $p<0.001$, Figure 4), however, the 2009 nesting levels decreased by 17.7% from the 2008 nesting season. There has been an increase of 46.7% in the mean number of clutches laid during the first three years of the project (2000-2002 mean = 155.7 clutches) compared to the most recent three years (2007-2009 = 228.3 clutches), with an annual average increase of 3.7% from 2000 to 2009. Data are not available prior to 2000 for the entire nesting season.

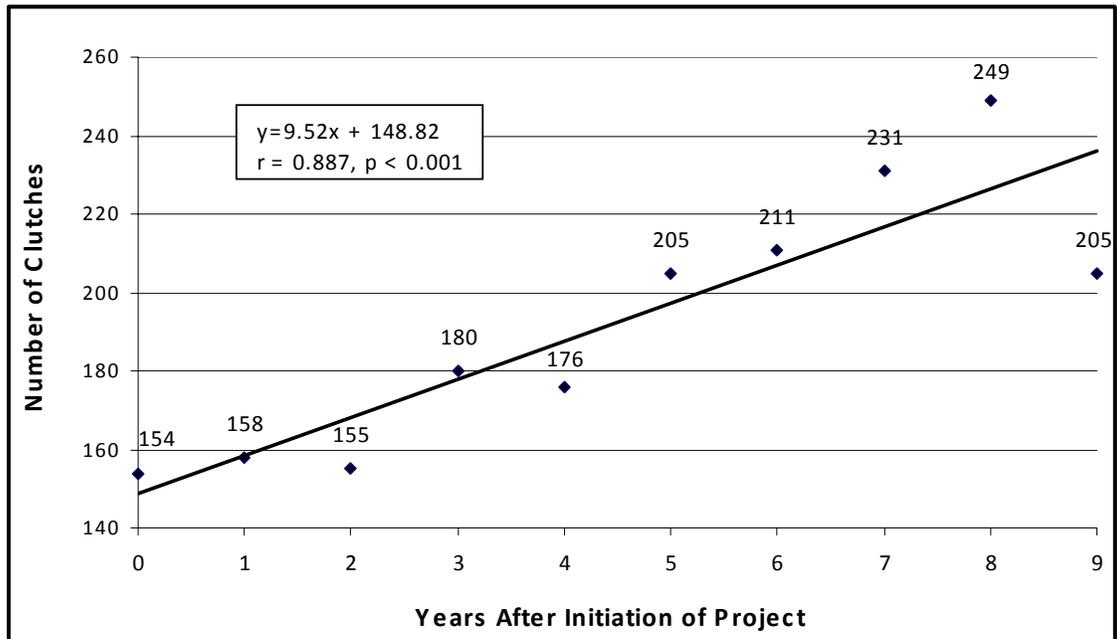


Figure 4. Trend in hawksbill nesting since project initiation in 2000 (year 0) to 2009 (year 9), Pearl Cays, Nicaragua.

Nest Excavations

Of the 196 clutches left to incubate, seventeen were affected by poaching activities (5 clutches were completely poached and 12 were partially poached). Eleven of the 12 partially poached clutches had at least one egg hatch. Of the remaining 179 clutches, 157 hatched; six clutches had no eggs hatch, five clutches were affected by high tides and/or water inundation, however, only one was completely lost; and 12 clutches were completely (1 clutch) or partially affected (11 clutches) by dog predation, on Lime (8 clutches), Bottom Tawira (3 clutches), and Baboon (1 clutch). One additional clutch on Lime Cay was dug into by dogs post-hatchling emergence. More than one third of all clutches on Lime Cay were either destroyed or disturbed by dogs (9 of 23 clutches). In total, 182 clutches had at least one egg hatch.

The overall poaching rate, regardless of when or if an entire clutch was poached, was 12.7% (14 completely poached, 12 partially poached) and occurred on 10 of the 13 cays (71.4%) where nesting occurred in 2009 (Table 3, Figure 3). Of the 26 clutches affected by poaching, the largest proportion occurred on cays used periodically by fishers or where *acopios* were permanently established (Table 3). In addition, poaching activities occurred on Crawl (prior to establishment of our base camp), Grape, Water, and Wild Cane cays, which are inhabited permanently by caretakers, watchmen, or residents (Table 3). Poaching events were particularly high on Columbilla, Bottom Tawira, and Wild Cane cays, and although on other cays poaching events were proportionately high (100% of clutches laid on Seal and Buttonwood cays), very few clutches were laid (two clutches and one clutch, respectively).

Table 3. Number and percent of clutches affected by poaching in 2009, Pearl Cays, Nicaragua. No poaching events were observed on Baboon, Lime, Maria Crow Cam, and Maroon cays in 2009.

Cay	Type & Duration of Human Presence	Total Clutches Laid	Number and (%) Poached (partially or completely)
Wild Cane	Caretaker, Permanent	57	5 (8.8)
Crawl	Caretaker, Permanent	27	1 (3.7)
Water	Caretaker, Permanent	25	2 (8.0)
Bottom Tawira	<i>Acopio</i> (fishers), Permanent	17	5 (29.4)
Grape	Residence, Permanent	17	1 (5.9)
Vincent	Fishers, Periodic	12	1 (8.3)
Columbilla	Fishers, Constant	10	7 (70.0)
Maroon	Fishers, Periodic	3	1 (33.0)
Seal	<i>Acopio</i> (fishers), Permanent	2	2 (100.0)
Buttonwood	<i>Acopio</i> (fishers), Permanent	1	1 (100.0)

For all clutches, hatching (HS) and emergence (ES) success was 69.4% and 68.1% (n=161), respectively; regardless if any eggs hatched. For those clutches where at least one egg hatched, HS and ES were 71.6% and 70.3% (n=154), respectively. For clutches left *in situ* HS and ES were 73.1% and 72.2% (n=115), respectively; and for relocated clutches 60.0% and 57.8% (n=45), respectively. HS and ES for clutches left *in situ* was significantly different than for relocated clutches (t-test, data were transformed using $x' = \text{Arcsin}\sqrt{x}$, HS: $t_{(158)} = -2.44$, $p=0.016$; ES: $t_{(158)} = -2.58$, $p=0.011$). We estimated a minimum 18,102 hatchlings were produced. The exact number of hatchlings cannot be determined because i) not all nests were located at excavation, ii) a few clutches washed out post-hatching, or iii) in some cases, eggshells were too fragmented to count. Mean time to emergence for *in situ* clutches was 69.0 days \pm 4.9 days (n=10, range= 58 to 74).

Night Surveys

From 23 May through 20 October, a total of 407 cay-night surveys (defined as each night a cay was patrolled) were conducted on 9 cays to encounter nesting females. The 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., Wild Cane. During these night patrols, we encountered nesting females on 99 occasions of which 62 (62.6%) successfully nested and 37 (37.4%) were non-nesting emergences. Of the 99 encounters, we sighted 39 individual females and the remaining 60 encounters were resightings of those same females. Of the 39 individual females encountered, 20 showed no evidence of having been previously tagged (“recruits”), thus all 20 of these females were tagged for the first time. The remaining 19 females remigrated to nest in the Pearl Cays and had been tagged in previous years by project staff (Table 4).

Of the 39 individuals encountered, 17 females (43.6%) were observed nesting once and 16 females (41.0%) were observed nesting more than once during the 2009 season, the remaining 6 females (15.4%) were only observed during a non-nesting emergence. Of the 16 females that nested more than once, eight females were observed nesting twice, five were observed nesting

three times, two were observed nesting four times, and one was observed nesting six times. Nine of the 16 females (56.3%) used the same cay for each nesting event, 6 (37.5%) used two different cays, and 1 (6.2%) used three cays. Females had an average renesting interval of 15.8 ± 1.7 days (range=13-20, n=22). Seven 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.

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	Number of Females Tagged	Number of Remigrants by Year							
		2002	2003	2004	2005	2006	2007	2008	2009
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
2003	34				10	2	8	5	4
2004	14					1	5	3	2
2005	13						3	3	3
2006	5							2	1
2007	20								3
2008	29								
2009	20								
Total	158	1	4	9	12	5	21	18	19

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

Remigration intervals (# of years prior to 2009 a remigrant was last seen in the Pearl Cays) ranged from two to seven years with a mean of 3.5 ± 2.0 yr, (n=19). Due to varied and incomplete coverage of the nesting beaches, some of the intervals could represent missed two or three year remigrations. In fact, at least 63.2% of returning turtles exhibited either a two or three year remigration interval. Shifts in remigration intervals were also observed in 2009, as in previous years. For example, in 2009, two females switched from three-year to two-year intervals, however, six females did not shift their remigration interval whether it had previously been a two or three year interval. There were also some extended remigration intervals of 6 and 7 years observed in 2009 (n=5), although it is likely that at least some of these turtles were missed during earlier remigrations due to incomplete coverage of the Pearl Cays nesting beaches.

Adult and Juvenile Hawksbills Killed

We estimate that since the 2008 Pearl Cays hawksbill final report (Lagueux et al., 2009) at least eight reproductively mature hawksbills (seven of these were females) and 13 juveniles were killed. Of the eight adults, one was captured by local fishers in the RAAN and seven by fishers in the RAAS. Five of the seven reproductive females were previously tagged in the Pearl Cays, the other two were not tagged. We believe that the number of juveniles killed is highly

underrepresented because of numerous reports we received of fishers inhabiting the northern Pearl Cays killing juvenile hawksbills, particularly on Savanna Cay. However, as a result of these reports our project field staff made 23 visits to the northern cays (Askill, Esperanza, Little Savanna, Savanna, and Walter) during the season to discourage the killing of juvenile hawksbills by lobster divers and to talk with *acopio* residents about hawksbill conservation. We successfully convinced several fishers to donate live turtles (in exchange for a specially designed T-shirt) to be tagged and released (see Incentive Program results below). We believe this effort resulted in an overall decrease in juvenile hawksbills being killed on these northern cays. To date, 11 lifejackets have been awarded.

Hurricane Ida

In November 2009, Hurricane Ida threatened the Pearl Cays and the central Caribbean coast of Nicaragua. The WCS field team was evacuated from the base camp on 4 November, prior to the arrival of the hurricane. After the hurricane passed the field team returned to the cays the following day and assessed the damage to the camp, beaches, and incubating clutches. Damage to cays included downed coconut branches, coconuts, and trees; coastal erosion, particularly where dune vegetation had been removed previously; and damage to permanent structures on many of the cays (e.g., damaged roofs and docks).

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 foraging and nesting habitats in the Pearl Cays. Ten of the fourteen cays monitored during the season were permanently or semi-permanently inhabited during the 2009 nesting season. Maroon Cay was inhabited only occasionally, and Vincent and Maria Crow Cam cays remained uninhabited throughout the nesting season. Seal Cay, although permanently inhabited, was surveyed only once by our team during the nesting season, and thus we have limited information on the numbers of humans inhabiting the cay during the season. The WCS survey team established a temporary base camp on Crawl Cay on 25 June and occupied the cay until 10 November, when the camp was dismantled and all materials removed.

Observations of human habitation on the Pearl Cays during the 2009 nesting season is summarized in Table 5. Of the cays that were inhabited, Bottom Tawira frequently had the most inhabitants, with >10 people/day observed 30% of the time on the cay (mean=8.9 ± 5.7 people/day, range=1-22 people, n=133 observations) throughout the nesting season. Crawl Cay, location of project base camp, had the highest single number of inhabitants with 52 people, as a result of a single day when 3 boats of tourists spent the day on the island. Excluding this single day high, Crawl Cay had a mean of 8.9 ± 3.0 people/day during the season (range=1-17 people, n=160 observations). Other cays with a high mean number of people/day were Columbilla (mean=6.3 ± 5.3, range=0-23, n=92) and Grape (mean=6.2 ± 3.8, range=0-20, n=160). Comparing the ratio of people to nesting beach length (excluding the one day high of 52 people on Crawl), the cays with the highest density of people were Black Mangrove, Columbilla, Grape, Bottom Tawira, and Buttonwood.

Table 5. Summary results of the presence of humans on each cay during the 2009 nesting season. Cays where no humans were observed during the nesting season were not included (i.e., Maria Crow Cam, Maroon, and Vincent), and Seal Cay was not included due to the absence of information. The ratio column is based on the mean and maximum number of people/day observed.

Cay	Total Length of Nesting Beach (m)	Mean Number of People/ Survey \pm SD	Range (number of surveys)	Percent of Surveys >10 People/Day	Ratio of People / 10m Nesting Beach - (maximum)
Baboon	310	3.2 \pm 1.5	1-9 (157)	0	0.1(0.3):10
Black Mangrove	7.5	3.5 \pm 3.6	0-13 (31)	3.2	4.6(17.3):10
Bottom Tawira	310	8.9 \pm 5.7	1-22 (133)	30.1	0.3(0.7):10
Buttonwood	226	4.2 \pm 3.7	0-15 (70)	5.7	0.2(0.7):10
Columbilla	113	6.3 \pm 5.3	0-23 (92)	21.7	0.6(2.0):10
Crawl {excludes single day survey of 52 people}	590	9.2 \pm 4.5 {8.9 \pm 3.0}	1-52 (161) {1-17 (160)}	21.7 {21.3}	0.2(0.9):10 {0.2(0.3):10}
Grape	120	6.2 \pm 3.8	0-20 (160)	16.3	0.5(1.7):10
Lime	393	2.3 \pm 2.0	0-16 (158)	1.9	0.06(0.4):10
Water	460	3.0 \pm 2.3	1-12 (158)	2.5	0.07(0.3):10
Wild Cane	517	2.1 \pm 1.1	0-10 (161)	0	0.04(0.2):10

Domestic and/or exotic animals were present during the nesting season on 11 of the 14 cays monitored, e.g., dogs, cats, pigs, chickens, and rats (Table 6). Bottom Tawira and Lime cays had the highest single-day count of domestic animals. Bottom Tawira had as many as 9 dogs and 5 chickens and Lime had 2 dogs, 1 cat, and 12 chickens. Dogs on Lime Cay dug into at least 9 hawksbill nests (39.1% of clutches laid on Lime), in some cases destroying incubating eggs. Bottom Tawira frequently had the highest number of domestic animals, usually from 10 to 14, comprised of up to 12 dogs and/or 10 chickens. On Bottom Tawira, dogs also dug into three hawksbill nests (17.6% of clutches laid on Bottom Tawira) during the season and destroyed incubating eggs. There were also a large number of dogs on Buttonwood Cay, with up to six dogs at one time; however, the only clutch laid on this cay was poached. For the first time since the project began, dogs were brought to Columbilla Cay by green turtle fishers.

The use of artificial lights at night on the cays was monitored from 22 June to 9 November 2009 and was observed on Black Mangrove, Crawl (campfire), Grape, Lime, and Water cays (Table

6). This is the first nesting season lights were observed on Grape Cay. In addition to a number of newly constructed buildings on this cay (see below), a generator has been installed which is used to illuminate several of the buildings as well as the grounds around the cay. During the nesting season, lights were observed most frequently on Grape Cay with 90 nights illuminated (64.3%, of 140 nights monitored) and were on as late as 0230 h. On Grape Cay, 46.4% (65 nights) of the nights lights were on after 2300 h, representing approximately 50% of the nocturnal period (prime nesting time for sea turtles). On Black Mangrove, lights were observed 25.0% (10 nights) of the time, and were most often (80.0%) turned off by 2200 h. On Water Cay, lights were observed 28 nights (20.4%) on the west and central portions of the cay, and most often (63.0%) were turned off by 2100 h. On Lime Cay, lights were observed 8 nights (5.8%) on the south side of the cay, and 50% of the time were turned off by 2200 h. Not only can electric lights negatively affect nesting females by deterring nesting activity, but also emerging hatchlings. On at least four occasions more than 170 emerging hatchlings were disoriented by lights on Grape Cay (3 times) and Water Cay (1 time), resulting in hatchlings crawling towards the lights instead of the sea, becoming “trapped” on land and exhausting limited energy needed to swim out to sea.

The most damage and destruction to nesting habitat in 2009 occurred on Grape Cay (Table 6). During construction of the buildings, two latrines were built on the beach with human waste left in the open (Photo 3). By the end of the nesting season the entire cay was covered with six newly constructed buildings. On Crawl Cay, construction of a two-story cement house in a former nesting area continued until authorities ordered the work discontinued, however, not until the construction was completed. Repairs to buildings from hurricane damage were conducted on Bottom Tawira, Grape, Water, and Wild Cane cays. In addition, a roof was installed on a partially constructed house on Lime Cay. A bar serving alcohol is now in operation on Grape Cay which will likely attract more people on the cay at night, further disturbing nesting females and disorienting emerging hatchlings, and increase boat traffic at night from potentially inebriated boat drivers, endangering themselves, their passengers, and other boaters.

Vegetation on the upper beach platform was altered on several cays during the nesting season (Table 6). Cutting or clearing of mangrove trees, underbrush or vegetation was observed on Bottom Tawira, Columbilla, Crawl, Grape, and Maroon cays. Ground vegetation on Grape Cay has been completely removed and maintained without ground cover. Large areas on Baboon, Crawl, Lime and Wild Cane (north side) were periodically raked, maintaining those areas devoid of vegetation and preventing the growth of native plants, which are often used by hawksbills for locating nesting sites and important in reducing coastal erosion. On Bottom Tawira, additional mangrove forest in the interior of the cay and the north side were cut.

On some cays, sections of the nesting beaches continue to be used to store fishing materials and/or pile-up dead vegetation such as coconut husks, fallen branches and drift wood. The small nesting areas on Black Mangrove, Bottom Tawira, and Buttonwood were at times 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 Grape Cay (Photo 4) on numerous occasions and from the south, east, and west sides of the cay to backfill a >50 m rock retaining wall on the north side (Photo 5 & 6) and possibly to mix with cement for building construction. Because all the ground vegetation was completely removed from this cay it is now more susceptible to erosion. To reduce erosion a retaining wall along the north shoreline was built, however, it is

Table 6. Summary of human activities and habitat alteration/destruction observed by survey teams during the 2009 hawksbill nesting season, Pearl Cays, Nicaragua. N/A = Not Applicable. Maria Crow Cam Cay not included in table due to absence 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 & Northwest	Permanent	Fowl, & occasional dog &/or cat	No	No	North & Northwest	None observed.	Periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area. Burning & raking at beginning of season and post hurricane (Nov).
Black Mangrove	All Sides	Semi-Permanent	Dogs	Yes	No	No	For a period beach was covered with lobster traps impeding hawksbills from accessing the nesting beach.	None observed.
Bottom Tawira	West & South	Permanent	Up to 12 dogs, chickens & ducks	No	No	Southwest	None observed.	Cut mangroves in north & other trees and brush in south (inside), and grass on west and south.
Buttonwood	All Sides	Semi-Permanent	Up to 6 dogs	No	No	North	For a period beach was covered with lobster traps impeding hawksbills from accessing the nesting beach.	Occasional cutting.
Columbilla	North & Northwest	Semi-Permanent	Dogs	No	No	North & Northeast	Several shelters for fishers, some on nesting beach.	Cut live coconut trees. Cleared ground vegetation from an area of 15 ft x 25 ft from the dune inland for a camp.
Crawl	All Sides	Permanent	Dogs, cats, & chickens	Yes (camp fire)	No	Northeast & East	Continued construction on large two-story cement building.	Cut brush & cleared ground vegetation. Cleared & raked to maintain most of cay denude of vegetation, including nesting area. Burn piles of dead vegetation on dune & inland.
Grape	All Sides	Permanent	Dogs	Yes Observed >150 hatchlings disoriented	Yes	East & North	Six buildings constructed, in-ground cement swimming pool & dock. Rock wall > 50 m constructed on north side, blocking nesting beach. Two open latrines built over beach with human waste dumping onto beach. Extensive sand mining of beaches.	All ground vegetation and brush cleared early in season. Large burn pile observed very close to nest. Old thatch palm & husked coconuts piled on top of nest, hatchlings could not emerge.
Lime	South	Permanent	Dogs, cats, & chickens	Occasional	No	All	Completed roof of interior cement house & repairing watchman house in Jan 2010. Additional buildings and cell tower constructed for Survivor reality show in Feb 2010.	Cleared & periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area. Burned piles of dead vegetation. Additional clearing for construction in Feb 2010.
Maroon	N/A	Occasional	None observed	No	No	All	Ranch with cement floor for new fish <i>acopio</i> built in Jan 2010, removed in Feb 2010 & cement debris discarded on nearby reef. Construction of shelters for Survivor reality show in Feb 2010, abandoned open latrine, discarded tie wire and string, and large burned area.	Brush & trees cut, & almost all ground vegetation removed.
Seal	All	Permanent	None observed	None observed	None observed	No	No new construction observed.	None observed.
Vincent	N/A	None	Rats	No	No	All	None observed.	One observation of burning.
Water	West & Center	Permanent	Dogs, rats, chickens & geese	Yes, >20 hatchlings disoriented	No	Northwest & South	Dock replaced on south side (early season), & some buildings repaired after hurricane Ida (November).	Burned piles of fallen trees and branches from hurricane damage (November) & cleared vegetation west of house in center of cay.
Wild Cane	North	Permanent	Small wild cat (possibly Margay)	No	No	North & West	Repairs to large white house after hurricane Ida (November). Construction of 3 ft ² wood structure for Survivor reality show, and camp shelters for participants.	Occasional burning.

now blocking nesting females from emerging on this side of the cay (Photo 5 & 6). Sand mining on Grape Cay left large gapping holes in the beach (Photo 4), resulting in further loss of limited nesting beach habitat, as well as increasing erosion of the cay. Furthermore, garbage and debris were regularly piled up on the beaches of Grape Cay, again blocking access to the cay by nesting females and potentially preventing hatchlings from reaching the water (Photo 7). Hatchlings from at least one nest were trapped and could not emerge. In addition, a burn pile was very close to a nest and could have easily overheated eggs or burned emerging hatchlings.

Incentive Program - Donation of Live Turtles

There were 126 donations of live turtles (Photo 8) during the hawksbill nesting season (June to November), of which 4 were recaptures of previously donated turtles. Of these 126 turtles, 5 were loggerheads, 21 were green turtles, and 100 were hawksbills. Loggerheads were large juvenile to adult in size, ranging from 51.1 cm to 80.6 cm straight carapace length, minimum (SCLmin). Four of the loggerheads were captured by green turtle fishers and one was captured in a shrimp trawler. Green turtles were small juvenile to adult in size, ranging from 25.7 cm to 89.5 cm SCLmin. Seven of the green turtles were captured by divers and 14 were captured by fishers (two in gill nets and 12 in green turtle nets). Seven of the hawksbills were nesting females captured by fishers, watchmen, and a cook residing on the cays, and the remaining 93 hawksbills were captured in the water. Eighty-two of the 93 hawksbill in-water captures were small or large juveniles (range = 22.0 – 74.8 cm, SCLmin) captured by divers and the remaining 11 were juvenile to adult size (range = 36.6 – 80.1 cm, SCLmin) captured by fishers in nets set for green turtles.

Awareness and Outreach

Throughout the nesting season, seven progress reports were compiled and distributed to 22 Nicaragua authorities, including: the Ministry of the Environment (MARENA, Ministerio del Ambiente y de los Recursos Naturales), National Police, Attorney General for the Environment, Navy, the south autonomous regional government, a local university, the local municipality, two territorial authorities representing the 12 communities who use the Pearl Cays, and the U.S. Embassy. Eighteen weekly updates were compiled and broadcast on Radio Caribbean Pearl (from Pearl Lagoon in English), Radio Zinica (from Bluefields in Spanish) and Radio Rhythm (from Bluefields in English). More than 40 people were hosted by the project and taken out to the cays to learn about hawksbill turtles and their conservation needs. Whenever possible, local authorities, teachers or older students were invited to accompany project staff on nesting beach surveys or night patrols. In addition, a Nicaraguan from San Juan del Norte (Edgar Coulson) was given hands on training in the Pearl Cays with local field staff to prepare him for expanding WCS sea turtle conservation activities on the El Cocal nesting beach and in his community.

Progress reports, radio broadcasts, and visitors to the project provided an opportunity 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 through the WCS Pearl Cays project to community members and personnel of other sea turtle conservation projects outside the region 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 authorities, and to members of the Nicaragua National Police.

DISCUSSION AND CONCLUSIONS

Overall the 2009 nesting season was a success in again contributing to reversing the decline of this important rookery with more than 18,000 hatchlings produced. We recorded more than 200 clutches for a fifth consecutive year, although the nesting level in 2009 was lower than the previous three nesting seasons. Annual fluctuations in hawksbill nesting levels is 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 influence food resources and remigration intervals of individual females. In addition, the Pearl Cays rookery is not in a stable state after decades of overexploitation and therefore would unlikely exhibit a consistent nesting trend from year to year. There may also be increased mortality of mature animals; however, continued monitoring is necessary to determine if the decrease observed in 2009 is more than a natural fluctuation.

Hatching success for all clutches was similar to previous years; however, the significant difference between *in situ* (73.4%) and relocated (60.0%) clutches in 2009 was unexpected and has not been previously observed. In addition, hatching success for relocated clutches in 2009 was lower than in 2007 (68.0%, Campbell et al., 2008) and 2008 (71.3%, Lagueux et al., 2009). The reason for this decrease is not apparent in our data analysis, thus, we will increase oversight of field staff during future seasons in an effort to ensure a greater hatching success with relocated clutches.

Poaching activity, while reduced from 2008, is still of concern at 12.7% for the 2009 season. Of particular concern is the continued poaching that occurs on Bottom Tawira, Columbilla, and Buttonwood cays. These cays are regularly inhabited by local fishers who are involved in either lobster and/or green turtle fisheries. These cays are particularly problematic with respect to improving nest protection due to weak leadership on these cays and lack of enforcement of existing regulations by local authorities; regardless, we continue to work with local fishers to gain their cooperation. In addition, this year there was an increase in poaching activity on Wild Cane Cay. This was possibly due to new security staff assigned to the cay that was not initially cooperative with nest protection efforts.

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 sites in the region (Hillis and Mackay, 1989). The ratio of recruits to remigrants decreased from 1.6:1 in 2008 (Lagueux et al., 2009) to 1.05:1 in 2009; however, it is still similar to previous seasons. The higher ratio in 2008 is likely reflecting the reduced tagging efforts in 2006 (considering the frequency of 2-yr remigration intervals) when we had to reduce our efforts during peak nesting. It is important to monitor recruitment into the reproductive population to aid in identifying changes in mortality of various segments of the population, thus we will continue to monitor recruitment to 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 for hawksbills that migrate to Nicaragua's coastal waters from throughout the Caribbean, and as stated above may help explain the reduced recruitment in 2009. Our results on hawksbill mortality are minimum estimates because most fishers know that killing hawksbills is illegal, and thus it is likely that most mortality is not reported. Although many hawksbills that feed in Nicaragua's Caribbean waters are produced in Nicaragua, many are not (e.g., Barbados, Costa Rica, U.S. Virgin Islands) based on tag recoveries and genetic analysis, and thus the actions of Nicaragua's fishers to continue killing hawksbills will not only affect Nicaragua's resources, but those of many nations around the region that are using limited financial resources in an attempt to recover hawksbill populations. Unfortunately, the ability of enforcement authorities in Nicaragua to take appropriate actions where needed is inadequate, and thus the illegal killing will only diminish if local fishers are willing to change their habits. Outreach efforts to raise awareness and increase collaboration among fishers along the Caribbean coast of Nicaragua should be a vital part of hawksbill recovery efforts throughout the region.

Destruction of nests by dogs was relatively high this year and occurred on at least three cays (Lime, Bottom Tawira and Baboon), with dogs on Lime Cay digging into several nests for the first time this year. Unfortunately, neither the owners nor caretakers were cooperative in removing the dogs nor limiting their movements on the cays, resulting in further nest destruction after the problem was initially encountered. Having the appropriate regulations in place that prohibit the presence of domestic and/or exotic animals on the Pearl Cays, followed by enforcement, is urgently needed to combat this problem. Much more work will be needed to mitigate this threat in the coming season.

Use of artificial lights continues to be problematic, although the locations of light use have changed somewhat. Of particular concern in the 2009 season is the frequent use of lights until very late at night on Grape Cay, and periodically on Water Cay. It is well documented that nesting females are deterred from nesting on beaches that are well lit and that hatchlings are attracted to lights visible from the beach. When females are deterred from nesting it can result in nesting in suboptimal habitat or dumping their eggs at sea, reducing their reproductive success and population recovery. Hatchlings disoriented from artificially lit beaches will likely die from land predators or dehydration from being stranded on land during daylight. 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; and campfires visible on the nesting beaches should also 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.

Construction on Crawl and Grape cays was again a problem due to the impacts imposed on these fragile islands, such as contamination of beaches (and adjacent waters) from improperly disposed human waste (Photo 3), removal of ground vegetation and sand from nesting beaches (Photo 4), and increased presence of lights and humans on beaches during the night. The occurrence of these and other activities without appropriate control and oversight is one of the biggest threats to the Pearl Cays hawksbill population. Despite a visit by a delegation of government officials to

witness first-hand the widespread damage occurring on these cays, and although some action has been taken, there has been no long-term resolution to this ongoing problem. As human use of the Pearl Cays continues to increase it is imperative that appropriate regulations be implemented so that the very resources that they depend on are not destroyed or diminished. Regulations to mitigate these threats are provided below in *Recommendations for the Pearl Cays*.

Donations of live turtles increased from 33 in 2008 to 126 in 2009. This is a result of increased effort by project field staff to raise awareness of local fishers about hawksbill conservation needs and provide an incentive for them to donate live turtles for tag and release. However, some hawksbills (although fewer) continue to be killed by some individuals and thus, it is vital to continue our efforts in these upper cays. A concerted effort to reduce the killing of hawksbill turtles by fishers in the Región Autónoma del Atlántico Norte (RAAN) needs to be put into place, and laws protecting hawksbills and their products need to be enforced at markets, fairs, tourist destinations, and at airports to reduce the demand for hawksbill jewelry.

We combined results from all ten years of the project to assess spatial and temporal trends in nesting. Fluctuations in nesting activity on all beaches in the Pearl Cays are apparent (Appendix 1, Figure 5). Several cays appear to have a slightly increasing trend, though not significant, (Baboon, Columbilla, Lime, Vincent, and Wild Cane); however, only Bottom Tawira and Water show a significant increasing trend. Black Mangrove, Buttonwood and Maroon cays show a slightly decreasing trend in nesting, although none are significant. The other cays are relatively stable with respect to the amount of nesting among years, i.e., Crawl and Grape. Reduced nesting on some cays during specific seasons coincides with increased human activity during those time periods. For example, nesting on Wild Cane decreased in 2002 and 2003 when construction and vegetation clearing activities occurred. But since human presence has decreased to only one or two watchman nesting levels have increased, except one noticeable change is that there is no longer nesting on the north side of Wild Cane. Prior to removal of all the ground vegetation on the north side of Wild Cane roughly 21% of all nesting on this cay occurred on the north side. Also, nesting on Crawl decreased in 2002 when a lighted boat was moored between Lime and Crawl cays. This light illuminated a principal nesting area on Crawl; and in 2008 during construction of a large cement house nesting decreased.

The pattern of cay use by Pearl Cays hawksbills shows that there are specific cays that are “preferred” nesting destinations, year after year, these principal cays are Wild Cane, Crawl, Grape, and more recently Water (Appendix 1, Figures 5, 6, and 7). Other cays show greater annual variability (Appendix 1, Figure 6) in their use by hawksbills, particularly Columbilla, where in 2008 50 clutches were laid, almost as many clutches as were laid on Wild Cane, and in other seasons as few as 1 to 4 clutches. Nesting on Water Cay also fluctuates widely, from exceeding Wild Cane in 2006 with 46 clutches to as few as 7 clutches in 2005 (Appendix 1, Figures 5 and 6). Also, nesting on Bottom Tawira has been highly variable (Appendix 1, Figures 6 and 7), although generally increasing (Appendix 1, Figure 5 and 7). Recent reductions in nesting on Maroon and Vincent cays are likely the result of beach loss due to severe erosion (Appendix 1, Figures 5 and 7). Some fluctuations in nesting are likely due to variability in human activities from year to year, i.e., when human activity increases on a particular cay nesting may shift to other cays and then shift back if the disturbance lessens (see previous paragraph). While it is important to understand these patterns, it is also 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.

The 2009 nesting season was again successful when compared with results from the first years of the project; however, 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 benefits they might receive from using hawksbill turtles sustainably, e.g., through ecotourism, as well as the benefits of healthy hawksbill populations in the region. Nevertheless, we remain optimistic that as we continue to educate more of the local inhabitants and as they 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. Human alteration of the cays and its surrounding waters, however, as well as the killing of juveniles and adults by local fishers, continues to pose a significant threat to population recovery in the region. The declaration of the Pearl Cays as a marine protected area with appropriate regulations to control human activities is an important and necessary first step in reducing threats to hawksbills and the fragile ecosystems in the area.

As we conclude the 2009 nesting season report, a new threat has arisen. An Italian television production company (Magnolia) is currently filming a reality show (L'isola dei Famosi) in the Pearl Cays. As we understand it, there will be two consecutive programs filmed over about a 6 month period (possibly more), the second program will occur during peak hawksbill nesting. The Pearl Cays are fragile and highly susceptible to disturbance, and the vegetation on the upper beach platform is very important for hawksbill nesting, as well as maintaining the integrity of the coastal zone. Despite numerous attempts to meet with Magnolia staff in-country to provide guidance and oversight to the production crew so that they may mitigate damage to this extremely valuable and fragile nesting habitat, our requests have been ignored. WCS strongly supports the economic benefits provided to the government and local communities in the area from the production of these shows, however, the lack of will to control and regulate negative impacts to natural resources undermines the long-term viability of those resources and the dependence of local communities on them for food and income.

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 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 should be prohibited from shining on nesting beaches during nesting and hatching seasons, 7:00 pm to 5:00 am from May through December.
- f) Use of artificial lights (e.g., generators and campfires) 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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Appendix 1

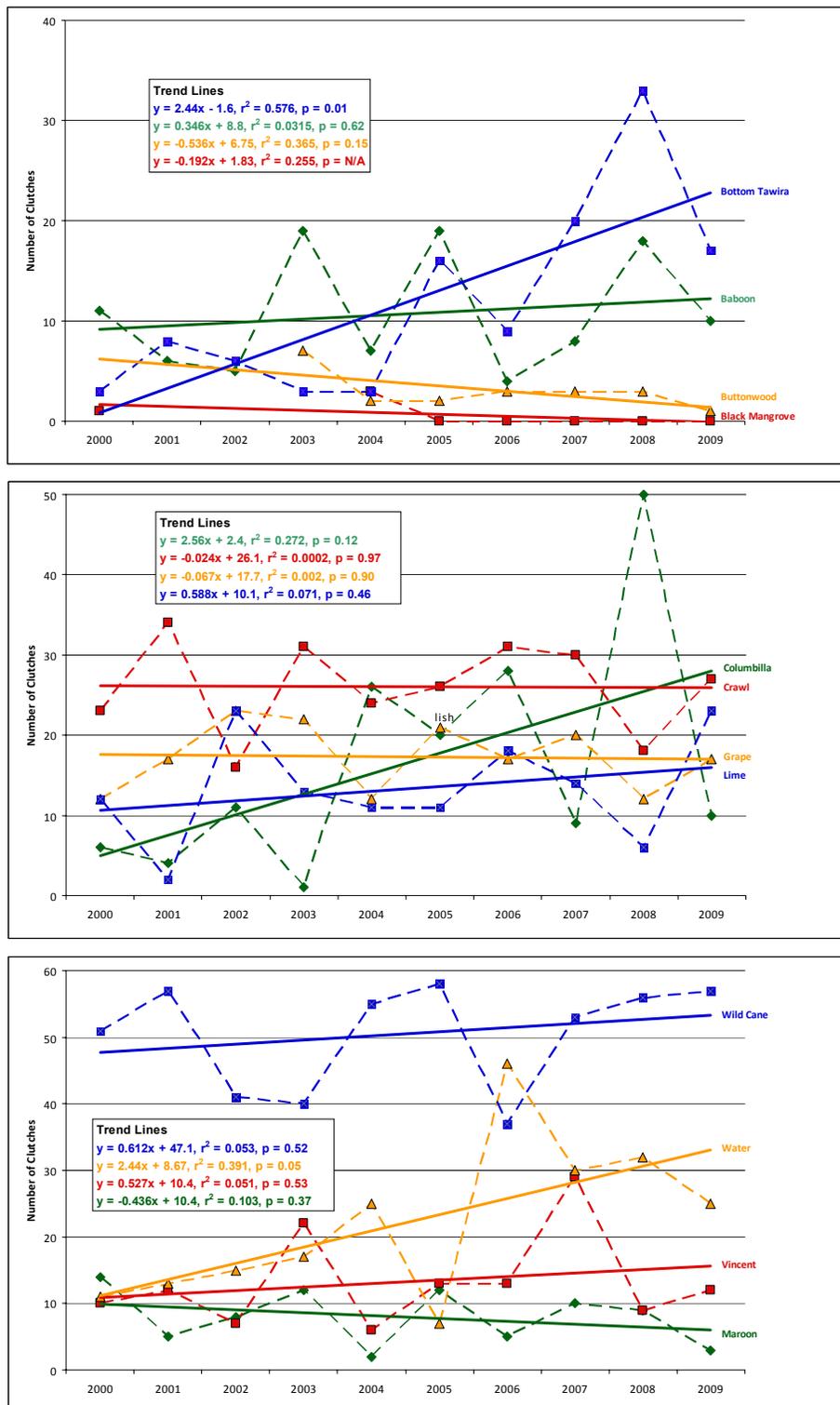


Figure 5. Trends in hawkbill nesting on each of the twelve regularly monitored cays from 2000 to 2009 in the Pearl Cays, Nicaragua. Annual number of clutches is shown for each cay with linear trend lines. Black Mangrove and Buttonwood cays were not monitored from 2001-2003 and 2000-2002, respectively. Note: scale of y-axes are not the same.

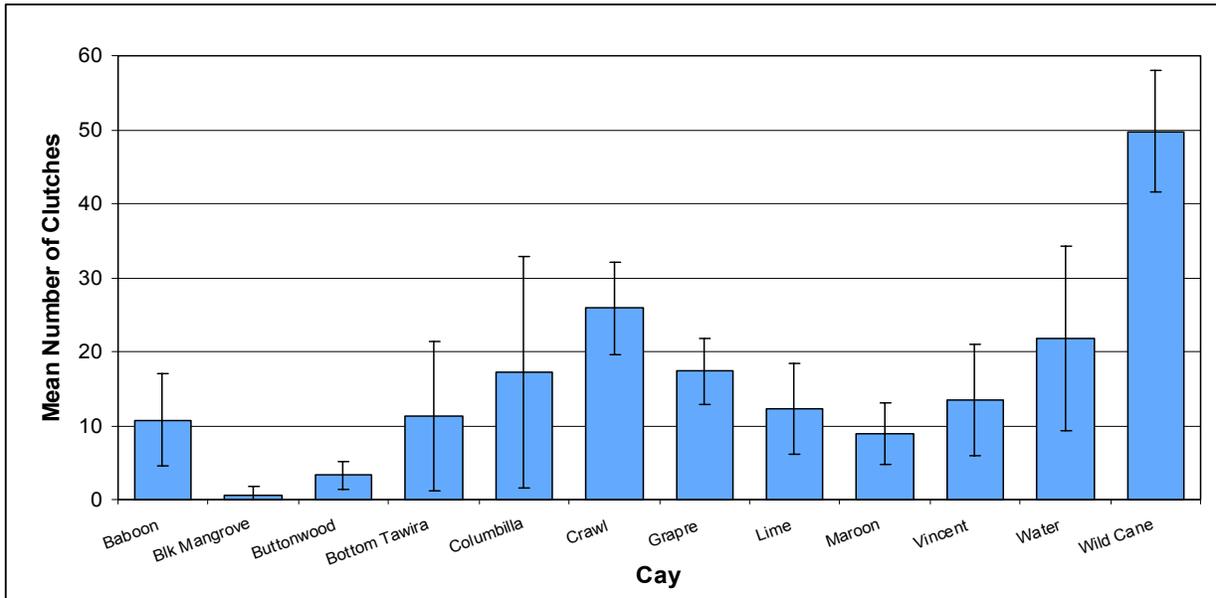


Figure 6. Mean annual clutch frequency for 12 of the Pearl Cays from 2000 to 2009. Bars show ± 1 SD. Black Mangrove and Buttonwood cays were not monitored from 2001-2003 and 2000-2002, respectively.

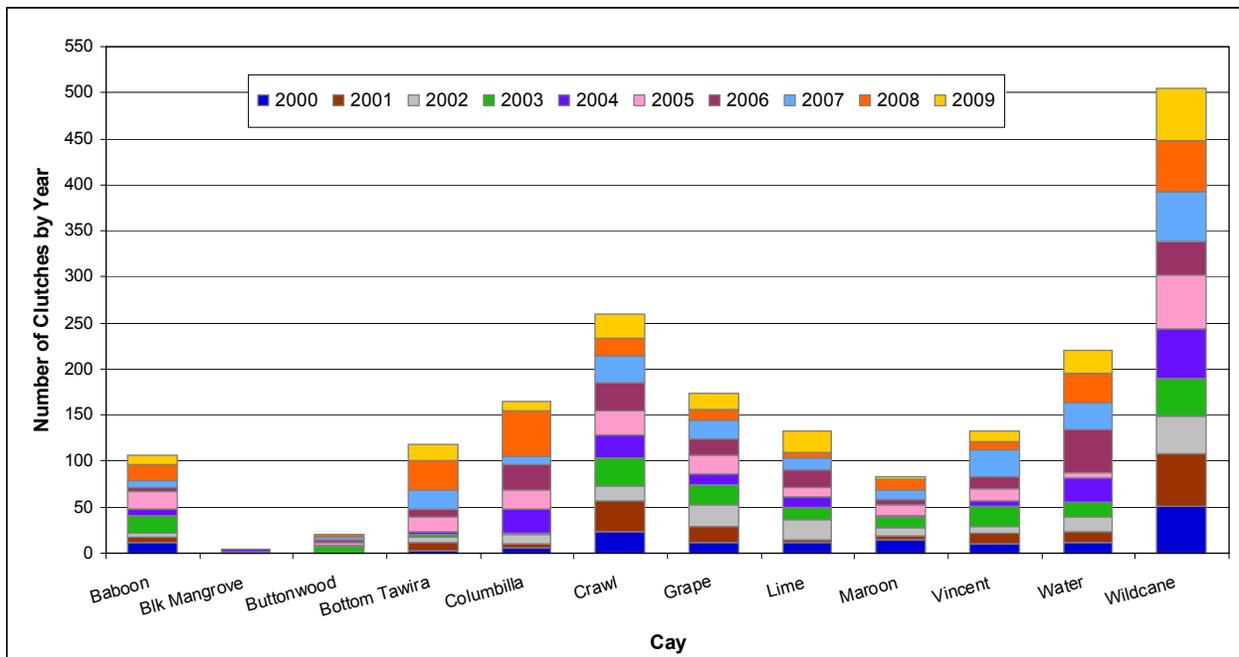


Figure 7. Cumulative and yearly number of hawksbill clutches laid on twelve regularly monitored cays for a 10-yr period from 2000 to 2009 in the Pearl Cays, Nicaragua. Black Mangrove and Buttonwood cays were not monitored from 2001-2003 and 2000-2002, respectively.

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Photographs



Photo 1. 2009 Hawksbill Project Team. Front row from left: Humberto Patterson (kneeling in front), Alex Alan, William McCoy (Field Supervisor), Harvey Antonio; second row from left: Carson Garth, Rafael McCoy, James Woods, Dr. Cathi Campbell (Program Science Director), Thelia Narcisso; back row from left: Dr. Cynthia Lagueux (Program Director), Gertrudis Hodgson, Police Jorge Ow, Jonathan Willans (Project Coordinator), and Dorian McCoy (kneeling). Missing in photo Dina Chang.



Photo 2. Life jacket, with turtle conservation message, given to community members when they complete 15 donations of live turtles for tag and release. For each prior donation, a specially designed T-shirt is awarded.



Photo 3. One of two open latrines on Grape Cay, contaminating the cay and allowing exposed human waste in a hawksbill nesting area.



Photo 4. One of many areas where sand mining occurred on Grape Cay, 2009.



Photo 5. Use of nesting beach sand to back-fill rock wall on Grape Cay, 2009.



Photo 6. Rock wall obstructing access to nesting beach on Grape Cay, 2009.



Photo 7. Obstruction of nesting beach with garbage and debris on Grape Cay, 2009.



Photo 8. Local high school teacher, Ellen Fox, releasing juvenile hawksbill donated to project by local fisher for tag and release, Pearl Cays, Nicaragua.