2008 PEARL CAYS HAWKSBILL CONSERVATION PROJECT, NICARAGUA

Adult female hawksbill leaving the nesting beach, Pearl Cays, Nicaragua. Photo: C. Campbell/WCS.

FINAL REPORT

Prepared By

Cynthia J. Lagueux, Cathi L. Campbell and William A. McCoy
Nicaragua Sea Turtle Conservation Program

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WILDLIFE CONSERVATION SOCIETY
Pearl Lagoon, RAAS
Nicaragua

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 2008 nesting season on the Pearl Cays, Nicaragua. The number of clutches recorded (n=249) continues to increase from previous years, and this is consistent with the positive nesting trend observed since initiation of conservation activities in 2000. Unfortunately, poaching activities increased from 5.8% in 2007 to 17.3% in 2008 on the cays monitored throughout the nesting season, one of the highest rates since 2002. The increase in poaching occurred on cays visited by fishers and *acopios*, however, poaching also occurred on cays permanently inhabited by caretakers. Hatching and emergence successes for clutches where at least one egg hatched were 75.5% and 74.3%, respectively. We estimated that a minimum of 22,356 hatchlings were produced during the 2008 season. At least eight nesting females and six juvenile hawksbills were killed during the 2008 nesting season. Furthermore, alteration and/or destruction of hawksbill nesting and developmental habitats continue in the Pearl Cays, and unregulated coastal development is the principal cause. Removal of dune vegetation, uncontrolled construction, artificial beach lighting during nesting and hatching seasons, presence of 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 valuable marine resources present in the area. We provide recommendations to minimize these threats, including regulating development and construction, 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.

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). It is widely recognized that most populations are in serious decline (Nietschmann, 1981; King, 1982; Groombridge and Luxmoore, 1989; Lagueux, 1998; Meylan, 1999; Meylan and Donnelly, 1999). On Nicaragua's Caribbean coast, hawksbill nesting occurs 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 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 habitat for hawksbill turtles from the Pearl Cays and from across the wider Caribbean, with 18 genetic haplotypes identified thus far, which represents up to seven or more rookeries occurring in Nicaragua coastal waters (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 their eggs, and by the opportunistic capture of foraging juveniles and adults (Nietschmann, 1981; 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 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 nesting beach 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; Lagueux et al., 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 in the 2005 nesting season indicates 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 14 of 15 cays used by nesting hawksbills are directly 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, fishery 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 management, 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 effects 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.

Objectives

Objectives for the 2008 nesting season were to:

1. quantify nesting activity spatially and temporally on 12 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 encompasses an area of approximately 700 km^2. The study area comprised 12 of the 18 Pearl Cays (Baboon, Black Mangrove, Bottom Tawira, Buttonwood, Columbilla, Crawl, Grape, Lime, Maroon, Vincent, Water and Wild Cane), ranging in size from 0.2 ha to 19.8 ha; although the size of the cay is not necessarily related to the amount of available nesting habitat (Table 1). Hawksbill nesting also occurs occasionally on Askill and Savanna Cays; although these cays were not included in the study because of their distance from our primary study area and infrequency of nesting; however, we did make several visits to these more northern cays when we learned about the possible killing of juvenile hawksbills. In 2007, nesting was observed on Seal Cay, for the first time (Campbell et al., 2008). Although we did not monitor this cay we confirmed periodically with local fishers based on this cay if they had observed any nesting activity during the 2008 season, however, no activity was reported. Nesting does not occur on Maria Crow Cam, Top Tawira or Walter Cays due to a lack of appropriate nesting habitat. These cays are comprised primarily of mangroves and/or coral rubble along their shorelines.

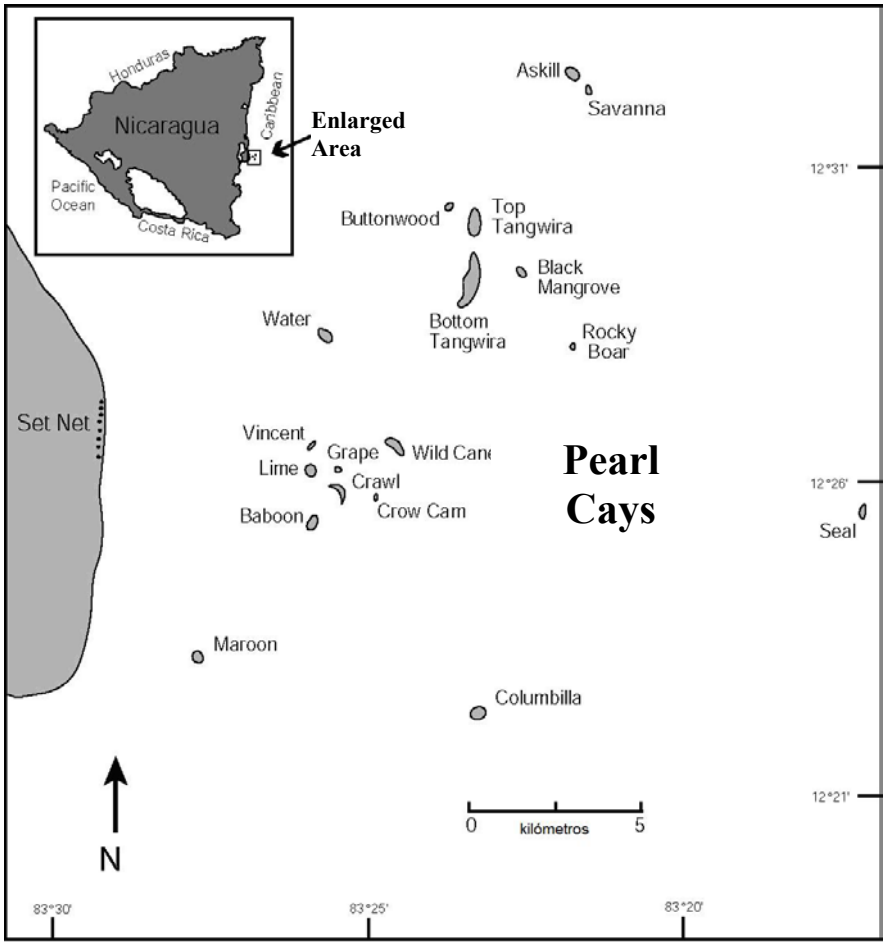

Figure 1. Map of the Pearl Cays, Nicaragua.

Table 1. Area and cumulative nesting beach length of the Pearl Cays monitored in the study.

Cay	Area (ha)/ nesting beach length (m)	Cay	Area (ha)/ nesting beach length (m)	Cay	Area (ha)/ nesting beach length (m)
Baboon	4.8 / 284	Columbilla	4.1 / 113	Maroon	0.4 / 364
Black Mangrove	0.9 / 16	Crawl	1.8 / 502	Vincent	0.2 / 151
Bottom Tawira	19.8 / 193	Grape	0.5 / 189	Water	4.9 / 350
Buttonwood	0.2 / 235	Lime	3.7 / 292	Wild Cane	7.6 / 467

METHODS

Nesting Beach Surveys

During the 2008 nesting season, nesting beach surveys were conducted on 12 of the Pearl Cays where the majority of hawksbill nesting occurs. Surveys were carried out by two WCS field teams alternating weekly. Field team members received classroom and field training by experienced WCS personnel in sea turtle biology, nesting ecology; and beach survey, data collection and nest relocation methods. Of the 14 participants in the one-day training workshop, nine (seven men and two women) were selected to work with the hawksbill project for the nesting season. As in previous years, the 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, Carson Garth, Roy Hodgson, Ruben Julio, Mykell Medrano, Humberto Patterson, Andrew Taylor, Gina Taylor, and Malanie Wilson (Photo 1), representing five local communities of the Pearl Lagoon basin (Haulover, Kahkabila, Pearl Lagoon, Orinoco, and Raiti Pura), and three of the six ethnic groups (Creole, Garifuna, and Miskitu) that reside on the coast. In addition, Field Supervisor, William McCoy, supervised and assisted with team activities. One or two Nicaragua National Police accompanied project staff during surveys.

To determine the onset of the nesting season and to protect clutches laid early in the season, surveys were initiated on 21 April, however, no nesting was observed until the next survey on 5 May. From 5 May until 19 June, surveys were conducted approximately weekly until the team camp was established on 19 June. From 19 June to 19 November surveys were conducted daily, and additional surveys were conducted between 19 November 2008 and 28 January 2009 when post-hatched nests were excavated.

During each cay-survey, 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 clutch 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 egg in its original orientation, and covering of the eggs. The new site was minimally disturbed and 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 clutch contents were excavated (for *in situ* clutches) or when clutches were relocated. Crawl length was measured along the track of the crawl from the most recent high tide to the center of the nest chamber. Also, nest location in relation to high tide was measured in a straight-line from the center of the

nest, perpendicular to the shore, to the most recent high tide line. Means are provided with standard deviation.

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 or nearly all of the 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, development could not be determined), 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. However, if hatchlings were active and already emerging 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 and 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 19 June to 17 November) by field staff, visitors, and project supervisors. Night surveys consisted of patrolling the beach at least every hour from approximately 1900 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, the team approached the turtle to check for flipper tags and determine whether or not biometric data needed to be collected. Individual females were only measured once during the nesting season; therefore, females that had already been encountered in 2008 by the field staff could be released immediately after being identified. Turtles that were encountered for the first time in 2008 by our staff 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 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 the right rear flipper of females not previously tagged.

RESULTS

Nesting Beach Surveys

From 21 April 2008 to 28 January 2009, a total of 1,565 cay-surveys were conducted on 12 of the Pearl Cays. We recorded 249 egg clutches and 84 non-nesting emergences. Nesting activity occurred from April to November with more than 50% of nesting activity occurring in July (29.5%) and August (27.8%), combined. Nesting activity in June and September were similar with 15.4% and 16.7% of the total nesting activity, respectively (Figure 2). The month of deposition was unknown for fifteen clutches.

Wild Cane Cay had the most nesting activity with 56 clutches (22.5%), followed by Columbilla with 50 clutches (20.1%), Bottom Tawira with 33 clutches (13.3%), and Water with 32 clutches (12.9%) (Figure 3). These four cays represent 68.7% (n=249) of all the clutches laid throughout the season. No clutches were recorded on Black Mangrove or Seal Cays.

Of the 249 clutches laid on the 12 cays monitored throughout the nesting season, 55.6% (n=134) were left *in situ* and 44.4% (n=107) were relocated by a survey team to a site near the original nest location. The remaining eight clutches were poached prior to encounter by a survey team.

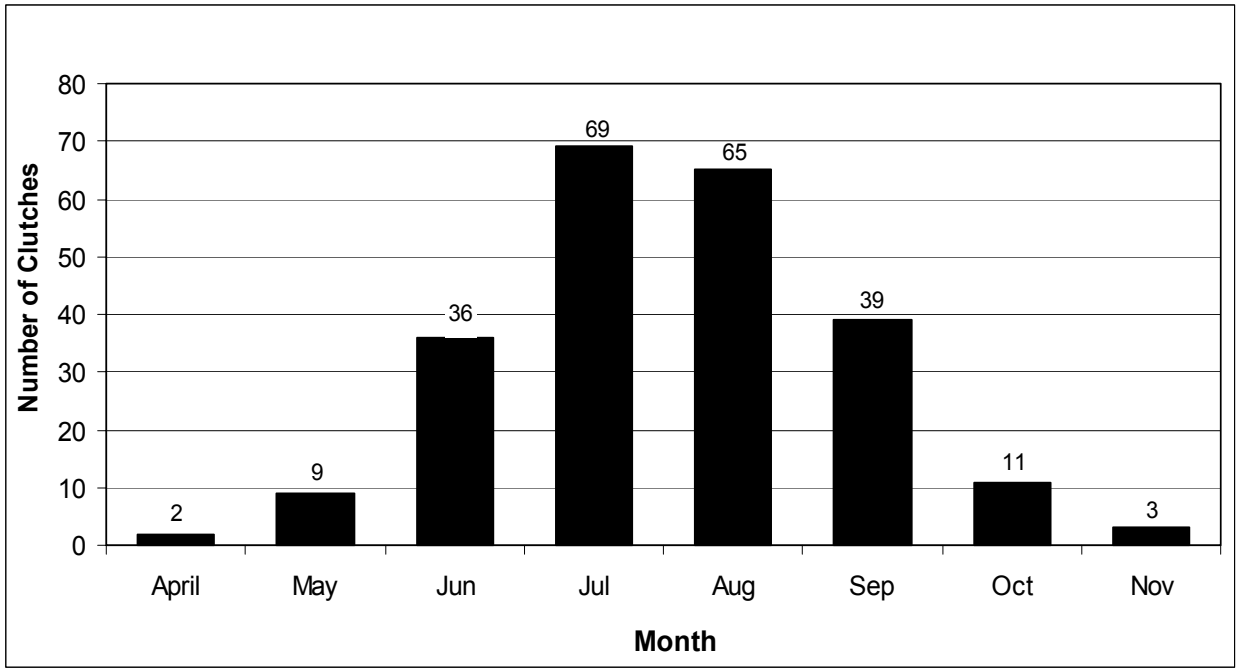

Figure 2. Temporal distribution of hawksbill clutches laid on 12 of the Pearl Cays, Nicaragua from April to November 2008 (n=234).

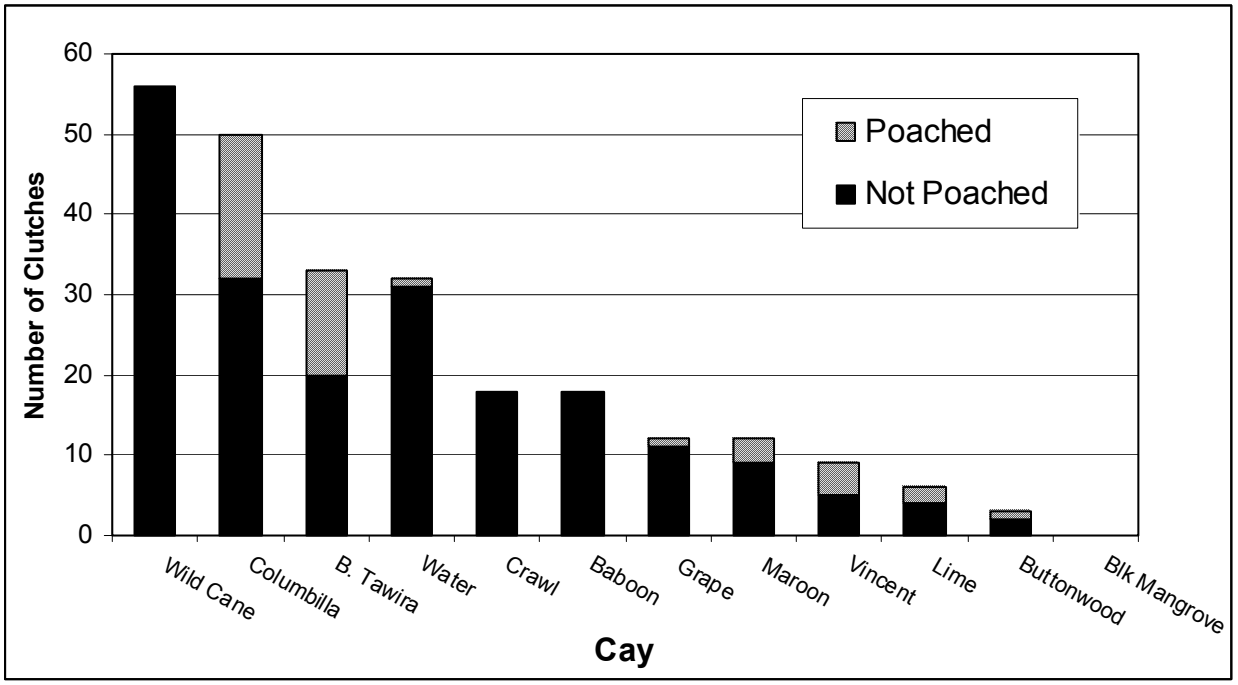

Figure 3. Spatial distribution of hawksbill nests on 12 of the Pearl Cays, Nicaragua during the 2008 nesting season. Bars show total number of clutches laid by cay divided into poached (partially or completely) and not poached.

Hawksbill nest parameters for 2008 are summarized in Table 2. Mean clutch size, based on relocated clutches, was 167.2 ± 28.4 eggs (n=106). Forty-seven yolkless eggs were observed in 21 clutches, ranging from 1 to 12 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 under-reported. Mean crawl length from the high tide line to the nest cavity for females that successfully nested was 8.8 ± 6.3 m (n=198); however, on at least 11 occasions females crawled more than 20 m before laying their clutch.

Table 2. Hawksbill nest parameters for 2008, Pearl Cays, Nicaragua.

	Mean	Standard Deviation	Range	n
Clutch size	167.2	28.4	55-246	106
Nest depth – *in situ* clutches (cm)	41.6	4.5	25.0-55.0	102
Nest depth – relocated clutches (cm)	36.7	6.1	4.5-55.0	104
Crawl length (m)	8.8	6.3	1.4-41.4	198
HTL[1] distance to nest (m)	5.1	3.5	0.2-26.0	226

[1]HTL = high tide line.

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 ($r=0.967$, $p<0.001$, Figure 4). Data are not available prior to 2000 for the entire nesting season; however, local fishers reported during informal interviews that the population had been declining.

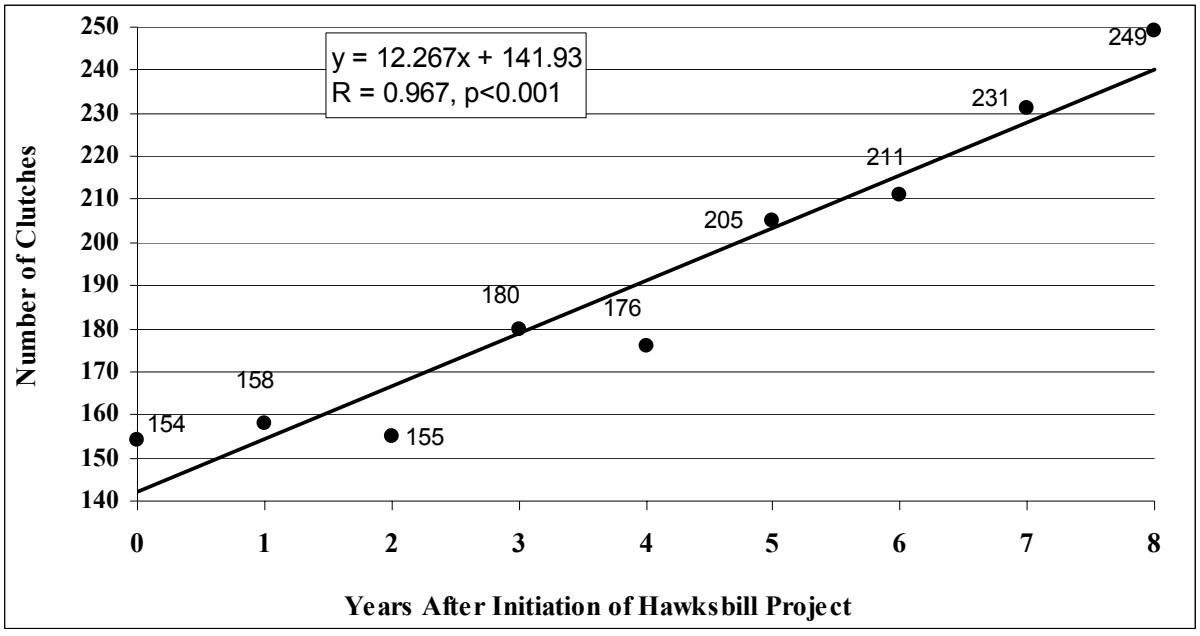

Figure 4. Trend in hawksbill nesting since project initiation in 2000 (year 0) to 2008 (year 8), Pearl Cays, Nicaragua.

Nest Excavations

Of the 241 clutches that were left to incubate, 183 clutches (75.9%) had at least one egg hatch. Thirty-five clutches (14.5%) were affected by poaching activities, 6 clutches were completely poached and 29 were partially poached. At least 14 nests (5.8%) were affected by high tides and/or water inundation (see section on Human Activities and Habitat Alteration/Destruction below). Four (1.7%) clutches were partially or completely destroyed by dogs on Bottom Tawira Cay, with 640 (92.1%) of the 695 eggs laid in these four clutches depredated. No eggs hatched in two clutches, and the remaining three clutches could not be found at excavation and thus their fate is unknown.

The overall poaching rate, regardless of when or if an entire clutch was poached, was 17.3% (n=43) and occurred on 8 of the 12 cays (66.7%) surveyed (Table 3, Figure 3). Of the 43 clutches affected by poaching, the greatest proportion occurred on cays used periodically by fishers or where *acopios* are permanently established (Table 3). In addition, poaching activities occurred on Lime and Water cays which are inhabited permanently by caretakers or watchmen (Table 3). At least 2,756 eggs were poached from a total of 5,415 eggs (50.9%, n=31 clutches) from clutches where we knew the original clutch size but which were subsequently poached, either completely or partially. In addition, an unknown number of eggs left to incubate in nests partially poached were likely negatively impacted by the disturbance caused when the poacher searched for the clutch, in the process of removing eggs, or recovering the clutch.

Table 3. Number and percent of clutches poached by cay in 2008, Pearl Cays, Nicaragua.

Cay	Type of Use	Total Clutches Laid	Number and (%) Poached
Vincent	Periodic	9	4 (44.4)
Bottom Tawira	*Acopio*	33	13 (39.4)
Columbilla	Periodic	50	18 (36.0)
Buttonwood	*Acopio*	3	1 (33.3)
Maroon	Periodic	12	3 (25.0)
Grape	*Acopio*	12	1 (8.3)
Lime	Caretaker	6	2 (33.3)
Water	Caretaker	32	1 (3.1)

Of the 14 clutches affected by erosion or inundation, five were located on Crawl, three each on Wild Cane and Water, and one each on Bottom Tawira, Grape, and Lime. At least 10 of these clutches were washed away, prior to hatching, when the coastline where they were incubating was lost.

For all clutches, hatching (HS) and emergence (ES) success was 73.9% and 72.7% (n=183), respectively; regardless if any eggs hatched. For those clutches where at least one egg hatched, HS and ES was 75.5% and 74.3% (n=180), respectively. For clutches left *in situ* HS and ES were 75.6% and 74.8% (n=112), respectively, and for relocated clutches 71.3% and 69.5% (n=71), respectively. HS and ES for clutches left *in situ* were not significantly different than for relocated clutches (t-test, data were transformed using $x' = \text{Arcsin}\sqrt{x}$, HS: $t_{(130)} = -1.08$, $p=0.28$; ES: $t_{(126)}=$

-1.26, p=0.21). We estimated a minimum 22,356 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.

Night Surveys

In total, 369 cay-night surveys were conducted on 11 cays (all but Black Mangrove Cay) from 19 June through 17 November to encounter nesting females. The cays selected for monitoring each night were based on the likelihood of encountering a returning nesting female. During these night patrols, we encountered nesting females on 98 occasions of which 69 (70.4%) successfully nested and 29 were non-nesting emergences. Of these 98 encounters, we sighted 47 individual females and the remaining 51 encounters were resightings of those females. Of the 47 females we encountered, 29 showed no evidence of having been previously tagged ("recruits"), thus all 29 of these females were tagged for the first time. The remaining 18 females remigrated to the Pearl Cays from an earlier nesting season and had been tagged previously by project staff. Of the 18 remigrants, five were originally tagged in 2002, five in 2003, three in 2004, three in 2005, and two in 2006 (Table 4).

Table 4. Number of nesting hawksbills newly tagged in 2008 and remigrants by year in the Pearl Cays, Nicaragua.

Year	Number of Females Tagged	Number of Remigrants by Year						
		2002	2003	2004	2005	2006	2007	2008
1999	1[a]		1					
2000	4	1	2		1		2	
2001	1		1		1		1	
2002	17			9		2	2	5
2003	34				10	2	8	5
2004	14					1	5	3
2005	13						3	3
2006	5							2
2007	20							
2008	29							
Total	138	1	4	9	12	5	21	18

[a] Female was originally captured in-water and tagged, and was encountered nesting four years later.

In total, 17 females were observed nesting more than once in the 2008 season. Twelve (70.6%) females were observed nesting twice, three (17.6%) females were observed nesting three times and two (11.8%) females were observed nesting four times. Of these 17 females, 12 (70.6%) used the same cay for each nesting event and 5 (29.4%) used two different cays. In 2008, females had an average renesting interval of 16.2 ± 1.5 days (range=13-19, n=18). Six females were observed renesting 30 days or more; however, these intervals 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.

In 2008, remigration intervals (# of years since a remigrant was last seen in the Pearl Cays) ranged from two to six years with a mean of 3.2 yrs ± 1.0, (n=18). Due to varied and incomplete coverage of the nesting beaches, some of the four-year intervals could represent missed two year remigrations and in the case of the six-year interval two or three year remigrations. In fact, at least 66.7% of returning turtles exhibited either a two or three year remigration interval. Shifts in remigration intervals have also been observed in this population. For example, in 2008, four turtles switched from two-year to three-year intervals, one turtle switched from a three-year to a two-year interval, and three turtles may have switched from a two-year to a four-year interval.

Female and Juvenile Hawksbills Killed

At least eight reproductively mature hawksbills were killed since last reported in the 2007 hawksbill final report (Campbell et al., 2008). Seven of them had been previously tagged by the project when nesting in the Pearl Cays. Four of these females were killed in the (Región Autónoma del Atlántico Norte (RAAN) when captured in nets set for green turtles (three of them by fishers from the community of Awastara and one by fishers from the community of Dakura). The other four females were killed in the Región Autónoma del Atlántico Sur (RAAS), all three bearing tags were captured by lobster divers from the communities of Sandy Bay Sirpi and Set Net Point. The fourth nesting female, which was not bearing tags, was reported killed by dogs when she emerged to nest on Buttonwood Cay on 20 August, however, no bite marks were observed on the carapace or soft tissue parts. Nicaragua National Police confiscated the shell, eggs, and meat when they arrived on the cay and found eggs and meat being cooked by local fishers.

At least six juvenile hawksbills, previously tagged by the project, were killed during this time period. Four of them were captured in nets, one by Sandy Bay Sirpi fishers, two by Kahkabila fishers, and one by Tasba Paunie fishers. A fifth juvenile was captured by a lobster diver from Tasba Paunie and another one was reported "found" dead near Savanna Cay. In addition, an unknown number of juvenile hawksbills were reported killed by a lobster diver based on Black Mangrove Cay, who was killing the juvenile hawksbills for meat.

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 potential impacts of human activities on hawksbill feeding and nesting habitats in the Pearl Cays (Table 5). All twelve cays surveyed throughout the nesting season were inhabited for at least part of the 2008 nesting season, although Vincent Cay was inhabited by shark fishers for only three days. Nine of the 12 cays surveyed had a permanent human presence (Baboon, Black Mangrove, Bottom Tawira, Buttonwood, Crawl, Grape, Lime, Water, and Wild Cane) (Table 5). A new *acopio* (location where marine products are purchased from fishers) was established on Grape Cay in 2008 to process and purchase sea cucumber. The WCS survey team set up a temporary base camp on Crawl Cay on 18 June and occupied the cay until 19 November, when the camp was dismantled and all materials were removed.

Of the cays that were inhabited, Water Cay had the single largest number of inhabitants on the cay at one time with 32 people during a 10-day training session for Navy personnel early in the

season, however, the mean number of people/day throughout the nesting season on this cay was much lower at 4.9 ± 6.9 (range=1-32, n=149 days). On average, Crawl Cay, location of project base camp, had the highest number of inhabitants with 11.2 ± 3.8 people/day (range=1-19, n=159 days). Excluding project personnel, the mean number of people/day on Crawl Cay was still relatively high (0=6.1 ± 5.8, range=0-23, n=82 days), and was the same as Buttonwood Cay (0=6.1 ± 2.6, range=1-13, n=159 days). Excluding Crawl and Water Cays, the four cays with *acopios* (Black Mangrove, Bottom Tawira, Buttonwood and Grape) had the highest mean number of people/day on each cay throughout the nesting season. On average, Black Mangrove had 8.8 ± 5.3 people/day (range=0-20, n=33 days), Bottom Tawira had 7.7 ± 4.7 people/day (range=1-26, n=130 days), and Grape had 4.8 ± 2.7 people/day (range=0-14, n=158 days). Of the remaining cays, Baboon, Columbilla, Lime, Maroon, Vincent and Wild Cane they each had, on average, less than four people/day occupying each of these cays throughout the nesting season.

In addition to humans, domestic animals were also present on many of the cays. On nine of the twelve surveyed cays, domestic and/or exotic animals were observed, including dogs, cats, pigs, and chickens (Table 5). Black Mangrove had the highest single-day count of domestic animals with 6 dogs, 3 cats and approximately 60 chickens; and the largest number of dogs on the cay with as many as 10 at one time. Bottom Tawira, however, had the greatest diversity of domestic animals, with up to four dogs, three cats, five pigs, and at least a dozen chickens on the cay at one time (Photo 2). The dogs on Bottom Tawira destroyed four egg clutches (see Results above for Nesting Beach Surveys). Buttonwood also had a large number of dogs on the cay with six present at one time. Rats were observed on Crawl, Vincent, and Water cays. On Wild Cane Cay, one wild cat (species unknown, but probably a margay, *Felis wiedii*, or an ocelot, *F. pardalis*, was observed roaming freely on the cay. This cat was reportedly captured in a mainland forest and brought to the cay approximately three years ago.

The use of artificial lights at night on the cays was monitored from 19 June to 12 November 2008 and was observed on Baboon, Black Mangrove, Bottom Tawira, Crawl, Lime, and Water (Table 5). The use of artificial lights was observed for the first time in 2008 on Baboon, Bottom Tawira, and Crawl cays. Compared to previous nesting seasons no lights at night were observed on Buttonwood or Wild Cane cays in 2008. Lights were observed on Black Mangrove 72.1% (n=68 nights) of the time, and the majority (51.0%) of the time lights were observed on until 0200 h, or later. On Water Cay, lights were observed 25.5% (n=137 nights) of the time on the west and central portions of the cay, although most often lights were turned off by 2000 h (n=24 nights). The south coast of Lime Cay was illuminated during 24 nights (16.6%) and most often lights were turned-off by 2200 h. Illumination on the other three cays was much more reduced with Bottom Tawira illuminated for nine nights, Baboon for three nights, and one night on Crawl. Not only can electric lights negatively affect nesting females and emerging hatchlings, for example, on Columbilla, at least 49 hawksbill hatchlings died when they crawled into a fisherman's campfire that was allowed to burn during the night.

New construction was recorded during the 2008 nesting season (Table 5). On Grape Cay, prior to the nesting season, a sea cucumber *acopio* was established. Five buildings were constructed for the workers, storage of product, and dive compressors. By 17 January 2009, three more buildings were in the process of being built by someone not associated with the *acopio*, one of which was constructed in cement, using sand from several locations on the beach. In addition, an open

latrine had been built over the beach and was being used by the workers (Photo 3). On Crawl Cay, construction continued on the two-story cement building that began during the 2007 nesting season. Other construction activities that occurred during the 2008 season were associated primarily with repairs or upgrades to existing structures. On Baboon, the dock was extended and repairs were made to the buildings. The swimming pool on Lime Cay was retiled and on Wild Cane the wood decking around the house and swimming pool was replaced with cement. None of the buildings constructed without government permits during previous years, have been removed.

Vegetation on the upper beach platform was altered on several cays during the nesting season (Table 5). Cutting or clearing of mangrove trees, underbrush or vegetation was observed on Bottom Tawira, Crawl, and Grape. Ground vegetation was completely removed from Grape Cay during construction of buildings in January 2009 (Photo 4). Previously, the manager of the *acopio* was cooperating with the project by not cutting the upper dune vegetation around the cay. Some areas on Baboon, Crawl, Lime and Wild Cane were periodically raked, maintaining those areas devoid of vegetation and preventing the growth of native plants. On Bottom Tawira, some sections of the mangrove forest on the south side of the cay and in the interior were cleared. During the nesting season, it was not uncommon to find females crawling long distances when they emerged in an area of a cay denuded of vegetation.

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. For example, drift wood taken from the beaches of Water Cay and dead vegetation were gathered and left in several large piles located in the nesting area, only a few meters away from incubating nests. The small nesting areas on Black Mangrove, Bottom Tawira, and Buttonwood were often covered with lobster traps during the nesting season, rendering them unusable by nesting hawksbills. The extraction of sand, or sand mining was observed on Baboon, Grape, and Lime cays during the 2008 nesting season. On Wild Cane, dead coral was removed from the east side of the cay and used to mitigate erosion occurring between the dock and beach.

In November, very strong winds, and high tides and waves impacted many of the Pearl Cays, particularly on the north side of the cays, and many human-built structures were damaged or destroyed (Photos 5 and 6). In addition, at least 14 nests were either inundated or washed away, and at least 11 of them prior to hatching. The dock on the north side of Wild Cane was totally destroyed and blown away and the north coastline severely eroded (Photo 5). The cement breakwater wall that had been built on Baboon Cay in 2006 to reduce erosion in front of two buildings that had been built on the nesting beach was destroyed (Photo 6). The coastline eroded under one building, and the northwest coastline was severely eroded. Much of Vincent and the south end of Bottom Tawira Cays nesting areas were reduced in size due to severe erosion. The coastline along the northeast end of Crawl and the northwest coastline of Maroon were severely eroded and many seedling and large coconut trees were washed away, respectively. At least two clutches were inundated with water which killed all developing embryos.

Table 5. Summary of human activities and habitat alteration/destruction observed by survey teams during the 2008 hawksbill nesting season, Pearl Cays, Nicaragua. N/A = Not Applicable.

Cay	Side of Cay Where Most Disturbances Occurred	Human Habitation	Domestic and/or Exotic Animals Present	Use of Artificial Lights	Sand Mining	Construction Activities	Vegetation Alteration
Baboon	North	Permanent	Cat & chickens	Yes	Yes	Dock extended and repairs made to buildings.	Periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area.
Black Mangrove	All Sides	Permanent	Dogs, cats & chickens	Yes	No	Hundreds of lobster traps stored on beach impeding hawksbills from accessing the nesting beach.	None observed.
Bottom Tawira	West & South	Permanent	Dogs, cats, chickens & pigs	Yes	No	None observed.	Cut-down mangroves & other trees. Cut grass.
Buttonwood	All Sides	Permanent	Dogs	No	No	Hundreds of lobster traps stored on beach impeding hawksbills from accessing the nesting beach.	None observed.
Columbilla	North	Frequent	None observed	Yes (camp fire)	No	None observed.	Cut leaves from live coconut trees.
Crawl	East & West	Permanent	Dog, cat, chickens, & rats	Yes	No	Continued construction of large two-story cement building.	Cut underbrush & cleared ground vegetation. Cleared & periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area. Burned piles of dead vegetation & drift wood.
Grape	All Sides	Permanent	None observed	No	Yes	Five huts built for sea cucumber divers, including dive compressors. Early 2009, 3 new houses were built, one in cement. Workers built an open latrine over beach with human waste dumping onto beach.	Cut & cleared all ground vegetation down to bare soil. Periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area.
Lime	South	Permanent	Dogs, cats, pig, & chickens	Yes	Yes	Retiling outdoor swimming pool.	Cleared & periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area. Burned piles of dead vegetation.
Maroon	N/A	Occasional	None observed	No	No	None observed.	None observed.
Vincent	N/A	Occasional	Rats	No	No	None observed.	None observed.
Water	West & Center	Permanent	Dogs, rats & chickens	Yes	No	None observed.	Burned piles of dead vegetation & drift wood. Cleared dune vegetation to make a 5ft-wide path on north side of cay.
Wild Cane	North	Permanent	Small wild cat	No	No	Dead coral taken from east side of cay & used to fill-in where coast eroded away from dock. Wood decking around house & swimming pool replaced with cement.	Cleared & periodically raked to maintain large area denude of all vegetation (dune & inland), including nesting area.

Donation of Live Turtles

A total of 33 sea turtles were donated to the project for tag and release during the hawksbill nesting season (June to November 2008). In return, a specially designed T-shirt is awarded to the person donating the turtle to acknowledge their contribution towards sea turtle conservation (Photos 7 and 8). Of these 33 turtles, three were loggerheads, five were green turtles, and 25 were hawksbills. The loggerheads were large juvenile to adult in size, ranging from 60.4 cm to 80.7 cm straight carapace length, minimum (SCLmin). The green turtles were small juveniles ranging in size from 26.5 to 36.8 cm SCLmin. Four of the hawksbills were nesting females captured by fishers or watchmen on the cays, and the remaining 21 were captured in the water. Sixteen of these 21 were juveniles (range = 21.8 – 49.7 cm, SCLmin) captured by sea cucumber or lobster divers, and the remaining five were juvenile to adult size hawksbills (range = 43.9 – 74.9 cm, SCLmin) captured by fishers in turtle or gill nets.

Awareness and Outreach

Throughout the nesting season, six progress reports were compiled and distributed to 23 Nicaragua authorities, including: the Ministry of the Environment (MARENA, Ministerio del Ambiente y Recursos Naturales), National Police, Attorney General for the Environment, the Navy, the south autonomous regional government, two local universities, the local municipality, two territorial authorities representing the 12 communities who use the Pearl Cays, and the U.S. Embassy. Two weekly updates were compiled and broadcast on Radio Caribbean Pearl (from Pearl Lagoon). No additional weekly radio updates were made due to a lighting strike that destroyed the radio equipment in Pearl Lagoon. Fourteen local residents 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, two Nicaraguan community members working on a sea turtle conservation project on the Pacific coast of Nicaragua were provided classroom and hands-on training by the project for a week. Furthermore, two Belizeans from the community of Gales Point (an important hawksbill nesting site) received 10 days of classroom and hands-on training with project staff.

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

The 2008 nesting season was another record breaking year with 249 clutches deposited in the Pearl Cays. Since hawksbills, like all sea turtles, require decades to mature, we cannot attribute this increase in nesting activity to an increase in the nesting population, but rather it is more

likely due to higher survival rates of nesting females when they come ashore to nest. As a result, more females can lay their complete complement of clutches for the season, rather than being killed after laying only one or two clutches. We attribute this probable increase in the survival rate of reproductive females in large part to the presence of the team on the cays throughout the nesting season, and the interest and cooperation of many local fishers in conservation efforts. Despite the collaboration of many fishers in hawksbill conservation, in 2008 at least eight nesting females and six juvenile hawksbills were killed by local fishers in the RAAN and RAAS. This is of great concern since it is estimated that the Pearl Cays population is only between 85 and 185 nesting females (Lagueux et al., 2003). It is important to note that almost all the females and all the juveniles that were killed were captured in the water, and to our knowledge only one female was killed on the cays that were monitored by project field staff. This demonstrates the importance of the WCS team in the Pearl Cays during the hawksbill nesting season and suggests that additional conservation efforts are needed on the cays not included in our primary study area, as well as with coastal fishers in general. Expanding our outreach efforts will continue to be a priority of the project in order to raise awareness and increase collaboration among all fishers along the Caribbean coast of Nicaragua.

Poaching activity has consistently decreased since 2000 with the exception of 2006 when the poaching rate increased to 21.8% due to a temporary suspension of project activities during peak nesting (Campbell et al., 2007) and during this most recent nesting season. In 2008, the poaching rate was 17.3% (n= 43 clutches), however, the majority of the poached clutches were partially poached (n = 29) from cays that were occupied by fishers (Bottom Tawira and Columbilla). It's apparent that more work needs to be done to educate and encourage collaboration of local fishers. Although project staff spoke with fishers on these two cays whenever they were encountered, apparently once project staff left the cay, some clutches were poached. It should be noted, however, that only one or two fishers can have a large impact on the poaching rate. It is possible that some people believe it is acceptable to take a portion of a clutch and as long as they leave some eggs they are contributing to conservation efforts, not considering the potential disturbance of egg removal caused to the remaining eggs or the overall decrease in production for the hawksbill population. Therefore, increased participation in conservation efforts, as well as educational activities, must continue to be an objective of the project in the coming years.

With few populations of hawksbills nesting on small island chains like the Pearl Cays, their nest site fidelity is not well known under these conditions. Hawksbills in the Pearl Cays have an apparent tendency to renest in relatively close proximity during subsequent nesting attempts within the nesting season and between nesting seasons, although there is variability. In the 2008 nesting season, almost three-quarters of the females encountered renested on the same cay. Since initiation of the project in 2000, 41.5% of the remigrant females renested on the same cay, 41.5% renested on at least two different cays, 14.6% renested on at least three different cays, and 2.4% renested on at least four different cays (n=41) (Lagueux and Campbell, unpubl. data). By distributing their nests on several cays, females spread out their reproductive effort, which in an unpredictable environment reduces the likelihood of loosing all their eggs. The combined circumference of the 18 Pearl Cays and small rocky patches above sea level, measures approximately 19.0 km, but only 3.3 km is suitable nesting habitat for hawksbills. The remainder of the coastlines is comprised of mangroves and dead corals which are unsuitable for nesting. Since individual females can nest on several cays and nesting was reported on 11 of the 12 cays

monitored, it is crucial to protect all nesting habitat available on the Pearl Cays. Protection of all suitable nesting habitat helps maintain the variability in the population and protect against stochastic environmental events.

Since the onset of the project, females have exhibited remigration periods of two years (59.4%), three years (26.1%), four years (13.0%), and one individual exhibited a six-year interval (n=69) (Lagueux and Campbell unpubl. data). Mean remigration interval estimated for nesting females in the Pearl Cays when all nesting intervals are combined is 2.6 ± 0.8 yrs (n=69) (Lagueux and Campbell, unpubl. data). These results are similar to those obtained on Buck Island, US Virgin Islands where female hawksbills nested on average every 16 days and remigrated every two to three years (Hillis and Mackay, 1989).

Adult hawksbills live primarily in association with coral reef habitat. After laying their full complement of clutches for a season, the females migrate to specific foraging areas. Data from satellite tracking post-nesting females from the Pearl Cays suggest that important foraging areas for hawksbills are located north and northeast of the cays (see our maps at http://www.wcs.org/international/marine/marinelacaribbean/nicaraguaseaturtle). During their migrations, hawksbills may be especially vulnerable to turtle fishing, incidental capture, and collision with boats. Efforts to protect hawksbill turtles on the Caribbean coast of Nicaragua are currently focused on the Pearl Cays. However, due to the migratory nature of these animals and the fact that important foraging areas are located outside the Pearl Cays, efforts to enforce existing regulations, increase awareness and educate local communities need to be extended to protect hawksbills along the entire Caribbean coast of the country.

Since the onset of the project in 2000, we have consistently reported on the serious threat uncontrolled and unregulated habitat alteration and destruction on the Pearl Cays possess to the reproductive efforts of this hawksbill population. Unfortunately, human activities on the cays and in the surrounding waters continue to increase, threatening critical hawksbill nesting and foraging habitats, and the persistence of this important rookery. During 2008, there were less construction activities on the Pearl Cays than during 2006; nevertheless, new buildings and structures were built without proper consideration for the impacts on hawksbill nesting and foraging habitat and the surrounding fragile ecosystem, which also supports valuable fisheries species. Furthermore, structures built without proper permits, recently and in the past, remain standing and obstructing nesting habitat. At the beginning of the nesting season five structures had recently been built on Grape Cay and by the end of the nesting season three additional structures had been built on this very small cay of only 0.5 ha. Construction on the upper beach platform not only occupies the space turtles use to nest, but also destroys the surrounding beach vegetation and generally increases human presence in the vicinity of dwellings. It has been observed that an increase in human activities on the Pearl Cays can lead to a decrease in hawksbill nesting activity, possibly resulting in hawksbills nesting in less suitable nesting habitat, inappropriate for egg incubation. For example, from 2000 to 2002, 23% of nesting activity on Wild Cane Cay occurred on the north coast, however, after significant development, complete removal of ground vegetation and increased human presence on the northern section, nesting decreased to less than 7% for every year since, with the exception of 2004 when it was 14.5% (Lagueux and Campbell, unpubl. data). In addition, mean crawl length ($\bar{O}$=16.2 ± 4.6 m) and straight-line distance from the high tide to the nest cavity ($\bar{O}$=9.5 ± 5.5 m) for the three

clutches laid on the north beach of Wild Cay in 2008 was almost twice the mean for all nests combined for these two measurements (0=8.8 ± 6.3 m, n=198 and 0=5.1 ± 3.5 m, n=226, respectively), indicating that these females crawled greater distances in search of suitable nesting habitat and ultimately laid their eggs farther from the water's edge.

In 2008, 7.2% (n=18 clutches) of clutches were laid on Crawl Cay which is approximately one-half the amount of clutches laid on this cay during the previous five nesting seasons. From 2003 to 2007, the percent of clutches laid was 15.9% (n=31 clutches), 13.6% (n=24 clutches), 12.7% (n=26 clutches), 14.7% (n=31 clutches), and 13.0% (n=30 clutches) (Lagueux and Campbell, unpubl. data). This decrease in nesting on Crawl Cay could be a result of the increased human activity due to construction of a large two-story, cement house on the cay.

Human habitation usually brings with it domestic and sometimes exotic animals. Animals that humans have brought to the Pearl Cays, intentionally or unintentionally, sometimes deter females from nesting (particularly dogs) and/or predate on hatchlings (e.g., dogs, cats and pigs), or turtle eggs (e.g., rats and pigs); thus, their presence should be prohibited or actively removed if already established on the cays. In 2008, dogs that were permitted to roam freely on the cays deterred females from nesting on Bottom Tawira and Water, on at least two occasions destroyed at least four clutches on Bottom Tawira, and dug-up two nests on Water. Artificial beach lighting also coincides with human habitation and occurred on several cays throughout the nesting season. Artificial lights, visible from the beach, are known to deter females from nesting and attract emerging hatchlings because hatchlings orient to the brightest light, which under natural light conditions is towards the ocean. Thus, in the presence of artificial light, hatchlings become disoriented and rather than crawling towards the ocean they crawl towards the artificial light, expending limited energy needed to reach the sea, increasing their vulnerability to land predators, and often resulting in their death due to exhaustion, dehydration or depredation. In 2008, at least 49 hatchlings burned to death when they crawled into a campfire left burning on the beach on Columbilla. Lights visible from nesting beaches should be prohibited during the nesting and hatching season (May through December, from 7:00pm to 5:00am), including campfires. Guidelines for "turtle friendly" lighting have been well established and should be used to 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 nesting beaches.

Hawksbills show a preference for nesting in the upper beach vegetation (Horrocks and Scott, 1991; National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998; Kamel and Mrosovsky, 2006; Lagueux et al., 2006). On many of the Pearl Cays this vegetation stratum has been repeatedly altered or destroyed. As a result, nesting females crawl longer distances in search of a nest site in areas without vegetative cover (Lagueux et al., 2006; Campbell et al., 2008), expending valuable energy needed to produce eggs and complete the labor intensive nesting process. Moreover, the removal of vegetation from the upper beach platform changes the environmental conditions under which clutches incubate which may lower hatching success and alter natural sex ratios. In the wider Caribbean, female biased sex ratios have been reported for hawksbill populations at several locations (Carrillo et al., 1999; Wibbels et al., 1999, Glen and Mrosovsky, 2004) and have become an issue of concern because it may have long-term consequences for population viability (Kamel and Mrosovsky, 2006). The removal of dune

vegetation also accelerates erosion, and therefore promotes additional loss of nesting habitat (Photo 4). In 2008, the coastlines of many of the cays were affected by high levels of erosion, causing loss of land and trees, and destroying nesting habitat (Photos 5 and 6). Although this may be due in part to natural variations in ocean currents and tides, it is also very likely that it is in part the result of clearing the vegetation cover of the upper beach platform on several of the cays. We strongly recommend that all hawksbill nesting beaches and upper dunes in the Pearl Cays be allowed to naturally revegetate, and where possible, encouraged to revegetate by planting native plant species typically found in the upper beach zone. This includes the removal of coconut trees from the nesting area (within 10 m of high tide).

A good example of the positive change that can occur when the dune vegetation is allowed to regenerate can be seen on Water Cay (Photos 9 and 10). For the past two years the dune vegetation on Water Cay has been allowed to regenerate, restoring the ground cover to native species of plants. Allowing native vegetation to regenerate creates a positive environment for both the ecosystem of the cays and nesting habitat for hawksbill turtles. The regeneration of native vegetation, especially on the dunes should be actively encouraged throughout the Pearl Cays.

The 2008 nesting season was successful with the continued increase in nesting activity, however, it was not as successful as in past years due to the increase in poaching activity. 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, eg., 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 they might gain by managing use of their natural resources sustainably positive changes will continue and the Pearl Cays hawksbill population will gradually move towards recovery. Nevertheless, human alteration of the cays and its surrounding waters, as well as the killing of nesting females continue to pose significant threats to the recovery of hawksbills in the region. The declaration of the Pearl Cays as a marine protected area with appropriate regulations to control human activities would be an important and necessary first step in reducing threats to hawksbills and the fragile ecosystems in the area.

Summary

a) The continued increasing trend in nesting observed in recent years suggests that efforts to conserve the Pearl Cays hawksbill population are succeeding, and the support of local communities and fishers is an important element in this success.

b) Egg poaching and killing of adults (especially reproductively mature females) and juveniles continue to be a problem. 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) 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 and biodiversity of the area (e.g., lobster, shrimp, and finfish).

d) Use of the Pearl Cays by humans continues to increase resulting in negative impacts to hawksbills and other marine resources. Regulating human activities, such as artificial light use and presence of domestic animals, will be necessary to mitigate these impacts.

e) 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.

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. 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, 7:00pm to 5:00am from May through December.

f) Use of artificial illumination (eg., 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, and resident animals should be removed.

h) Human activity on the nesting beaches during nesting and hatching season 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. 2008 Pearl Cays Hawksbill Survey Team. Front Row (left to right): Mykell Medrano, Andrew Taylor, Alex Allen, Gina Taylor, and Sub-Oficial Carminia Downs. Back Row (left to right): Roy Hodgson, Ruben Julio, Carson Garth, Humberto Patterson, William McCoy (Field Supervisor), Cynthia Lagueux (Project Director), and Oficial Lorenzo Mejia.

Photo 2. Domestic pigs on Bottom Tawira Cay during 2008 nesting season.

Photo 3. Open latrine built on hawksbill nesting beach on Grape Cay, January 2009.

Photo 4. Complete removal of ground vegetation on Grape Cay, January 2009.

Photo 5. Severe erosion on northside of Wild Cane Cay, November 2008.

Photo 6. Severe erosion on Baboon Cay, November 2008.

Photo 7. Brigilio Hodgson (Set Net Point) receiving specially designed T-shirt from William McCoy (WCS Field Supervisor) acknowledging his donation of a live sea turtle for mark and release.

Photo 8. Keyvon O'Neil (MARENA Delegate, Pearl Lagoon) releasing a juvenile hawksbill turtle (*Eretmochelys imbricata*) donated to the project by a local fisher.

Photo 9. Ground vegetation (in background) cleared from Water Cay (compare to Photo 10), November 2007.

Photo 10. Regeneration of ground vegetation on Water Cay (compare to Photo 9), September 2008.