

REPORT ON THE 2007 GREEN TURTLE PROGRAM AT TORTUGUERO, COSTA RICA

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Executive Summary

Monitoring and Research Activities Conducted

- 1 During 2007, a total of 39 track surveys were conducted along the entire 18 miles of beach between Tortuguero river mouth and Jaloa lagoon.
- 2 Green turtle nesting was observed between March and November, 2007; although false crawl emergencies were seen from mid-February until December. Peak nesting was recorded on 2 September, 2,193 nests were counted in a single night.
- 3 An estimated 177,620 green turtle nests were laid during 2007.
- 4 A total of 21.0% of all green turtle nests recorded during track surveys were deposited between Tortuguero river mouth (mile -3/8) and mile 5, where all night patrols took place.
- 5 Jaguars killed a minimum of 12 green turtles in 2007.
- 6 Hawksbill nesting density was very low throughout the season, with only two nests recorded; one in May, the other in July.
- 7 During daily track surveys conducted by RAs between 13 June and 31 October, a total of 24,499 green turtle nests and 23,324 green turtle false crawls were recorded between the Tortuguero river mouth and the mile 5 marker.
- 8 19 green turtles and 183 nests were recorded as poached during daily track surveys. Illegal poaching activity was observed on 50.4% of surveys.
- 9 119 green turtle nests were depredated by dogs.
- 10 A total of 1,077 green turtles were newly tagged, 669 green turtles with tags from previous years and 508 reneesters were recorded during 1,923 team hours of night patrols between 11 June and 30 October.
- 11 75 of the previously tagged turtles had been originally tagged more than 10 years ago; two turtles were first tagged in 1982, which is a new nesting history record for the project. One turtle was first seen in 1984 and five others were from 1986.
- 12 Twenty-one green turtles from other projects were encountered nesting in 2007; three were tagged on the beach in Pacuare Nature Reserve, four were from Mondonguillo and 12 were tagged by researchers from Caño Palma, north of the Tortuguero river mouth.
- 13 One turtle had tags that were recorded as having been used on Ascension Island in 1997; unfortunately no records were available from researchers to confirm the tag number or the date/location it was applied.
- 14 One turtle had originally been tagged as a juvenile in 1995 by Drs Peter and Anne Meylan as part of their in-water tagging project in the Bocas del Toro province of Panama. This is the first record of a juvenile from that project being observed as a sexually mature adult on a nesting beach.
- 15 Park rangers recovered a tag from a green turtle that had been killed by a jaguar which had a Cuban return address; the Scientific Director has contacted Cuban sea turtle biologists to attain more information about when/where the tag was applied.

- 16 Overall probability of within-season tag loss from first to last encounter was low at 2.6%, and there was considerable variation between taggers and between months.
- 17 Newly tagged green turtles had evidence of old tag holes or notches in at least one front flipper in just 3.7% of cases.
- 18 Tagging efficiency for night patrols varied from 0 - 100%, with a mean of 9.2%, for nights preceding track surveys.
- 19 Green turtles encountered during night patrols nested in the open zone in 28.8% of cases (n = 650), 54.0% (n = 1,215) were located in the border zone and 8.6% (n = 193) in the vegetation zone. 7.1% of turtles were encountered during a false crawl emergence (n = 161).
- 20 Eight newly tagged and one previously tagged hawksbill turtles were encountered during the 2007 Green Turtle Program; one of these females was observed twice during the season.
- 21 Three of the hawksbill nests were laid in the open zone, six nested in the border zone, and one nested in the vegetation zone.
- 22 Eleven leatherback turtles were encountered during the 2007 Green Turtle Program; six were re-nester females that had been seen during the 2007 Leatherback Program and the other five were remigrants.
- 23 One loggerhead turtle was encountered during a night patrol on 7 July; she was making a false crawl, but researchers had time to tag her.
- 24 Mean carapace length for newly tagged green turtle females without evidence of previous tagging was 104.6cm (CCLmin) and 98.6cm (SCLmax); for newly tagged green turtle females with old tag holes or notches 106.0cm (CCLmin) and 99.9cm (SCLmax), and for previously tagged females 105.6cm (CCLmin) and 99.4cm (SCLmax). Overall carapace length was 105.1cm (CCLmin) and 99.0cm (SCLmax). Mean clutch size for the same groups of females was 101 eggs, 106 eggs and 114 eggs, respectively.
- 25 Measurement precision of green turtles was the same for CCLmin than for SCLmax within a single encounter; 0.3cm. For turtles encountered two to five times, the SCLmax measurements were more precise.
- 26 Mean carapace length for newly tagged hawksbill turtles was 90.5cm (CCLmin) and 83.6cm (SCLmax) and for previously tagged individuals 95.3cm (CCLmin) and 87.7cm (SCLmax).
- 27 Mean carapace length of previously tagged leatherbacks was 154.0cm (CCLmin).
- 28 The loggerhead had a carapace length of 98.8cm (CCLmin) and 93.7cm (SCLmax).
- 29 Of the 105 green turtles carefully examined for the presence of fibropapilloma tumors only two were recorded with tumors (1.9%). An additional 18 females encountered were found to have tumors present; these ranged in size from 3 - 14cm and were typically located on the front flippers or the neck area.
- 30 A total of 125 green turtle nests were marked and the fate was determined for 110 nests. Overall hatching success is estimated at 74.8% (7,938 empty shells from 10,610 eggs) and overall emerging success at 67.0% (7,107 hatchlings from 10,610 eggs).
- 31 The biggest cause of nest loss was poaching 6.4% (n=7), while other females dug up five nests

(4.5%) and depredation affected a further three nests (2.7%).

- 32 Comparison between egg counts at excavation and the moment of oviposition showed a mean difference of 1.4 less eggs counted at the time of the excavation.
- 33 Mean depth for undisturbed green turtle nests ($n = 84$) at excavation was 59.5cm from the sand surface to the top egg and 77.9cm to the bottom of the egg chamber.
- 34 The mean incubation period for undisturbed green turtle nests ($n = 46$) was 55 days.
- 35 A total of one albino and 17 deformed embryos were observed in unhatched eggs, accounting for 0.17% of eggs.
- 36 Four hawksbill nests were monitored and their fate determined; of these one was a nest that was relocated at the time of laying. Hatching success of undisturbed nests ($n = 3$) was 38.7% and emerging success was 36.7% . For the relocated nest hatching success was 46.8% and emerging success was 42.5%.
- 37 Mean depth for *in situ* hawksbill nests ($n = 3$) at excavation was 45.3cm from the sand surface to the top egg and 63.3cm to the bottom of the egg chamber.
- 38 Rainfall was monitored from March - November 2007; November was the wettest month (1,193.2mm) and September was the month with least rain (168.2 mm).
- 39 Mean minimum air temperature was lowest in November (22.8°C); mean maximum air temperature was highest in August (28.4°C).
- 40 Mean monthly sand temperatures were highest in August/September (open zone), October (border zone) and June (vegetation zone). For all zones the lowest sand temperatures were recorded in November.
- 41 A total of 30,019 persons visited the CCC Natural History and Visitors Center in 2007, a slight decrease from numbers recorded in 2006.
- 42 Tourist visitation to Tortuguero National Park (TNP) increased significantly in 2007, to 116,751 paying visitors. Entrance fees to TNP generated a total of ₡299,368,170 (~ US\$607,238).
- 43 The capacity of hotels and cabins in the Tortuguero available to tourists decreased slightly in 2007 to 645 rooms and bed capacity dropped to 1,399 beds.
- 44 A total of 43,065 tourists were issued permits to go on guided turtle tours in 2007; an average of 323 tourists per night during the green turtle season (July - October). The peak in tourist activity was on 18 August when 682 people went on turtle tours.
- 45 In 2007 a new funding initiative was implemented for the Turtle Spotter Program; an information brochure was designed and offered to tourists for a donation of \$4. It was incredibly successful with 70.6% of tourists supporting the program; over \$100,000 was raised which completely covered all of the program expenses for the season.
- 46 Most of the lights visible on the beach were from Tortuguero village, with up to 20 lights / survey visible in each 1/8 mile from miles 2 6/8 - 3 3/8. The majority were street lights, though some were from cabins and houses. Away from the villages some lights can still be seen from the lodges as well as houses and street lights in San Francisco, and Tortuga Lodge on the other side of the river.

- 47 The mean angular range of green turtle hatchlings crawling from nests ($n = 22$) was 34.7° if outliers were excluded and 50.4° if outliers were included. For leatherback nests ($n = 4$) the angular range of hatchlings was 17.0° (outliers excluded) and 43.0° degrees (outliers included).
- 48 On two occasions evidence of hatchling disorientation caused by artificial lighting behind the beach was observed.
- 49 Numerous environmental education activities were carried out during the 2007 Green Turtle Program including two workshops for high school students, and teachers from the education establishments in Tortuguero and San Francisco. More than 150 students from kindergarten to grade 9 were involved in a range of theoretical and practical activities relating to turtles, conservation and regional flora and fauna.
- 50 Two independent research projects were conducted during the 2007 Green Turtle Program; one was a stable isotope analysis of the green turtle population to determine feeding locations, the other was an investigation into the level of multiple paternity in Tortuguero green turtles.

Conclusions

- 1 The vast majority of green turtle nesting was observed between July and October.
- 2 Daily track surveys conducted by the RAs are essential to evaluate the effectiveness of the management actions aimed at reducing the impact of tourism visitation.
- 3 Daily track surveys showed that the illegal take of green turtle females and nests continued throughout the nesting season but was at levels lower than those observed in 2006.
- 4 There was a noticeable increase in the number of nests predated by dogs, as recorded during the daily track surveys.
- 5 The number of green turtles killed by jaguars is a very small proportion of the number of nesting females, and this does not represent a serious survival threat to the Tortuguero green turtle population.
- 6 For green turtles measured on two or more occasions, SCLmax had greater precision than the CCLmin measurements.
- 7 The frequency of albinism and deformed embryos was very low in 2007.
- 8 The continued implementation of the new turtle-tour visitation system (Turtle Spotter Program), which began as a pilot project in 2004, has been successful in reducing the impact on nesting turtles.
- 9 The new funding initiative for the Turtle Spotter Program was extremely successful and provided sufficient resources to cover program expenses during the entire green turtle nesting season.
- 10 With an additional FC it was possible to develop a more comprehensive program of environmental education activities within the communities of Tortuguero and San Francisco.

Recommendations

- 1 The RA training and orientation program should encompass not only aspects related to sea turtle biology and conservation, but also provide a more general introduction to the region, such as the

local flora and fauna, the history of Tortuguero village and the creation of the National Park.

- 2 It is strongly suggested that daily track surveys by the RAs be continued during future Green Turtle Programs, to assist with the evaluation of the new turtle tour system and to provide information of the levels of illegal take and predation of nests by dogs.
- 3 Increased marine patrols by park rangers and foot patrols along the northern 5 miles of beach during the green turtle nesting season are necessary to reduce illegal take of turtles and eggs.
- 4 To ensure increased hawksbill nesting in the future any action aimed at protecting nesting females and nests should be encouraged. Efforts by researchers to ensure the survival of hawksbill nests on the beach should be continued. It is suggested that nesting hawksbill females not be shown to tourists, to avoid any possible negative impacts on this critically endangered species.
- 5 There is a continued need for increased coordination and data exchange between sea turtle conservation and monitoring projects being undertaken along the Caribbean coast of Costa Rica.
- 6 Continued efforts should be made to accurately determine the fate of all marked nests.
- 7 CCC should be involved in a campaign to try and reduce the number of dogs in the community, as they are causing considerable damage to nests laid close to the village. The situation will only deteriorate if the population is not controlled. It is recommended that efforts be made to establish a veterinary clinic to spay/neuter animals, with an associated education campaign as to the impact of dog predation on the turtle population.
- 8 Collection of physical data should be conducted on a daily basis throughout the year, to monitor changes in environmental conditions in Tortuguero and act as a baseline for possible studies into the effects of climate change on sea turtles and their habitats.
- 9 The Turtle Spotter Program should be continued and monitoring to evaluate its success related to minimizing impacts on nesting turtles be maintained. CCC should remain an integral part of this program to ensure that the minimum amount of disturbance is caused to the nesting turtles.
- 10 Hotel and beach front property owners should be encouraged to maintain or replant native vegetation to reduce light pollution. Further efforts should be made to educate the community about the impact of the lights on nesting turtles and hatchlings.
- 11 Environmental education activities within the community should be continued, and all efforts made to improve local participation in research and conservation activities. The practice of employing two FCs, one with a focus on community involvement, should be continued.
- 12 While independent research projects undertaken by RAs can provide valuable information to support conservation and management decisions, it is important to ensure that the data collection for their study does not impede their ability to complete their responsibilities as an RA. It is strongly recommended, therefore, that in future careful consideration be given to any applicant wishing to conduct their own research project. Only those studies for which data can be collected with minimal additional input on the part of the student should be permitted, or the student should be advised to conduct the research as an independent investigator and not part of the RA Program.
- 13 An effective communication system on the beach is essential, not only to ensure the security of CCC personnel during research activities, but also to facilitate information exchange with National Park staff. The radio system currently in operation at the field station needs extensive maintenance to allow for improved reception throughout the entire study area.

1. Introduction

Dr. Archie Carr began studies of green turtles (*Chelonia mydas*) in Tortuguero in 1954 (Carr et al. 1978). Since 1959, the Caribbean Conservation Corporation (CCC) has implemented the annual Green Turtle Program. Prior to the 1998 nesting season, CCC staff and the Scientific Advisory Committee revised the Green Turtle Program monitoring protocol. The new protocol defines that the Green Turtle Program is conducted in order to fulfill CCC's scientific mission in Tortuguero:

'CCC will provide the scientific information necessary to conserve the populations of sea turtles that nest at Tortuguero, Costa Rica, so that they fulfill their ecological roles'

The 2007 Green Turtle Program represents the tenth consecutive year of implementing the revised monitoring protocol.

The objectives of this report are to summarize and discuss the results of the 2007 Green Turtle Program and provide recommendations for future sea turtle programs, conservation efforts and research activities in Tortuguero.

2. Methods

2.1 Preparations

At the start of the 2007 Green Turtle Program the newly arrived RAs completed an extensive orientation and training program that covered all aspects of the monitoring protocol for the research activities, in addition to ensuring that all of the beach markers placed during the 2007 Leatherback Program were still intact and in good condition. As part of the orientation the RAs were introduced to various members of the Tortuguero community and National Park personnel.

2.2 Track Surveys

2.2.1 Weekly track surveys

Track surveys were carried out approximately weekly during the entire Green Turtle Program. The track surveyor conducted surveys between the Tortuguero river mouth (mile -3/8) and Jalova lagoon (mile 18). The surveys commenced at dawn (4:30-5:00am) at the Tortuguero river mouth, or at Tortuguero village, and finished between 9:30am-12:00pm at Jalova lagoon. If the survey started at the village, and the section between Tortuguero river mouth and the village had not been surveyed in the morning, the same person surveyed that beach section upon completing the other part of the survey.

Only tracks from the previous night were recorded and for each track the following information was recorded:

- Species
- Mile
- Nest or false crawl
- If the nest and/or turtle was poached
- If the turtle was depredated

A nest was recorded as poached if there were signs of human disturbance, including footprints around the nest, poke holes from a stick, evidence of digging, an empty egg chamber or fresh egg shells close to the nest. A turtle was considered poached when the track indicated that humans had dragged the turtle off the beach.

Dead turtles were considered depredated by jaguars (*Panthera onca*) when they were surrounded by jaguar tracks or showed characteristic jaguar injuries, such as extensive bites marks to the neck.

2.2.2 Daily track surveys

In addition to the weekly track surveys of the entire 18 miles of nesting beach, between 13 June - 31 October, the FCs and RAs conducted daily track surveys along the northern 5 2/8 miles of beach (from the Tortuguero river mouth to the mile 5 marker). These surveys commenced at 6.00am each morning.

Only tracks from the previous night were counted, and for each track the following information was recorded:

- Species
- Mile
- Nest or false crawl
- If the nest and/or turtle was poached
- If the turtle was depredated by jaguars

Once a nest had been recorded two lines were drawn through the track to ensure that it was not counted on future surveys.

2.3 Tagging of Nesting Sea Turtles

Tagging teams patrolled the beach every night between 11 June - 30 October (except for 11 October). The northern part of the beach was divided into two sections: Boca - from the river mouth to the field station (at mile 2 5/8) and Park - from the field station to the mile 5 marker. Separate teams patrolled each section during two shifts: 8pm - 12am and 12 - 4am, when the number of researchers and participants allowed.

Female turtles encountered during the patrol were tagged after finishing oviposition or when returning to the sea. Leatherbacks (*Dermochelys coriacea*) were tagged in the rear flippers; green and hawksbill (*Eretmochelys imbricata*) turtles were tagged axillary, close to the first scale on the front flippers. All turtles were double-tagged to allow identification even if one tag was lost between nesting emergences.

For each encounter the following information was recorded:

- Date
- Mile marker (to the north of the turtle)
- Species
- Tag numbers of existing tags and/or evidence of old tag holes or notches

The location of the nest was classified into one of three groups:

- Open – open beach with no vegetation and no shading
- Border – nest partially shaded by vines or other sparse vegetation for some part of the day
- Vegetation – dense vegetation completely shading the nest throughout the day.

Tags used during the 2007 Green Turtle Program include National Band & Tag Company (NBTC) Inconel #681 tags no. 107005-107023, 107034-107050, 107143-110000.

2.3.1 Green turtles

Inconel #681 tags were used to tag a minimum sample of 1,000 green turtles not carrying old tags. Every effort was made not to mix Inconel and Monel tags on the same individual. Thus, if a turtle was

encountered carrying one Monel tag this was removed and two Inconel tags were applied. If it was not possible to remove the Monel tag for some reason, a second Monel tag was applied to the other flipper.

The probability of tag loss was calculated for green turtles tagged with two Inconel #681 tags that were subsequently encountered with one or two tags. The probability of tag loss is:

$$1 - K_i = 1 - ((2r_{di}) / (r_{si} + 2r_{di}))$$

where K_i is the probability of retaining a tag during the interval i ; r_{di} is the number of turtles encountered carrying two tags at interval i ; and r_{si} is the number of turtles encountered carrying one tag at interval i (Wetherall 1982). Probability of tag loss was estimated for the first-to-last encounter during the 2007 season.

2.3.2 Hawksbill turtles

Hawksbill turtles were tagged with Inconel #681 tags. Once tagged, a disposable sterile scalpel or a biopsy punch was used to collect tissue samples from all hawksbills encountered, when possible. The samples were stored in ethanol until the relevant CITES permits were obtained and then the samples were sent for genetic analysis to Dr Peter Dutton of the National Marine Fisheries Service. Due to the very low level of hawksbill nesting at Tortuguero, and the fact that they are listed as critically endangered, researchers always remained with the turtle until she returned to the sea and then they thoroughly erased the track afterwards, to minimize the possibility of the nest being taken by poachers.

2.3.3 Leatherback turtles

Leatherback turtles were tagged in the rear flippers using Monel #49 tags.

2.4 Biometric Data Collection

2.4.1 Green turtles

Biometric data were collected from a sample of nesting green turtles. An attempt was made to count one clutch of eggs per night in each of the two beach sections (Boca and Park). Eggs counts were conducted as the eggs were laid, by a person wearing a plastic glove so as not to contaminate the nest. Eggs were counted using an egg counter; any yolkless eggs were counted separately. All egg counts were conducted after midnight, when there were no tour groups present on the beach.

All tagged turtles were measured after they had finished nesting, if time allowed. Curved carapace length minimum (CCLmin), from where the skin meets the carapace by the nuchal notch to the posterior notch between the supracaudals, along the midline, was determined to the closest millimeter using a fiberglass tape measure. Straight carapace length maximum (SCLmax), from the anteriormost edge of the carapace to the posterior tip of the longest supracaudal, was determined, to the closest millimeter, using a set of calipers. Both CCLmin and SCLmax measurements were taken three times by the same person, whose name was recorded in the field book, in order to determine the precision of the measurements. Precision is defined as the difference in centimeters between the longest and the shortest of the three measurements. Precision for females encountered more than once during the 2007 season is defined as the difference between the shortest and the longest of all measurements taken from the same turtle.

2.4.2 Hawksbill turtles

CCLmin and SCLmax measurements were taken for all hawksbills encountered during night patrols.

As for green turtles, the same observer measured the turtle three times for each measurement, to allow the precision to be calculated. Whenever possible the clutch was counted, if the hawksbill had not already started to lay eggs when encountered.

2.4.3 Leatherback turtles

For leatherbacks, CCLmin (from where the skin meets the carapace by the notch of the neck to the posterior end of the caudal projection, next to the central ridge) was measured using a 300 cm fiberglass measuring tape. Each turtle was measured three times to determine an average CCLmin. No SCLmax measurements were taken as the calipers were not sufficiently large enough to measure a leatherback turtle.

2.5 Fibropapilloma Assessment

For a minimum sample of 100 green turtles, those for which clutches were counted, an examination for fibropapilloma was also conducted. All soft body parts, including the cloacal region, were inspected for tumors, using a flashlight with a red filter. The following data were recorded for each assessment:

- The absence or presence of fibropapilloma tumors
- Location of fibropapilloma tumors
- Size of any tumors detected
- The name of the person examining the turtle

Any evidence of fibropapilloma tumors on turtles for which the clutch was not counted was also recorded during the season.

2.6 Determination of Nest Survivorship and Hatching Success

A sample of green turtle and hawksbill nests was marked during oviposition. These nests were all located between Tortuguero river mouth (mile -3/8) and the mile 5 marker. The nests were marked using three pieces of flagging tape that were attached to vegetation behind the nest. While the turtle was laying eggs the distance from the centre of the egg chamber to each of these tapes was measured to the nearest cm, so that the location of the nest could be determined at the time of excavation using triangulation. Three marker tapes were used to compensate for the loss of any tapes as a result of camouflaging turtles, insects or persons removing the tapes intentionally; if one marker tape was lost it was still possible to locate the nest using the other two tapes. The distance to the most recent high tide line was also recorded at the time of oviposition.

All of the marked nests were inspected daily at 6:00am. Evidence of depredation, poaching or beach erosion were noted and resulted in termination of monitoring for that nest; if the evidence was inconclusive, monitoring continued as normal, but the date of the observed disturbance was recorded, so that any resulting anomalous excavation data could be accounted for. If evidence of hatching was observed, the date was noted and the nest was excavated two days later. If no depression or hatchling tracks were recorded, the nest was excavated after 65 days.

After 65 days, or sooner if signs of emergence had been recorded, the nest was excavated, once the distances from the marker tapes had been re-measured to confirm that it was the original nest. Nests that had no obvious depressions were located by probing for soft sand using a wooden stick (only after 65 days, when it was presumed that hatching and emergence had occurred), and this technique greatly aided in locating several of the marked nests. The excavation was discontinued if the researcher encountered a large number of hatchlings in the nest; in such cases the hatchlings were re-buried and the nest excavated at a later date. If a few hatchlings were encountered, they were placed in a shallow

hole close to the nest site and covered with sand so that they could reach the sand surface and emerge the following night.

For each nest the following information was recorded during the excavation:

- Nest code
- Mile marker
- Name of persons conducting excavation
- Date laid, hatched (if available) and excavated
- Number of empty shells – only shells corresponding to more than 50% of the egg were counted
- Number of hatchlings – alive or dead
- Number of unhatched eggs - these were categorized as
 - Without embryo – no visible embryo observed
 - Embryo – an embryo at any stage of development was present
 - Full embryo – an fully developed embryo was present
- Number of pipped eggs – embryo had broken the shell but failed to hatch
- Number of predated eggs
- Number of deformed embryos – including albinism or multiple embryos in a single egg
- Number of yolkless eggs

In addition, the depth from the surface to the top of the egg chamber (to the first egg encountered), and the bottom of the egg chamber (after the last egg was removed) was measured to the nearest centimeter.

If a nest could not be found when excavated, an attempt was made to determine the fate of the nest. Nests were considered poached if an empty egg chamber was encountered. Nests were assumed dug-up by another turtle if broken eggshells and a new body pit were encountered where the original nest was supposed to be located. Nests were considered depredated if a large number of opened eggshells were found in close proximity to the location of the marked nest, and there were signs of digging by animals, or tracks. If human footprints and digging was observed at the location of the nest, the nest was considered dug-up by tour guides or other persons to show the hatchlings to tourists. Nests for which the fate could not be determined with certainty or which were not excavated entirely were excluded from the sample.

2.7 Physical Data Collection

Throughout the 2007 Green Turtle Program several environmental variables were monitored on a daily basis at the John H. Phipps Biological station in Tortuguero.

- Rainfall was collected in a gauge that was emptied each day at 9.00am and recorded to the closest 0.1mm.
- Air temperature was recorded at 9.00am; the minimum and maximum values for the previous 24 hours, and the current temperature were noted.
- Sand temperature was measured using data loggers buried at 30, 50 and 70cm depth in the open, border and vegetation zones of the beach in front of the CCC station. The data loggers were set to take a temperature reading every hour. The data were downloaded in the middle and at the end of the 2007 Green Turtle Program.

2.8 Collection of Human Impact Data

2.8.1 Visitors to Tortuguero

The number of visitors paying to enter the CCC Natural History and Visitors Center was recorded each day during 2007. Staff at the Tortuguero National Park headquarters at Cuatro Esquinas provided information on tourist visitation to the park during 2007.

2.8.2 Capacity of hotels and cabins

The FCs, Xavier Debadé and Dagnia Nolasco collected information on the room and bed capacity from cabina owners and hotel managers in Tortuguero at the end of the 2007 Green Turtle Program.

2.8.3 Turtle tours

The number of tourists going on guided turtle tours during the 2007 Green Turtle Program was calculated from the permits issued to tour guides by Tortuguero Conservation Area (ACTo). In 2007, the Turtle Spotter Program, the visitation system introduced in 2004 that aimed to reduce negative impacts of tourism on nesting sea turtles, was implemented for the entire northern five miles of beach where tourism is permitted (from the Tortuguero river mouth to the mile 5 marker). A new funding mechanism was implemented in 2007; an information brochure about the Turtle Spotter Program was designed and offered to tourists participating in turtle tours for a donation of \$4 to foreign visitors and \$2 to Costa Rican nationals. Each brochure contained a sticker which visitors were encouraged to wear during their tour, to show their support for the Program. Funds generated from these brochures were used to employ thirteen turtle 'spotters' from the community of Tortuguero. The turtle spotters patrolled the beach searching for nesting turtles, and reported their location to the tour groups waiting with their guides at designated areas behind the beach. When the turtle was close to laying eggs, guides led their group to her location using a path behind the beach, thus reducing the number of people walking along the beach who could potentially disturb other turtles as they came ashore to nest.

2.8.4 Artificial lights

To assess the level of impact of artificial lights on the Tortuguero nesting beach a light survey was conducted each month. Dates as close as possible to the new moon were selected when natural light levels on the beach were minimal. The beach was surveyed from the Tortuguero river mouth to the mile 5 marker. For each survey the following data were recorded:

- Date
- Beach section – Boca or Park
- Name of observers
- Mile section
- Number of lights visible from the beach
- Light source (if possible to determine)
- Location of light source (beach side or river side)

To avoid duplicate recording of the same light source in more than one 1/8 mile section of beach, only those lights that could be seen while viewed perpendicular from the beach were recorded in each 1/8 mile.

2.8.5 Hatchling orientation and disorientation

Hatchling orientation was determined for a sample of nests from which hatchling tracks were

observed. For each nest:

- Date
- Nest code (if it was a marked nests)
- Name of observers
- Mile section
- Distance from the nest to the most recent high tide line (m)
- Approximate number of tracks
- Number of outliers
- Number of 'circlers' – hatchlings that didn't go directly to the sea, that were maybe disorientated

In addition, at a distance of 10m from the nest, using a compass held at waist height about the nest, the following data were recorded:

- Angular range of all tracks (in°)
- Angular range of tracks minus any outliers (in°)
- Modal direction of tracks

Any evidence of hatchling disorientation was also recorded, for marked or unmarked nests. Where possible the light source causing the disorientation was noted.

2.9 Environmental Education Activities

Presentations about sea turtle biology, conservation and the work of the CCC in Tortuguero were given opportunistically to groups staying at or visiting the John H. Phipps Biological Station. In addition, the 2007 Green Turtle Program RAs implemented a series of environmental education activities at the Tortuguero school and high school, and also at the school in San Francisco village.

2.10 Independent Research Projects

2.10.1 Stable isotope study of adult green turtles

A PhD student at the University of Florida in Gainesville (Hannah Vander Zanden) collected tissue samples from adult female green turtles nesting at Tortuguero in 2007, for inclusion in a stable isotope analysis to help locate foraging grounds for this population. The ratio of naturally occurring isotopes in a sample can be used to determine the diet of an organism, or the area in which it is feeding. A sample of 100 females was included in the study; tissue samples were taken from the neck of the individual when she had completed oviposition, using a sterile 6mm biopsy punch. The samples were stored in alcohol until the end of the 2007 Green Turtle Program and then exported to the University of Florida under the restrictions of a CITES permit.

2.10.2 Determination of the level of multiple paternity in the Tortuguero green turtle population

During the 2007 Green Turtle Program a Masters student at the University of Copenhagen, Denmark (Alonzo Alfaro Nuñez) collected tissue samples from adult female and hatchling green turtles for inclusion in a genetic study to determine the level of multiple paternity within the Tortuguero nesting population. Multiple paternity is the existence of more than one father within a single clutch of eggs.

50 individuals encountered in a one mile stretch of beach (from the CCC field station to mile 1 4/8) were included in the study. This distance restriction was imposed due to the study protocol requiring that each nest be monitored every two hours at the end of the incubation period for signs of hatchling emergence, and thus there were physical constraints on the distance that could be effectively monitored so frequently. For each female observed prior to laying the nest was marked using the standard CCC

protocol, with the exception that an I-button data logger was placed in the nest to monitor the temperature during incubation. Once the female had finished oviposition a tissue sample was taken using a sterile scalpel. Each female was marked with a large 'X' on her carapace, using non-toxic white paint. This mark was to enable researchers to easily identify study individuals if they returned to nest later in the season, as one of the objectives of the study was to monitor consecutive nests from the same female.

Marked nests were monitored daily throughout the incubation period. At 50 days a wire mesh canister was placed over the site of the egg chamber; this was to retain hatchlings upon emergence for tissue sample collection. Once the canister had been positioned, and until emergence was observed or 65 days, the nest was monitored every two hours for signs of hatching, to ensure that hatchlings were not retained for extensive periods of time which could be detrimental to their survival.

When hatching was observed tissue samples were taken from a minimum of 50 hatchlings per nest. In addition the length and width of the carapace were recorded to the nearest millimeter. A measure of force for each hatchling (ie. crawling speed over a known distance) was also determined. Once the tissue sample and measurements had been taken, all hatchlings were released. The nest was then excavated, according to the CCC protocol, and the I-button data logger retrieved.

All tissue samples were stored in alcohol until the end of the 2007 Green Turtle Program and then exported to the University of Copenhagen under the restrictions of a CITES permit.

3. Results

3.1 Preparations

The RAs arrived in Tortuguero on 11 June, 2007. During the first two weeks of the 2007 Green Turtle Program the RAs received an intensive training program and general orientation. This included lectures about sea turtle biology and conservation, and a detailed explanation of the Green Turtle Program monitoring protocol. In addition to theoretical instruction they also received practical training in flipper tagging, nest marking and other data collection procedures from the FCs. Training patrols were conducted on several nights along sections of beach close to the field station (between the Tortuguero river mouth and mile 5), during which the FCs demonstrated field techniques and supervised RAs tagging and measuring turtles, and recording data in the field books.

During the first week of the program the mile markers on the beach between the Tortuguero river mouth and the mile 5 marker were replaced and/or repainted as necessary, to ensure that there were three markers at each 1/8 of a mile. These markers were put in the same locations as those positioned at the start of the 2007 Leatherback Program.

The RAs were given a tour of Tortuguero village and introduced to key members of the community, including the school directors and teachers. They were also presented to National Park staff at the Cuatro Esquinas ranger station, in order to facilitate cooperation during nightly beach patrols.

3.2 Track Surveys

3.2.1 Weekly track surveys

Thirty-nine weekly track surveys were conducted from January to December 2007; unfortunately data were lost for a 6-week period from 29 September - 17 November.

Nesting of green turtles was observed from March - November (See Figure 1), although false crawl emergences were seen as early as 17 February, and recorded until 8 December. Peak nesting was observed on 2 September when 2,193 nests were recorded in a single night (See Figure 1). Using the methodology of Troëng & Rankin (2005), it was estimated that 177,620 green turtle nests were laid during the 2007 nesting season (See Figure 2).

Green turtle nesting density was found to be highest away from the river mouths that mark the end of the beach, between miles 4 - 15, with the highest density occurring in the centre of the beach at mile 9 (See Figure 3). Nests laid between the Tortuguero river mouth and the mile 5 marker, where nightly beach patrols were regularly conducted, made up 21.0% of the nests laid on the entire beach (See Figure 3).

Between 28 April and 2 September the track surveyor reported a total of 12 green turtles that had been killed by jaguars the night before.

Very low levels of hawksbill nesting activity were recorded during the weekly track surveys in 2007; two hawksbill nests were observed (26 May and 14 July) and one false crawl was seen on 24 June.

Leatherback nesting activity was observed from mid-February to late June, with peak nesting occurring on 14 April when 12 nests were recorded. It was estimated that a total of 489 leatherback nests were laid in 2007 (See Figure 4). For a more detailed discussion of the temporal and spatial distribution of leatherback nesting in 2007, and levels of illegal take, see Nolasco *et al* (2008).

Figure 1. Temporal distribution of green turtle nesting at Tortuguero in 2007, as determined from weekly track surveys

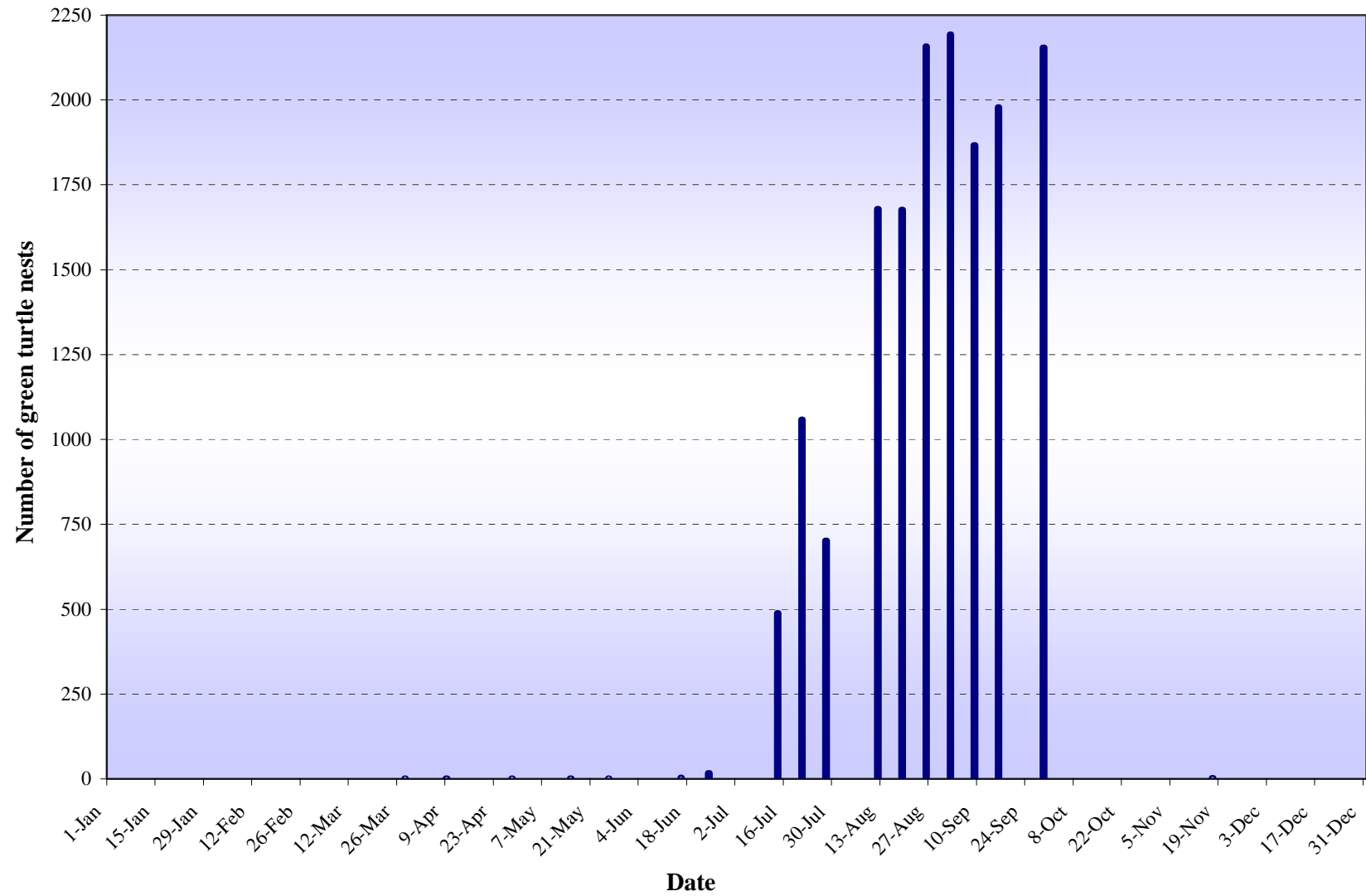


Figure 2. Green turtle nesting trend at Tortuguero, 1986 - 2007, as determined by weekly track surveys of the entire beach

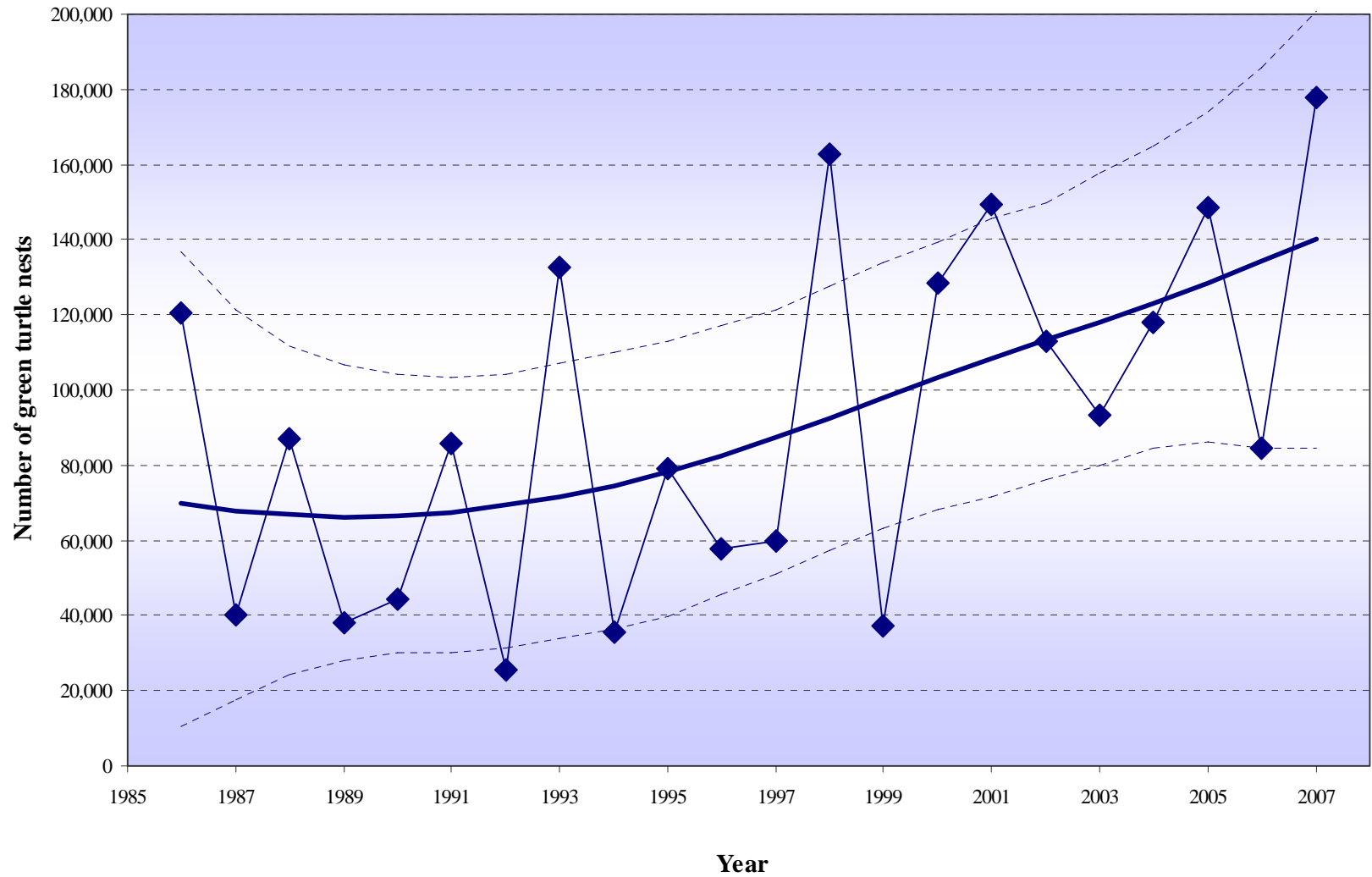
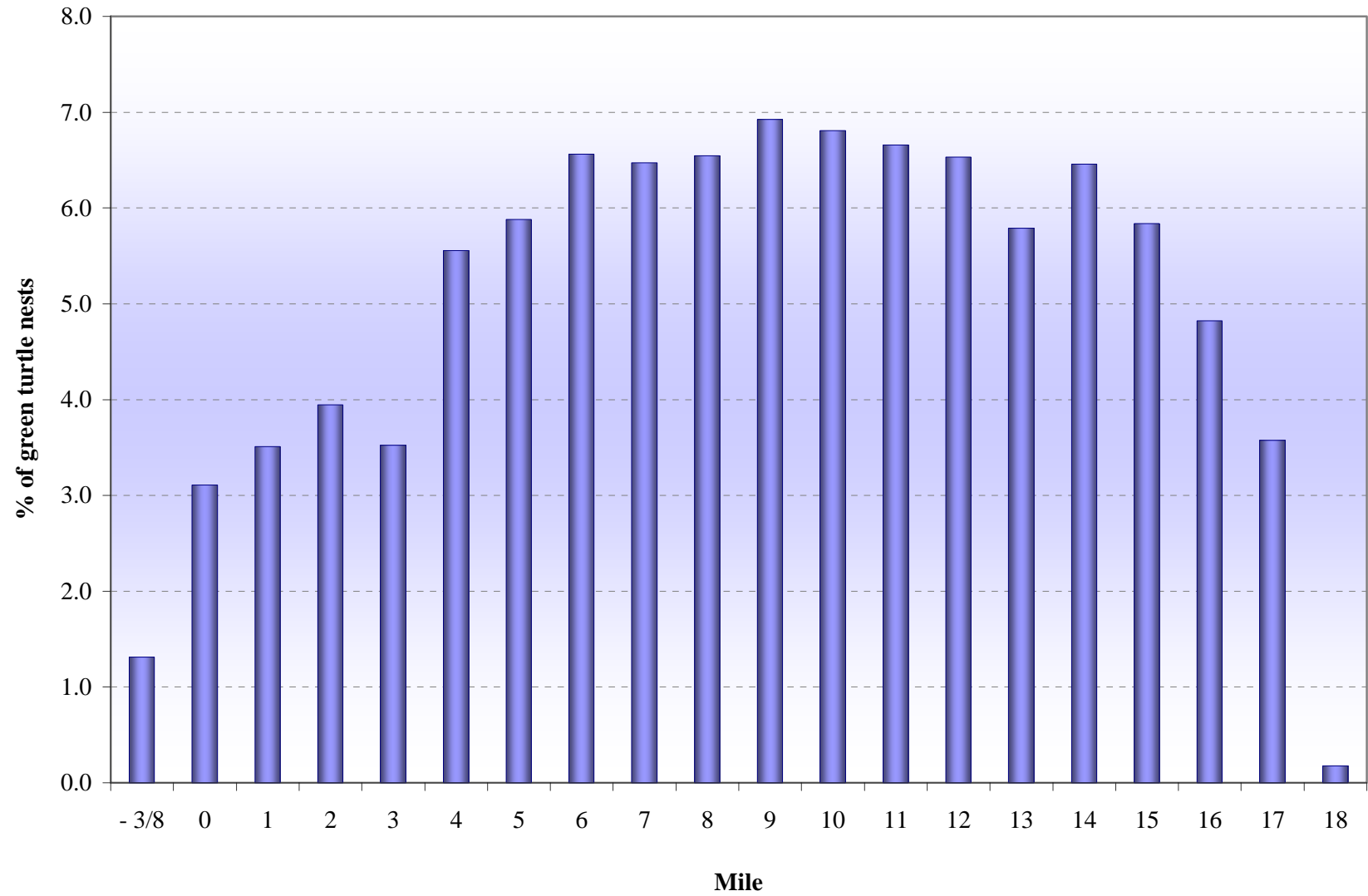


Figure 3. Spatial distribution of green turtle nesting at Tortuguero in 2007, as determined from weekly track surveys



3.2.2 Daily track surveys

Daily track surveys were conducted by the FCs and RAs between 13 June and 31 October (except for 12 October). A total of 24,499 green turtle nests and 23,234 green turtle false crawls were recorded between the Tortuguero river mouth and the mile 5 marker (See Figure 5); successful nesting was observed in 51.3% of female emergences.

Figure 5a shows the spatial distribution of nests and false crawls for the northern 5 2/8 miles of beach. Although nesting density per 1/8 mile was greater within the National Park (past 3 2/8) the overall number of nests recorded was almost equal outside and within the park (50.4% and 50.6%, respectively). As in previous years, nesting density was lowest close to the river mouth (close to mile - 3/8) and in front of Tortuguero village (miles 2 7/8 - 3 2/8).

The temporal distribution of nesting for the 2007 Green Turtle Program is shown in Figure 5b. Peak nesting activity was recorded on 9 September, when 601 green turtle nests were counted from the previous night. Nesting activity remained above 50 nests/night from 15 July - 23 October (except for 17 and 19 July, and 14 October, though more than 40 nests were recorded on these nights). Even towards the end of October more than 20 nests were observed each night.

Twelve leatherback nests and seven false crawls were counted during the same time period; the last nest was recorded on 5 July.

Hawksbill nesting activity was observed from June to October; a total of 15 nests and 2 false crawls were seen during track surveys. The last hawksbill nest was observed on 21 October.

One loggerhead track was recorded on 8 July; the female made a false crawl at mile 0, close to the river mouth.

During the daily track surveys researchers also noted the level of illegal take of both eggs and female turtles (See Figure 6). In total, 183 green turtle nests and 19 females were poached from June - October.

From 15 June – 31 October, poaching (of either nests or turtles) was observed during 71 of 141 (50.4%) track surveys (See Figure 6b). The highest number of poached nests was recorded on 31 July, when 14 green turtle nests were taken in one night. Highest poaching levels were observed during the months of peak nesting, from the end of July to mid-September (See Figure 6b).

In addition, 119 green turtle nests were recorded as depredated by dogs from June – October. Groups of dogs were often observed by researchers during track surveys, occasionally with more than 10 individuals. They tended to be found close to the village (from miles 2 6/8 – 3 2/8) though dogs were also seen north of the CCC station. In October concerned guides sent a letter to the National Park personnel regarding the situation of increasing dog predation of turtle nests; they requested that MINAE try to find a solution to the problem.

Figure 4. Leatherback nesting trend at Tortuguero, 1995 - 2007, as determined by weekly track surveys

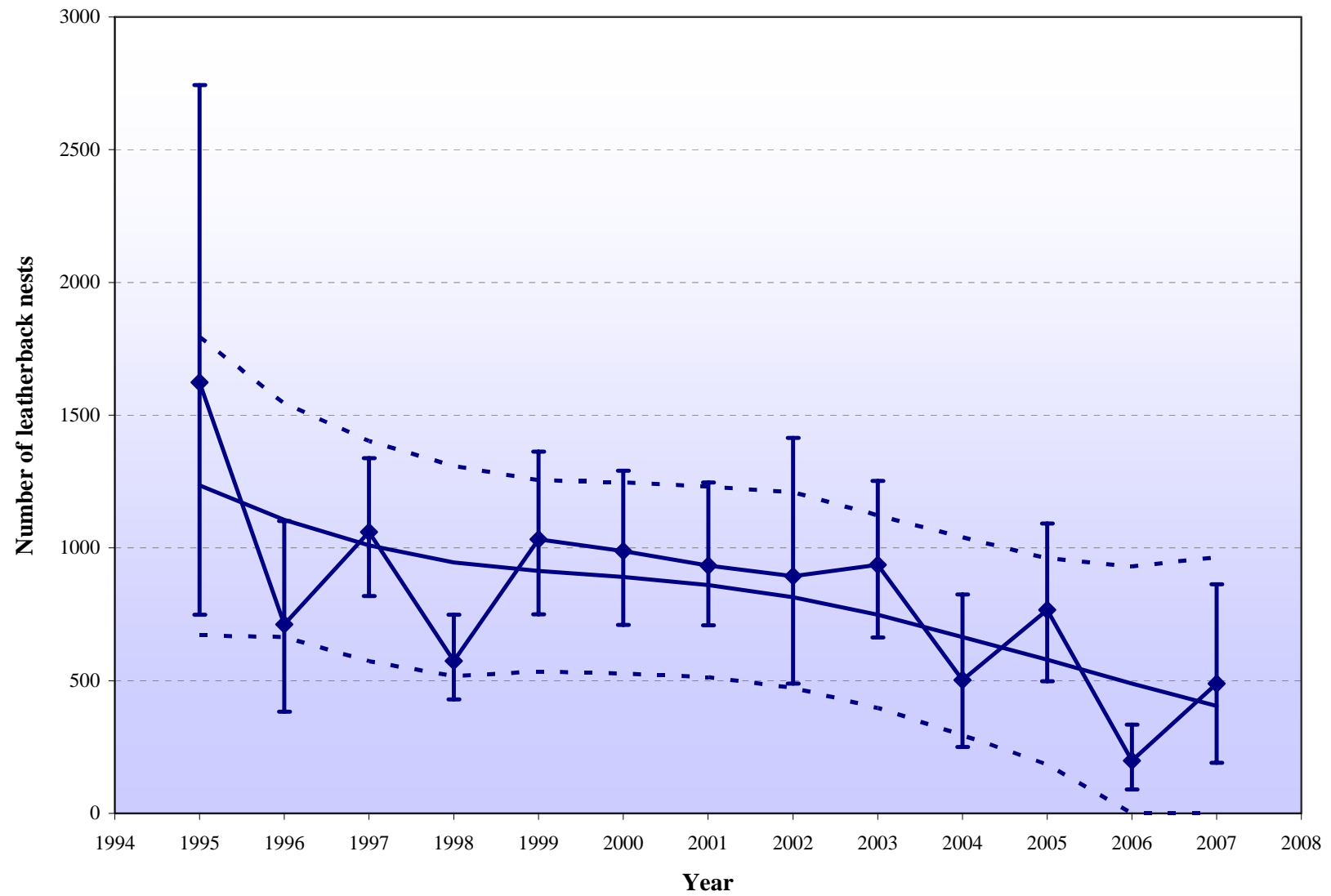
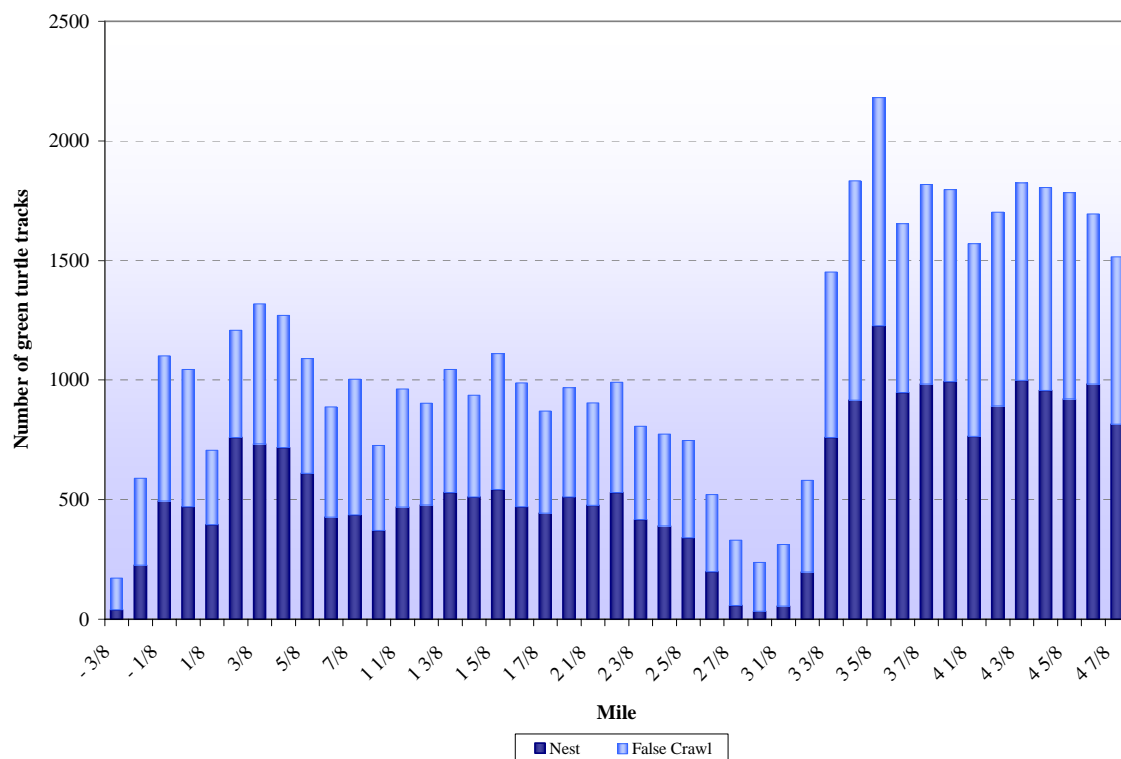


Figure 5. Results of daily track surveys of the northern 5 2/8 miles of beach in 2007

a) Spatial distribution



b) Temporal distribution

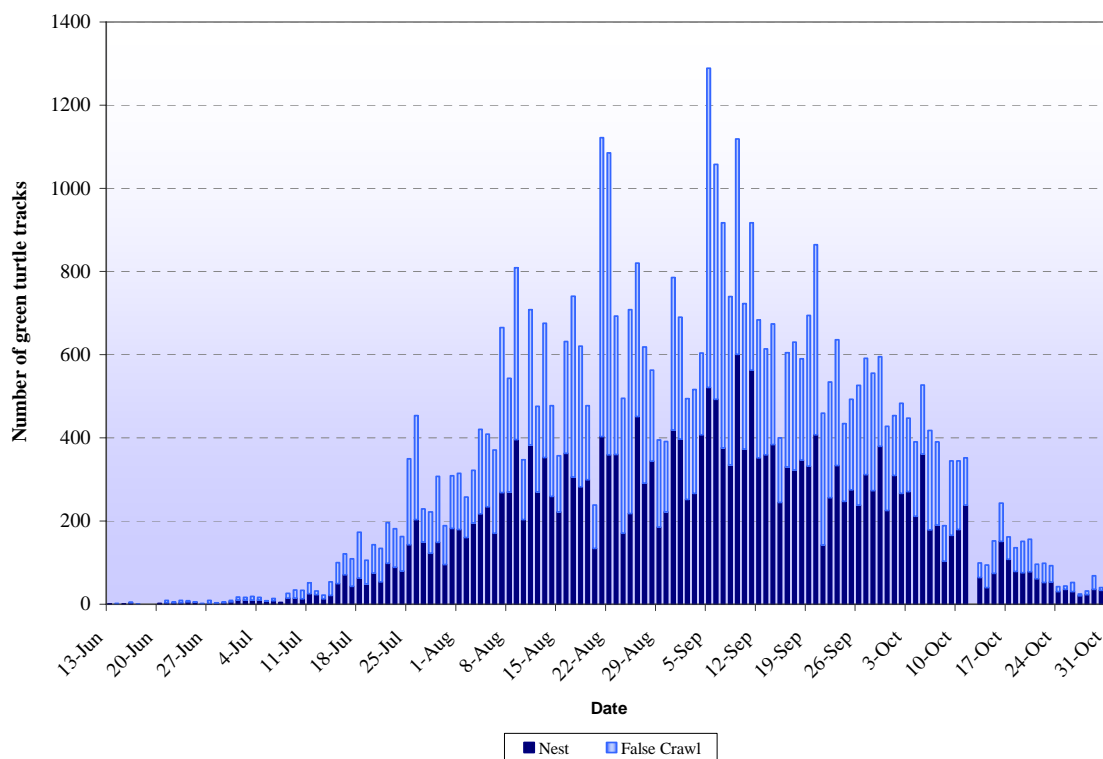
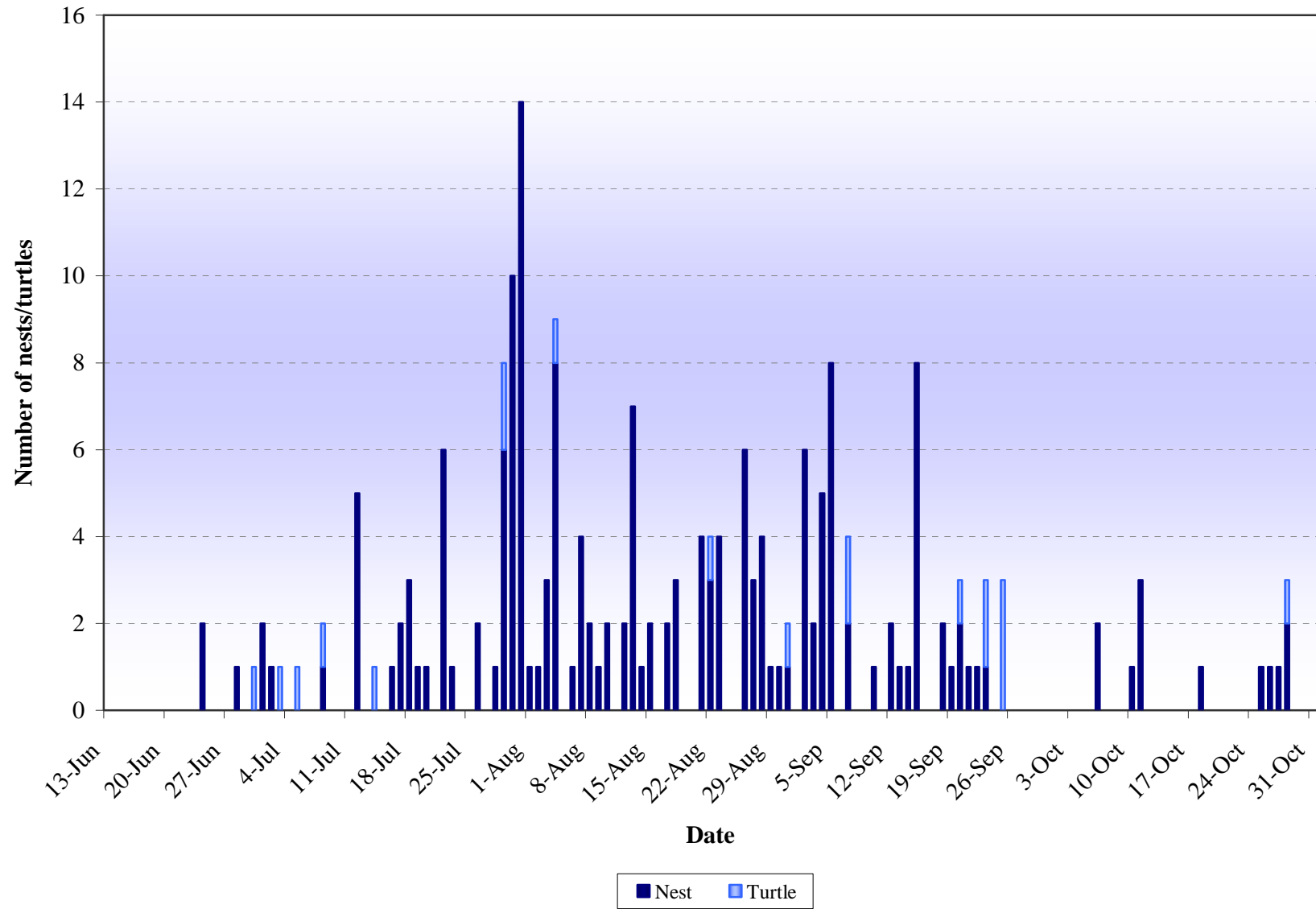


Figure 6. Temporal distribution of illegal take of green turtle nests and females in 2007, as determined from daily track surveys of the northern five miles of beach



3.3 Tagging of Nesting Sea Turtles

3.3.1 Green turtles

A total of 2,254 green turtle encounters were recorded during 1923 team hours of night patrols between 11 June and 30 October 2006 (See Appendix 1). These encounters involved 1,746 individual females; 1,077 (61.7%) initially observed without tags and 669 (38.3%) who had tags. In addition there were 508 encounters with turtles observed more than once during the 2007 nesting season.

During the 2007 Green Turtle Program, 21 green turtles tagged at other nesting beach projects in Costa Rica were encountered; 12 were tagged by researchers from the Caño Palma turtle monitoring project (which is based north of the Tortuguero river mouth), three were tagged in the Pacuare Nature Reserve and four were originally tagged in Mondonguillo, both of which are beaches south of Tortuguero National Park.

In addition one female was observed with tags that had originally been applied by Drs Anne and Peter Meylan, as part of their in-water research project in the Bocas del Toro province of Panama. The turtle was caught in nets off the Zapatilla Cays (in Bastimientos Island National Marine Park) in 1995. At that time she was a juvenile, measuring 76.8cm; when encountered in 2007 she measured 106cm. This is the first record for that project of a juvenile being encountered as a mature, reproductive adult on a nesting beach.

One turtle was encountered bearing tags that from the data base were in a sequence that had been distributed to Ascension Island during the 1997 nesting season. As this would be a significant record of movement between different nesting beaches, the Scientific Director contacted various biologists involved in the research project in Ascension Island to find more information about the history of the tag. Unfortunately, limited records are available, and no definitive answer was determined. It is more likely that the number was recorded incorrectly during the patrol, and that it was not originally used in Ascension Island, but was actually applied in Tortuguero.

The FCs also received a tag from the National Park guards that they had recovered from a green turtle that had been killed by a jaguar. The address on the reverse of the tag was from Cuba; the Scientific Director is still waiting for confirmation from Cuban turtle researchers as to where and when the tag was originally applied, and whether it was on a nesting beach or in a feeding ground.

Seventy-five green turtles that bore tags from Tortuguero were originally tagged more than 10 years previously. Two females were observed on 2 August (Id# 23897 and 24436), both of whom had first tagged in 1982; this is the longest nesting history record for the Tortuguero project. One of these females was observed 22 times during nine subsequent nesting seasons; the other was observed on 20 separate occasions during seven nesting seasons. In addition to these females there was one female with tags from 1984, and five individuals first tagged in 1986.

Of the other species observed during the 2007 Green Turtle Program, one of the hawksbill females was a remigrant; she was first tagged in Tortuguero in 2005. A leatherback encountered on 11 June had an unusual indentation in her central ridge; she was found to be a turtle that had been fitted with a satellite transmitter during the 2003 Leatherback Program. This was the first record of this female in Tortuguero since 2003, although she was observed nesting in Parismina in 2005; on that occasion she still had her harness and transmitter attached, although they were removed by research personnel. The indentation in the central ridge observed in 2007 is a healed scar from the harness. The turtle was thoroughly examined and had no other visible scars and she nested successfully on 11 June.

Of 1,077 newly tagged green turtles, 148 (13.7%) were recorded as having evidence of either old tag

holes or notches in at least one front flipper when encountered for the first time during the 2007 Green Turtle Program.

Tagging efficiency for green turtles emerging (nests and false crawls) between the Tortuguero river mouth and the mile 5 marker on nights before track surveys (n = 140) ranged from 0% to 100% (at the start of the season when few turtles were emerging), with an overall mean of 9.2%.

Green turtles encountered during night patrols nested in the open beach zone in 28.8% of cases (n = 650), 54.0% (n = 1,215) were located in the border zone, 8.6% (n = 193) in the vegetation zone and 1.5% (n = 34) had no zone recorded. 7.1% of turtles were encountered while making a false crawl (n = 161).

Of 221 turtles tagged with two tags and seen again during the 2007 Green Turtle Program, only 11 were reported to have lost one tag, resulting in an overall within-season probability of tag loss of 2.6%. Table 1a highlights the differences observed in tag loss between turtles tagged in different months; the highest tag loss was seen for turtles tagged in June (14.3%) and the lowest was observed for turtles tagged in October (0%), although the sample size was very small (n = 1). Tag loss was seen to decrease later in the season; August = 1.0% and September = 1.1%. There was also considerable variation in the probability of tag loss between researchers, ranging from 0% to 9% (See Table 1b).

Table 1. Probability of within-season tag loss from first-to-last encounter

a) By month

Month	r_{di}	r_{si}	1-K_i ± 95% CL
June	3	1	0.143 ± 0.283
July	59	7	0.056 ± 0.042
August	103	2	0.010 ± 0.014
September	44	1	0.011 ± 0.022
October	1	0	0 ± 0
Total	210	11	0.026 ± 0.016

b) By tagger

Tagger	r_{di}	r_{si}	1-K_i ± 95% CL
RA1	19	0	0 ± 0
RA2	18	0	0 ± 0
RA3	10	0	0 ± 0
FC1	10	0	0 ± 0
RA4	8	0	0 ± 0
RA5	6	0	0 ± 0
RA6	5	0	0 ± 0
RA7	5	0	0 ± 0
RA8	4	0	0 ± 0
RA9	3	0	0 ± 0
RA10	2	0	0 ± 0

Table 1. Continued

Tagger	r_{di}	r_{si}	1-K_i ± 95% CL
RA11	2	0	0 ± 0
RA12	1	0	0 ± 0
Mixed taggers 1	1	0	0 ± 0
Mixed taggers 2	1	0	0 ± 0
RA13	23	1	0.021 ± 0.043
RA14	29	2	0.033 ± 0.047
RA15	13	1	0.037 ± 0.074
RA16	10	1	0.048 ± 0.095
RA17	10	1	0.048 ± 0.095
FC2	14	2	0.067 ± 0.094
RA18	6	1	0.077 ± 0.153
RA19	10	2	0.091 ± 0.128
Total	210	11	0.026 ± 0.016

Key to table

FC = Field Coordinator

RA = Research Assistant

Mixed taggers = Two RAs tagged the same turtle

r_{di} = Number of green turtles encountered with two tagsr_{si} = Number of green turtles encountered with one tag1-K_i = Probability of tag loss

95% CL = 95% confidence limits

During the last month of night patrols (2 - 30 October) no new green turtles were tagged, however all females that were encountered were examined and a record was made of those that did not have tags (n = 611). These were turtles that could have potentially been tagged had the minimum sample of 1,000 tagged individuals not already been reached, and had more tags been available. This study was conducted to determine whether additional tags should be purchased for the 2008 Green Turtle Program.

3.3.2 Hawksbill turtles

Nine female hawksbill turtles were encountered during the 2007 Green Turtle Program; eight were newly tagged, and one was previously tagged in Tortuguero in 2005 (See Appendix 1). Of these nine individuals one was seen twice during the nesting season. Only one of the newly tagged hawksbill turtles (n = 8) showed evidence of previous tags.

For the 10 recorded hawksbill nests; three (30%) were laid in the open zone, six (60%) were laid in the border zone and one was laid in the vegetation zone (10%).

3.3.3 Leatherback turtles

A total of 11 leatherback encounters were recorded at the beginning of the 2007 Green Turtle Program; the last encounter was on 4 July. Six of the females were reneesters who had been observed during the 2007 Leatherback Program. The other five were remigrants; two had been originally tagged in Tortuguero, in 2000 and 2005; one was tagged at Caño Palma in 2007; one was first seen in

Mondonguillo in 2003 and the other had been tagged in Pacuare in 2005. All 11 turtles nested in the open zone.

3.3.4 Loggerhead turtles

One loggerhead female was observed on 7 July. The turtle was encountered during a false crawl emergence, and was tagged by researchers.

3.4 Biometric Data Collection

3.4.1 Green turtles

Table 2 shows the mean carapace length and clutch size of green turtle females measured during the 2007 Green Turtle Program. To ensure independence of the data, only the first measurements taken for each individual were included in the analysis. The overall mean curved carapace length (CCLmin) was 105.1cm (Range = 87.4 – 123.4cm) and the overall mean straight carapace length (SCLmax) was 99.0cm (Range = 81.1 – 117.0cm).

Newly tagged females without evidence of previous tags were slightly smaller than the mean length calculated for 2007, whilst newly tagged individuals and previously tagged females were, on average, slightly larger; this was true for both CCLmin and SCLmax measurement (See Table 2).

Clutch size ranged from 35 - 186 for all nests counted ($\bar{x} = 108$ eggs, $n = 123$). Newly tagged females (with or without evidence of tags) laid smaller clutches than previously tagged individuals (See Table 2).

Table 2. Mean carapace length and clutch size of green turtles

Sample	CCLmin / cm		SCLmax / cm		Clutch size / eggs	
	n	$\bar{x} \pm \text{S.D.}$	n	$\bar{x} \pm \text{S.D.}$	n	$\bar{x} \pm \text{S.D.}$
Newly tagged females – no OTH/OTN	904	104.6 \pm 4.7	862	98.6 \pm 4.5	15	101 \pm 28
Newly tagged females – OTH/OTN	134	106.0 \pm 5.0	134	99.9 \pm 4.7	72	106 \pm 24
Previously tagged females	610	105.6 \pm 4.7	585	99.4 \pm 4.3	36	114 \pm 25

OTH = Old tag hole, OTN = Old tag notch

For green turtles both CCLmin and SCLmax were measured with a greater degree of precision by research assistants than by participants (See Table 3a), although the range of precision values were similar for both groups. The two different carapace measurements taken during one encounter were equally precise (See Table 3a).

For females encountered and measured on two or more occasions during the 2007 Green Turtle Program, the SCLmax measurements had a higher level of precision than the CCLmin measurements (Table 3b), except for the one female that was observed five times. For both CCLmin and SCLmax measurements there were several occasions when the difference between the length measurements on subsequent encounters was greater than 5.0cm (See Range values in Table 3b).

Table 3. Precision of carapace measurements for green turtle females**a) During the same encounter**

Observer	CCLmin / cm			SCLmax / cm		
	n	$\bar{x} \pm \text{S.D.}$	Range	n	$\bar{x} \pm \text{S.D.}$	Range
Research assistants	1574	0.3 ± 0.2	0.0 – 1.7	1576	0.3 ± 0.2	0.0 – 1.4
Participants	566	0.4 ± 0.3	0.0 – 1.6	466	0.4 ± 0.2	0.0 – 1.4
Total	2140	0.3 ± 0.2	0.0 – 1.7	2042	0.3 ± 0.2	0.0 – 1.4

b) Between encounters

Encounters	CCLmin / cm			SCLmax / cm		
	n	$\bar{x} \pm \text{S.D.}$	Range	n	$\bar{x} \pm \text{S.D.}$	Range
2	291	1.1 ± 0.9	0.1 – 9.0	279	1.0 ± 1.0	0.1 – 10.0
3	70	1.5 ± 1.1	0.3 – 8.5	61	1.2 ± 0.9	0.4 – 6.7
4	8	1.4 ± 0.9	0.5 – 3.4	6	1.2 ± 0.4	0.8 – 1.8
5	1	1.6	N/A	1	2.5	N/A

3.4.2 Hawksbill turtles

Carapace measurements were taken for eight of the nine hawksbill females observed during the 2007 Green Turtle Program (See Table 4). CCLmin ranged from 85.8 - 95.3cm and SCLmax from 77.9 - 89.4cm. On average, newly tagged females were smaller than the previously tagged individuals encountered (See Table 4). Average size for the two clutches that were counted was 216.5 eggs.

Table 4. Mean carapace length of hawksbill females

Sample	CCLmin / cm		SCLmax / cm		Clutch size / eggs	
	n	$\bar{x} \pm \text{S.D.}$	n	$\bar{x} \pm \text{S.D.}$	n	$\bar{x} \pm \text{S.D.}$
Newly tagged females	7	90.5 ± 3.4	5	83.6 ± 4.3	2	216.5 ± 26.2
Previously tagged females	1	95.3	1	87.7	0	N/A

For hawksbill turtles, the precision of CCLmin measurements was the same as that of SCLmax measurements, $\bar{x} = 0.4\text{cm}$ (See Table 5). An inter-species comparison shows that the precision of both CCLmin and SCLmax measurements is slightly greater for green than for hawksbill turtles (Table 3a and Table 5).

Table 5. Precision of carapace measurements for hawksbill females

Sample	CCLmin / cm			SCLmax / cm		
	n	\bar{x}	Range	n	\bar{x}	Range
Females	8	0.4	0.1 – 0.7	6	0.4	0.1 – 1.4

3.4.3 Leatherback turtles

During the 2007 Green Turtle Program, 11 leatherback females were encountered. The mean carapace length (CCLmin) of these turtles was 154.0cm, with a range of 142.6 – 164.5cm (See Table 6). Two leatherback clutches were counted; with a mean of 63 eggs and 40 yolkless eggs. The precision of CCLmin measurements was 0.4cm, with a range of 0.1 – 0.8cm.

Table 6. Mean carapace length of leatherbacks

Sample	CCLmin / cm		Clutch size / eggs		
			n	Normal eggs	Yolkless eggs
	n	$\bar{x} \pm \text{S.D.}$		$\bar{x} \pm \text{S.D.}$	$\bar{x} \pm \text{S.D.}$
Females	5	154.0 \pm 7.2	2	63 \pm 22.6	40 \pm 12.7

3.4.4 Loggerhead turtles

The one loggerhead female had a CCLmin of 98.8cm and a SCLmax of 93.7cm. The precision of the SCLmax was greater than that of the CCLmin measurements; 0.3cm compared to 0.7cm, respectively.

3.5 Fibropapilloma Assessment

A total of 105 green turtles were subject to a thorough examination for the presence of fibropapilloma tumors; only 2 individuals (1.9%) were recorded to be affected. Two females were checked twice, and on both occasions recorded as having no tumors. One of the affected turtles was newly tagged (with no evidence of prior tagging) and the other was a remigrant tagged female. The tumors on these females were small and located on the front flippers and neck area.

In addition to the females who were checked specifically for the presence/absence of fibropapilloma, tumors were also recorded for another 18 individuals; these were observed during the routine check for physical abnormalities conducted for each turtle encountered. One female was encountered on two separate occasions, and tumors were recorded both times. Of these females, four were remigrants with tags and 14 were newly tagged individuals (two of whom showed evidence of having been previously tagged). Tumors ranged in size from 3 - 14cm, and in the majority of cases were located on the front flippers or the neck/shoulder area.

3.6 Determination of Nest Survivorship and Hatching Success

The mammal predators observed disturbing nests or taking hatchlings during the 2007 Green Turtle Program were domestic dogs (*Canis familiaris*) and humans (*Homo sapiens sapiens*).

The bird predators observed include black (*Coragyps atratus*) and turkey vultures (*Cathartes aura*) that were seen depredating eggs and hatchlings from nests that had been opened by other predators or nesting turtles. The vultures also depredated inactive hatchlings if they emerged during the day.

In addition, ghost crabs (*Ocypode quadrata*) were observed depredating hatchlings and fly larvae (*Megaselia scalaris*) were observed depredating eggs, pipped hatchlings and hatchlings in the nest.

3.6.1 Green turtles

A total of 125 green turtle nests were marked between 12 April and 1 October, 2007; one of which was marked during the 2007 Leatherback Program. Of these nests, on six occasions another turtle laid a

nest very close to the marked nest, so the excavation could not be conducted without disturbing the new nest; one nest was washed out, and the fate of eight nests could not be determined with certainty. These 15 nests were excluded from subsequent analysis, leaving a sample of 110 green turtle nests monitored from the date of oviposition until their fates could be determined.

Table 7 lists the fate of all of the green turtle nests marked in 2007. It can be seen that the majority of nests (76.4%) remained undisturbed during incubation ($n = 84$). Of those that were disturbed, nesting turtles partially destroyed 4.5% of nests while depredation accounted for 2.7% of disturbances. In addition, poaching resulted in the loss of a further seven nests (6.4%).

Table 7. Fate, hatching and emerging success of marked green turtle nests in 2007

Fate	Boca n	Park n	Total n	% of total	Hatching success (%)	Emerging success (%)
1. Undisturbed	48	36	84	76.4	83.0	73.7
2. Dug up by nesting turtle	2	3	5	4.5	78.9	77.6
3. Two nests together	0	2	2	1.8	69.9	67.5
4. Predated	2	1	3	2.7	49.8	47.6
5. Poached	3	4	7	6.4	0.0	0.0
6. Unhatched	2	7	9	8.2	0.0	0.0
Total	58	55	110	100	74.8	67.0

<i>Not included in analysis</i>			
Unknown	4	4	8
Another nest laid close	1	5	6
Washed out	0	1	1
Total	4	8	15

Data from the nest excavations of the 110 green turtle nests monitored through incubation are summarized in Table 8. Overall hatching success was calculated as 74.8% (7,938 shells from 10,610 eggs) and overall emerging success was estimated as 67.0% (7,107 hatchlings from 10,610 eggs) (See Tables 7). Average clutch size (determined from egg counts conducted at the time of oviposition) was 108.0 eggs ($n = 124$).

Of the 110 marked green turtle nests included in the analysis, the majority (63.6%) were deposited in the border ($n = 70$), 31.8% in the open zone ($n = 35$), and only five (4.6%) were laid in the vegetation zone. Disturbed nests (which includes those nests that were dug up by another turtle, were two nests together, predated or poached; $n = 17$) were more likely to be laid in the border zone than in the vegetation or open zones (64.7% compared to 5.9% and 29.4%, respectively). Unhatched nests were also more likely to have been laid in the border zone (55.6%, $n = 5$).

Table 8. Summary of excavation data for green turtle nests marked in 2007

Fate *	n	Hatchlings		Empty shells	Pipped eggs	Unhatched eggs			Depredated eggs	Destroyed eggs
		Live	Dead			No embryo	Embryo	Full embryo		
1	84	240	577	7,472	26	688	327	116	283	0
2	5	0	1	70	0	6	3	0	7	0
3	2	11	0	315	23	64	19	2	28	0
4	3	2	0	81	0	18	3	0	91	0
5	7	0	0	0	0	0	0	0	0	0
6	9	0	0	0	0	134	699	0	135	0
Total	110	253	578	7,938	49	910	1,051	118	544	0

* For fate code details see Table 7

A comparison between egg counts at the time of oviposition and at excavation for a sample of undisturbed nests (n = 83) shows a mean of 1.4 less eggs counted at the time of excavation than at the time of oviposition (range: -126 to +80 eggs, SD = 25.8 eggs).

The distance between the sand surface and the top eggshell at the time of excavation for undisturbed nests (n = 84) ranged between 14 and 115 cm with a mean of 59.5 cm. The distance between the sand surface and the bottom of the egg chamber varied between 40 and 125 cm with a mean of 77.9 cm.

The incubation period for undisturbed nests for which emerging was observed (n = 46) ranged from 50 to 65 days with a mean of 55 days.

Unhatched eggs that contained albino, twin, triplet and deformed embryos accounted for 0.17% of all eggs laid in undisturbed and disturbed nests that were excavated (See Table 9). Of the deformed embryos 11 were found in the same nest.

Table 9. Incidence of albinism, twins and deformed embryos in 2007

Type of abnormality	n	% of total
Albino	1	0.01
Twin/Triplet	0	0.0
Deformed embryo	17	0.16
Total	18	0.17

3.6.2 Hawksbill turtles

Seven hawksbill nests were marked between 23 May and 25 September 2007; one of these females was observed during the 2007 Leatherback Turtle Program. Three nests were undisturbed, one was dug up by another turtle, one was depredated by roots and one was poached. In addition, one nest was relocated at the time of oviposition as it was laid in an area thought to have a very high risk of it being poached. The results of the excavations of hawksbill nests are shown in Table 10.

Mean hatching and emerging success for undisturbed hawksbill nests (n = 3) was 38.7% and 36.7%, respectively (See Table 10). The nest that was relocated had a hatching success of 46.8% and an emerging success of 42.5%. Overall hatching success was 36.0% (209 empty shells from 580 eggs) and emerging success was 32.9% (191 hatchlings from 580 eggs).

Table 10. Summary of hawksbill nest excavations from 2007

Fate ¹	n	Empty shells	Hatchlings		Unhatched eggs			Pipped	Depredated	Hatching success %	Emerging Success %
			Live	Dead	No embryo	Embryo	Full embryo				
1	3	122	9	1	39	13	52	10	104	38.7	36.7
2	1	0	0	0	0	0	0	0	0	0	0
4	1	0	0	0	0	0	0	0	54 ²	0	0
5	1	0	0	0	0	0	0	0	0	0	0
10	1	87	2	6	2	4	58	0	35	46.8	42.5
Total	7	209	11	7	41	17	110	10	193	36.0	32.9

¹For fate code details see Table 7; 10 = Relocated nest

² Depredated by roots

The mean distance between the sand surface and the top eggshell at the time of excavation for undisturbed hawksbill nests ($n = 3$) was 45.7 cm (Range = 35 - 67 cm). The mean distance between the sand surface and the bottom of the egg chamber was 63.3 cm (Range = 55 - 75 cm).

3.6.3 Leatherback turtles

The hatching and emerging success of leatherback nests laid at Tortuguero in 2007 is discussed in detail in Nolasco *et al.* (2008).

3.7 Physical Data Collection

3.7.1 Rainfall

Rainfall was recorded daily from 6 March – 30 November, 2007, during the Leatherback and Green Turtle Programs (See Table 11). The driest month was September with a total of 168.2mm of rain recorded. In contrast, the end of the nesting season had the most rain, with 1,193.2mm recorded during November. The total amount of rain recorded at the station during the months with monitoring activities was 3,926.6mm; an average of 14.9mm per 24 hours. Average rainfall each month ranged from 5.8mm to 39.8mm per 24 hours (September and November, respectively). The highest rainfall recorded for a single 24 hour period was on 17 November, with 255.4mm; this was more than the total rainfall observed during the entire month for August, September or October.

Table 11. Summary of rainfall data – March to November, 2007

Month	Total rainfall mm/month	\bar{x} rainfall mm/24 hours
March ¹	313.6	12.5
April	436.0	14.5
May ²	360.2	12.9
June ³	414.9	14.3
July	607.8	19.6
August ⁴	186.0	6.4
September ⁵	168.2	5.8
October ⁶	246.7	8.2
November	1,193.2	39.8
Total	3,926.6	14.9

¹ Data from 6 March; Data for 48 hours 26-27 March

² Data for 48 hours 13-14 May and 22-23 May

³ Data for 48 hours 13-14 June

⁴ Data for 48 hours 1-2 August and 31 August-1 September

⁵ Data for 48 hours 30 September-1 October

⁶ Data for 48 hours 18-19 October

3.7.2 Air temperature

Mean monthly minimum and maximum temperatures for months when monitoring activities were conducted during 2007 (March – November) are shown in Table 12.

Table 12. Summary of air temperature data – March to November, 2007

Month	Mean minimum air temp / °C	Mean maximum air temp / °C
March ¹	23.2	27.6
April	24.2	27.9
May ²	23.7	27.8
June ³	24.2	28.1
July	23.1	28.0
August ⁴	23.5	28.8
September ⁵	23.6	28.2
October ⁶	23.5	28.4
November	22.8	26.4
Overall mean	23.5	27.9

¹ Data from 6 March; no data for 26 March

² No data for 13 or 22 May

³ No data for 13 June

⁴ No data for 1, 14, 15, 17, 18 or 31 August

⁵ No data for 30 September

⁶ No data for 2, 13 or 18 October

Recorded air temperature ranged between 20°C and 33°C during the period of monitoring activity. November was the coolest month, with the lowest mean minimum and maximum temperatures (22.8°C and 26.4°C, respectively); August had the highest mean maximum temperature (28.8°C). The daily variation in temperature ranged from 0 - 10°C, with an average of 4.4°C difference between the minimum and maximum temperature recorded over a 24 hour period.

3.7.3 Sand temperature

Mean sand temperatures recorded during the 2007 Green Turtle Program are shown in Table 13. Mean monthly sand temperatures ranged from 23.9 – 32.6°C between June and November. At all depths, temperatures were greater in the open zone and lower in the vegetation zone (See Table 13). The highest sand temperatures were recorded in the second half of August and the beginning of September (open zone), October (border zone) and June (vegetation zone). For all zones, and at all depths, the lowest sand temperatures were recorded in November (See Table 13).

Table 13. Mean monthly sand temperatures during the 2007 Green Turtle Program

Zone	Open			Border			Vegetation		
	\bar{x} temperature / °C			\bar{x} temperature / °C			\bar{x} temperature / °C		
Depth / cm	30	50	70	30	50	70	30	50	70
June	31.8	31.8	31.7	N/A	29.8	27.8	27.1	27.1	27.2
July	29.1	29.1	29.1	N/A	27.7	25.8	26.0	26.0	26.2
August – to 10/8 ¹	31.0	30.7	30.4	N/A	28.6	26.5	26.4	26.4	26.5

Table 13 Continued. Mean monthly sand temperatures during the 2007 Green Turtle Program

Zone	Open			Border			Vegetation		
	\bar{x} temperature / °C			\bar{x} temperature / °C			\bar{x} temperature / °C		
Depth / cm	30	50	70	30	50	70	30	50	70
August – from 10/8	32.6	32.3	31.8	29.4	29.6	27.4	26.7	26.7	26.9
September	32.4	32.3	32.0	29.8	29.8	27.6	26.8	26.8	27.1
October	32.1	32.1	31.9	30.2	30.4	28.0	26.5	26.7	27.0
November ²	26.8	26.8	26.9	25.8	26.0	23.9	24.5	24.5	24.8
Retrieval depth / cm 29 November	32	50	70	50	69	86	36	58	73
Overall mean	30.8	30.7	30.5	28.8	28.8	26.7	26.3	26.3	26.5

N/A = No data logger at that depth during that month

¹ No retrieval depths recorded on 10 August

² Data to 29 November

3.8 Collection of Human Impact Data

3.8.1 Visitors to Tortuguero

The number of visitors paying to enter the CCC Natural History and Visitor Center in Tortuguero is shown in Table 14. In 2007, visitation decreased by over 2,500 visitors from the number recorded in 2006, from 32,733 to 30,019. The pattern of visitation throughout the year was similar to that observed previously, with most visitors coming from January – March, with a sharp decline in May and June. The increase in visitation observed during July and August coincides with an increase in green turtle nesting; one of the major tourists attractions to the area.

Table 14. Number of visitors to the CCC Natural History and Visitors Center 2005 - 2007

Month	2005		2006		2007	
	Total	\bar{x} / day	Total	\bar{x} / day	Total	\bar{x} / day
January	2,503	81	3,061	99	3,842	124
February	3,662	131	3,996	143	3,812	136
March	3,841	124	4,395	142	3,455	111
April	2,390	80	3,020	101	2,904	97
May	1,187	38	1,601	52	1,238	40
June	1,605	54	2,022	67	1,705	57
July	2,593	84	3,610	117	3,007	97
August	3,001	97	3,272	106	2,951	95
September	1,509	50	1,697	57	1,149	38
October	1,335	43	1,338	43	1,298	42
November	2,344	78	2,043	68	2,055	69
December	2,352	76	2,678	86	2,603	84
Total	28,322	78	32,733	90	30,019	82

The mean number of visitors per day in 2007 ranged from 38 (September) to 136 (February), with an average of 82 visitors per day for the year, which was lower than that recorded for 2006. Only January and November had a higher daily visitation rate in 2007 than in 2006.

The number of people visiting Tortuguero National Park (TNP) rose in 2007, continuing the trend that has been observed over the last 10 years (See Table 10). It is interesting to note that this trend is observed both in the number of Costa Rican nationals and foreign tourists visiting the park. In 2007, data from the Tortuguero Conservation Area (ACTo) show that 116,751 tourists were registered as paying the entrance fee to the park; an increase in over 15,000 visitors from the number recorded in 2006. No visitors were recorded to Barra del Colorado Wildlife Refuge during 2007. In 2007, the entrance fees to TNP generated ₡299,368,70 (~US\$607,238) for MINAE; an increase of almost \$150,000 from 2006.

Table 15. Number of paying visitors to Tortuguero National Park, 1998 - 2007

Year	Tortuguero National Park			Barra del Colorado Wildlife Refuge Total visitors	TNP and BCWF Total fees raised
	CR visitors	Foreign visitors	Total visitors		
1998	4,284	12,550	16,834	23,256	₡23,990,280
1999	5,767	32,863	38,630	3,650	₡69,641,550
2000	5,543	36,354	41,897	2,639	₡71,409,282
2001	6,175	39,057	45,232	2,941	₡76,556,437
2002	5,745	44,594	50,339	3,999	₡98,495,745
2003	8,643	59,026	67,669	386	₡143,715,204
2004	9,545	71,912	81,457	190	₡178,313,657
2005	9,292	77,791	87,083	241	₡185,347,680
2006	21,257	80,087	101,344	109	₡239,924,070
2007	23,898	92,853	116,751	0	₡299,368,170

3.8.2 Capacity of hotels and cabinas

The number of hotel rooms available to tourists in Tortuguero actually showed a slight decrease in 2007, dropping from 658 rooms in 2006 to 645 in 2007 (See Table 16). This can be accounted for by some of the cabinas continuing to rent their rooms exclusively to locals, and so are not included in the calculation of rooms available to tourists.

Table 16. Room and bed capacity of the hotels and cabinas in the Tortuguero area

Hotel / Lodge	Rooms	Beds	Cabina	Rooms	Beds
Anhinga ¹	32	68	All Rankin Lodge	14	37
Evergreen	36	72	Aracari	14	*
Ilan-Ilan	24	60	Balcón del Mar	4	11
Jungle ²	48	84	Cabinas Evelyn ³		
Laguna	99	251	Caribbean Sunrise ⁴		
Manatus	12	24	Casa Marbella	6	12

Table 16. Room and bed capacity of the hotels and cabinas in the Tortuguero area

Hotel / Lodge	Rooms	Beds	Cabina	Rooms	Beds
Mawamba	58	139	La Casona	5	9
Pachira	88	176	Ella y Yo	4	8
Samoa	20	49	La Espiga de Oro ⁵		
Tortuga	26	60	Hostel el Icaco	14	35
Turtle Beach Lodge	43	86	Lapa Verde	10	20
Total – Hotel/Lodge	486	1,069	Meryscar	10	31
			Miss Miriam	6	18
			Miss Miriam #2	8	21
			Miss Junnie Hotel	12	35
			Princesa	8	24
			Princesa del Rio ⁶	9	*
			Princesa Resort ⁷	12	23
			Taylor's Place	3	5
			Tortuguero	11	21
			Tropical Lodge	9	20
			Total – Cabina	159	330⁸
			CCC ⁹	8	36
Total – 645 Rooms, 1,399 Beds⁸					

* Information not provided by cabina owner

¹ Formerly Tortuga Verde

² Closed in September for extensive renovations

³ Formerly Caribbean Dreams; Closed during 2007 for renovations

⁴ Formerly Cabinas Ever; Rented exclusively to locals

⁵ Rented exclusively to locals

⁶ Formerly Joruki; Partially closed due to renovations

⁷ Formerly Sabina

⁸ Minimum number as two cabinas did not provide information on the number of beds

⁹ Only available to CCC volunteer participants

The smaller cabinas in the village accounted for 24.7% of the overall room capacity, a decrease of 1.3% from 2006. Several of the lodges and cabinas changed names and/or owners during 2007; in addition, several hotels were undergoing renovations.

3.8.3 Turtle tours

Since 2005 the Turtle Spotter Program (TSP) has been implemented along the entire 5-mile stretch of beach (from Tortuguero river mouth to mile 5) where tourism is permitted by MINAE. In 2007 thirteen local turtle spotters were employed for the duration of the official green turtle nesting season (1 July – 31 October).

The number of visitors who participated in night-time turtle tours during 2007 is shown in Table 17. The 'Public Beach' is the northern 3 3/8 miles of beach from Tortuguero river mouth to the limit of

Tortuguero National Park, just south of the village of Tortuguero; this section of beach is divided into three sections for the TSP. The 'Park Beach' is the 1 5/8 miles of beach, from the limit of the National Park to mile 5, and is divided into two sections for the TSP. Visitors who participate in tours within the Park section of beach are required to have a National Park entrance ticket valid for that day.

Table 17. Number of visitors participating in turtle tours in 2007

Month	Public Beach # visitors	Park Beach # visitors	Total # visitors	\bar{x} visitors / night
January	N/A	N/A	N/A	N/A
February	N/A	N/A	N/A	N/A
March ¹	5	32	37	4 ²
April	98	586	684	23
May	360	217	577	19
June	749	800	1,549	52
July	7,313	4,125	11,438	369
August	9,642	5,874	15,516	501
September	5,641	1,555	7,196	240
October	4,409	1,146	5,555	179
November ³	328	185	513	64
December	N/A	N/A	N/A	N/A
Total	28,545	14,520	43,065	186⁵

Data from ACTo

N/A – No tours conducted during those months

¹ First permit issued 21 March

² Calculated for 10 days during which tours were conducted in March

³ Last permitted issued 8 November

⁴ Calculated for 8 days during which tours were conducted in November

⁵ Calculated from 21 March - 8 November

Over 43,000 visitors participated in turtle tours between 8 March and 21 November 2007 (See Table 17), continuing the increasing trend in visitation. Of those, almost twice as many went to the Public Beach (28, 545) as went to the Park Beach (14,520). As seen in other years, peak visitation occurred in August, when 15,516 visitors went on tours, with an average of 501 visitors per night during that month (See Table 17). An average of 186 visitors per night was recorded for 2007, but this number increased to 323 per night when limited to the official green turtle season (1 July – 31 October). The maximum number of tourists who participated in turtles tours on a single night was 682 on 13 August (Data from ACTo).

In contrast to previous years when TSP activities were funded by donations collected from local hotel and cabina owners, in 2007 a new initiative was introduced to raise money for the TSP in a more sustainable and self-sufficient manner.

To avoid the problems that were associated with the non-payment of voluntary contributions by the hotel/cabina owners that occurred from 2004 – 2006, at the end of the 2006 season the TSP Committee members, in association with the NGO ProParques, formulated a new concept to try and raise funds for the TSP from tourists participating in the turtle tours. Over the course of several months an

information brochure was designed (See Appendix 2); the idea was to offer this brochure to tourists in return for a donation to the TSP. Each brochure was bilingual, Spanish and English, and provided a brief history of the TSP in Tortuguero, and explained how the donation would be used to support TSP activities. Each brochure contained a sticker that tourists were encouraged to wear during their night-time tour, to demonstrate their support of the program.

It was hoped that sufficient funds could be raised to cover all of the expenditure associated with the TSP, including salaries, equipment and the production of promotional materials and merchandise. Additional income raised would be used to develop the TSP activities, improve the infrastructure associated with the program (such as the tourist waiting areas) and in the future support community projects in Tortuguero; with priority given to those projects related to conservation or natural resource protection within the National Park.

Following meetings in San Jose and Tortuguero prior to the start of the official green turtle season, during which the new funding initiative was unveiled to hotel owners, tour operators, tour guides and members of the community, the idea received overwhelming support, especially from the hotel owners who included the brochure in the package offered to tourists visiting Tortuguero during the nesting season. CCC was asked to administer the funds generated from the brochures and the sale of t-shirts.

Throughout the four months of the official green turtle season (1 July – 31 October) 39,705 tourists participated in turtle tours; of these 27,698 purchased a brochure, or 69.8% of all visitors. The brochures, additional donations, and the sale of t-shirts to the end of December 2007 raised a total of \$115,991. This amount completely covered the expenditure for the TSP during the entire season (\$53,136), which included all the salaries and benefits of the spotters, the purchase and maintenance of equipment, production of merchandise and all administration charges; leaving a surplus of \$62,855. Unfortunately, in October \$5,100 was stolen during the transfer of TSP funds from Tortuguero to San Jose; these funds were subsequently replaced by CCC.

At the beginning of 2008 it was decided that the first priority for the excess funds from 2007 was to construct two new tourist waiting areas for sectors 4 and 5 within the National Park; these had previously consisted of logs for the visitors to sit on, and offered no protection from inclement weather. In addition, the surplus funds were used to produce new brochures and t-shirts prior to the 2008 season, and to provide a cash buffer to cover program start-up expenses for the new season.

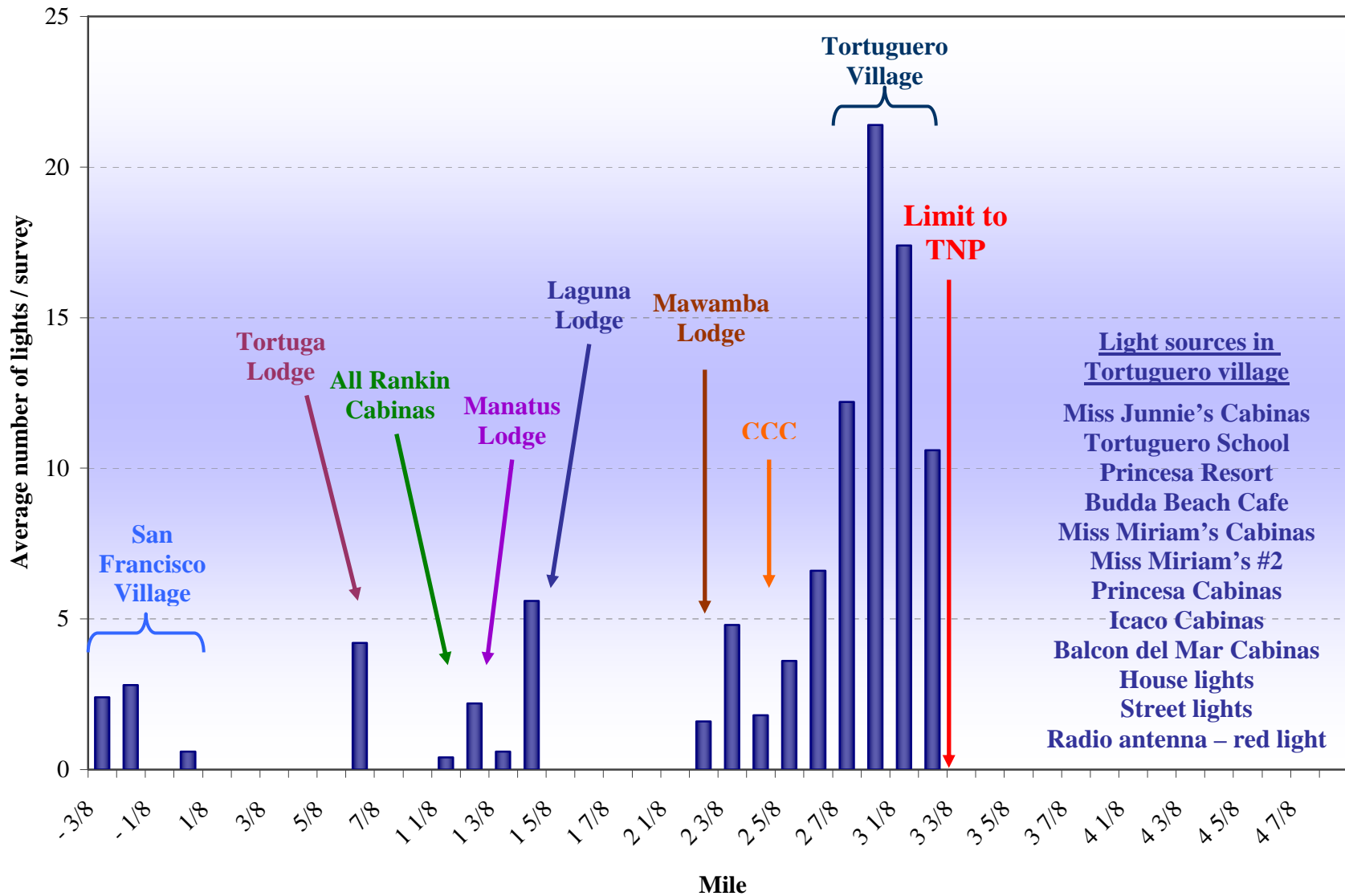
3.8.4 Artificial lights

Five light surveys were conducted during the 2007 Green Turtle Program, once a month from June to October. The results from these surveys are summarized in Figure 7.

Most of the lights visible on the beach were from buildings in Tortuguero village, between miles 2 6/8 - 3 3/8 (See Figure 7); these included cabinas, restaurants, houses, street lights and the school. In addition, clusters of lights were also visible from the lodges located north of the village. Unfortunately a couple of lights are still visible from within the CCC station. The brightest lights remain the tall street lamps, which in the past have occasionally been shaded by the electricity company.

The majority of lights were located on the beach side of the river, although those of houses and street lights in San Francisco, and of Tortuga and Manatus lodges, were also visible from the other side of the river. As can clearly be seen from Figure 7, there are no artificial lights in the National Park due to the absence of any buildings past mile 3 3/8.

Figure 7. Summary of monthly light surveys conducted during the 2007 Green Turtle Program



3.8.5 Hatchling orientation and disorientation

Turtle hatchling orientation results from the 2007 Green Turtle Program are summarized in Table 18. A total of 26 emergences were observed, 22 green turtle and four leatherback nests. On average, more hatchling tracks were recorded for green turtle nests than for leatherbacks (51 compared to 21 tracks per nest, respectively). The mean angular range when outliers were excluded was 34.7° for green turtle hatchlings and 17.0° for leatherbacks (See Table 18). When outliers were included in this calculation values were less disparate, though green turtle hatchlings were still, on average, more disperse than leatherbacks (50.4° compared to 43.0°, respectively).

Table 18. Turtle hatchling orientation

Species	n	No. hatchling tracks $\bar{x} \pm SD$	Angular range (°) $\bar{x} \pm SD$	Angular range including outliers (°) $\bar{x} \pm SD$
Green turtle	22	51 \pm 20	34.7 \pm 10.6	50.4 \pm 13.4
Leatherback	4	21 \pm 7	17.0 \pm 3.8	43.0 \pm 14.8

Twice during morning nest surveys in November evidence of disorientated green turtle hatchlings was recorded by researchers (See Table 19). On both occasions several hatchlings tracks were observed that did not go directly from the nest towards the sea, but which showed that the hatchling had wandered around on the beach for some time. On neither occasion were hatchlings found, either dead or alive, suggesting that they had presumably eventually reached the ocean.

Table 19. Hatchling disorientation

Date	Mile	Cause of disorientation	No. hatchlings disorientated	No. hatchlings found dead	No. hatchlings found alive
8 Nov	3 1/8	Village lights	5	0	0
24 Nov	2 3/8	Mawamba Lodge	3	0	0

3.9 Environmental Education Activities

Numerous environmental education activities were organized by the FCs and RAs during the 2007 Green Turtle Program. Over 150 students from the Tortuguero and San Francisco kindergarten, school and high school were involved in a variety of fun and educational events relating to turtle biology, the work of the CCC and the flora and fauna of the region. The following is a summary of the activities:

- In June third grade students from Tortuguero were given a presentation about how to identify the different sea turtle species found in Tortuguero; they took part in a competition to create a sand turtle out on the beach, using the information from the presentation.
- In August, approximately 20 students from the San Francisco school took part in an environmental ‘treasure hunt’. Several of the RAs and the FCs were dressed up as different animals or plants and positioned at various locations around the school grounds. Groups of students had a map, and visited each station; there they were given instruction on a task they had to perform, relating in some way to the animal/plant represented at the station. On successful completion of the task they received clues to the next location and a piece of a puzzle; once they had visited all the stations, and had performed all the tasks, they had to solve the puzzle. Each student who competed received

a small prize.

- 20 high school students took part in a discussion about the value of sea turtle conservation in Tortuguero; they received information in the form of a quiz incorporating different sectors involved in turtle conservation in the National Park.
- In October 30 students from San Francisco school, aged 8 - 12, took part in an activity aimed at raising their awareness about the different animals that exist in the National Park. A game of 'bingo' was designed which featured a variety of animals; during the game they were given interesting facts about each animal. They also received an explanation of the work performed by the CCC research groups on the beach at night, and had the chance to participate in a mock 'patrol' in the Visitor Centre, using the model display turtle.
- A group of 20 high school students conducted a beach clean-up activity in October; beforehand they were given a short presentation about the formation of a beach, its dynamics and the consequences of pollution for the beach ecosystem.
- During October the students from the Tortuguero and San Francisco kindergartens were invited to an "Afternoon of Environmental Education". The children were given a tour of the CCC Visitor Center, played several educational games aimed at teaching them about turtle biology and conservation, and learned how to use their different senses to respond to the natural environment.
- In November, two different groups of first grade students from Tortuguero school were given talks about the diet of different sea turtle species, and how they were each adapted to their prey items.
- A group of 14 second grade students from Tortuguero school visited the CCC Visitor Center in November; there they learned about the different threats (natural and artificial) that turtle nests face. They participated in a nest excavation with the FCs during which they were taught the importance of this data for the CCC. They gained hands-on experience in identifying unhatched and hatched eggs, and they were shown different developmental stages of embryos.

In addition to these activities the FCs also conducted two workshops during the 2007 Green Turtle Program. The first of these was the "Scientific Workshop on Sea Turtles and their Ecosystems" that was offered to students at the Tortuguero high school. The objective of the series of lectures and activities was to give the participants a more detailed understanding of sea turtles, especially those species nesting in Tortuguero. The idea was to focus on various themes, to provide the students with an in-depth awareness of the ecological role of turtles in various ecosystems, their behavior patterns, and strategies used in their conservation, to allow a better comprehension of the purpose of conserving these important species. A primary goal was to instill an interest in the younger generation in the natural environment, with a hope of producing future research assistants or conservationists in the region. Appendix 3 includes photographs of the students participating in the workshop activities.

- Three different sessions were conducted that included turtle migration, navigation, diving capabilities, threats on the nesting beach and at sea, and the ecological role of sea turtles in the marine ecosystem. Unfortunately scheduling difficulties curtailed the workshop, and so not all of the planned sessions were conducted.
- Sessions included a theoretical presentation followed by a practical activity that allowed for the interactive participation of the students.
- 36 students attended at least one of the sessions, although only six received the certificate for completing the entire course.

The second workshop was organized for the teachers at the school and high school in Tortuguero and San Francisco, at the request of the teaching staff to learn more about sea turtles and the research and conservation work of the CCC. The workshop was entitled "Pro² Tortugas – Profesores Protegiendo Las Tortugas" (Teachers Protecting Turtles). Photographs of some of the workshop participants are

included in Appendix 3.

- Four different theoretical sessions were conducted, with the aim of providing the teachers with a greater understanding of sea turtle biology, the monitoring protocol of the CCC, turtle conservation on the nesting beach at Tortuguero, the laws concerning sea turtles in Costa Rica and tourism related to turtles. In addition, participants were required to assist with several night patrols on the beach, to gain practical insight into the monitoring protocols of CCC, and to have hands-on experience with nesting turtles.
- 19 members of staff from the different educational institutions signed up for the workshop; of which 13 completed the required minimum of 50% of theoretical and practical sessions. Each received a certificate for their participation.

3.10 Independent Research Projects

3.10.1 Stable isotope study of adult green turtles

Tissue samples were collected from nesting female green turtles that were encountered between 4 May - 20 July; 96 viable samples were obtained from different individuals. As the protocol required samples from females recently arrived at the nesting beach, samples were also taken during the Leatherback Program, following the methodology provided by the student.

The student visited Tortuguero for two weeks in June to collect samples in the field and also process some of the samples previously obtained by the FC and RAs; this processing required the specialized drying of samples and their storage.

All samples were successfully shipped to the University of Florida in December 2007 and are currently being analyzed by the student.

In addition to the tissue samples from nesting females, the student also collected plant samples for analysis during a second field visit to Tortuguero in December 2007. These samples were also collected by permission from MINAE officials.

3.10.2 Determination of the level of multiple paternity in the Tortuguero green turtle population

Tissues samples from 41 nesting females were collected between 19 July - 9 September; they were all taken from individuals that nested in the one mile section of beach from the CCC field station to mile 1 4/8. Unfortunately no individual was observed on more than one occasion within the delineated study area and so there was no possibility to study more than one nest per female.

Logistical difficulties arose regarding the monitoring of nests, and so the student acquired an assistant to help ensure that regular surveys of the nests could be achieved throughout the day, to minimize the possibility of hatchlings emerging and remaining in the sun for extended periods of time.

A total of 559 were collected from hatchlings, from 14 different nests. The hatchling sampling protocol proved to be incredibly time-consuming and so was limited to a maximum of 50 individuals per nest, and the force measurement determination (crawling speed) was eliminated from the protocol. Problems were also encountered during the excavations, and several of the I-button data loggers were not retrieved from study nests.

All tissue samples were stored in alcohol until the end of the 2007 Green Turtle Program and successfully exported to Denmark in December 2007. The samples are currently being analyzed by the student and we are awaiting the final results of the study.

4. Discussion

4.1 Preparations

The RA training and orientation program provides a good introduction to all aspects of the monitoring protocol for which they will be responsible. The theoretical presentations are balanced with numerous practical sessions to gain familiarity with the equipment and the data collection methods used on the beach. Unfortunately at the start of the nesting season it can sometimes be difficult to encounter sufficient nesting turtles during practice night patrols to ensure that the FCs can oversee all the RAs performing all of the different tasks. This potential problem is overcome by the FCs continuing to monitor the RAs during the first few weeks of the program. For the RAs participating in the second group (from August - November) their arrival coincides with the peak nesting density, and so there are typically ample turtles nesting during the training weeks. It is suggested for future RA Programs that the entire second group of eight RAs be scheduled to arrive at one time, and not staggered as has been the practice in previous years; this should facilitate their training and an overlap of one week with the first group would permit research activities to continue uninterrupted during the training period. It is also recommended that the orientation not be limited to sea turtles and their conservation, but be expanded to include background information on the development of Tortuguero village (perhaps with a local resident talking to the RAs about their personal experiences); the formation of the National Park and a summary of the laws relating to sea turtles in Costa Rica (provided by National Park personnel); and a tour of the National Park to give them an awareness of the diversity of the local flora and fauna. Furthermore, throughout the Program, emphasis should be given to developing good group dynamics amongst the RAs, and activities should be organized to work on building a cohesive research team. This will help to reduce tension within the group as a result of a demanding work schedule in often adverse environmental conditions.

Fortunately the majority of the beach markers placed at the start of the 2007 Leatherback Program were still in excellent condition at the start of the 2007 Green Turtle Program and so the RAs were limited to replacing an occasional missing marker and repainting those still in place. GPS locations of all the markers were taken to facilitate their replacement in future years.

4.2 Track Surveys

4.2.1 Green Turtles

Green turtle nesting was observed from March to November although false crawl emergences were recorded in February and December; with peak nesting occurring in early September, when over 2,000 nests were observed in a single night (See Figure 1). Unfortunately several weeks of track survey data were lost (for the period from October to mid-November). This resulted due to a miscommunication between the track surveyor and the Scientific Director, when the field book in which the original data were recorded was accidentally discarded before the data had been transcribed. A new system for collecting the original data and transcribed sheets was established to prevent such a loss in the future.

The 2007 season showed an extremely high level of green turtle nesting, with over 170,000 nests estimated to have been laid. However, the missing data from the end of the nesting season might have artificially raised this estimate; a subsequent analysis incorporating typical data values for this missing time period gave a revised estimate closer to 132,500 nests. However, even this revised estimate indicates that the 2007 season was amongst one of the best recorded since the track surveys of the entire beach began in the mid-1980's.

The daily track surveys conducted between the Tortuguero river mouth and the mile 5 marker by the

FCs and the RAs required considerable efforts on part of the 2007 Green Turtle Program team. However, the results of these surveys provide essential data to help evaluate the effectiveness of the management actions aimed at reducing the impact of tourist visitation on nesting turtles. In addition, they provide a detailed record of the level of illegal take of nesting females and eggs during the green turtle nesting season in the northernmost five miles of beach. For these two important reasons it is strongly suggested that these surveys be continued in future programs.

It was interesting to note that in 2007 green turtle nesting between the Tortuguero river mouth and the mile 5 marker represented 21% of all nesting for this species between the river mouth and Jalova lagoon; in previous years this section had accounted for less than 15% of nesting. It is tempting to speculate that this could be a result of the improved supervision of tourists on the beach via the Turtle Spotter Program, leading to fewer turtles being disturbed by tour groups, which in turn leads to a lower proportion of false crawl emergences. However, further analysis of the data is necessary to support this hypothesis. The high levels of nesting density observed in the season might have contributed in part to the change in spatial distribution along the beach; from Figure 2 it can be seen that whilst the majority of nesting is still occurring in the centre of the park (beyond mile 5) the often observed distinct peak (typically centered around miles 8 - 12) is much more diffuse in 2007.

No illegal take of turtles or nests was reported during the weekly track surveys, which belies the fact that poaching of both females and eggs was observed during the daily track surveys of the northernmost five miles of beach. This would seem to indicate that more emphasis needs to be placed on the weekly track surveyor to ensure that attention is paid to detecting signs of illegal harvest of fresh nests or turtles. Results from the daily track surveys of the northernmost five miles revealed that illegal take of green turtles and nests occurred in this section of the beach throughout the 2007 Green Turtle Program (See Figure 6); 183 nests and 19 females were taken from June - November. The extent of poaching was lower than that observed in 2006, but a similar pattern of take was recorded, with a peak recorded in August, as nesting density increased. Unfortunately, despite providing information to National Park staff regarding the timing and location of poaching incidents, no park ranger patrols were observed during morning surveys or night patrols. While it is understood that MINAE has limited resources to complete all its protection functions within the National Park, it appeared that rangers were particularly underfunded during 2007. A priority for future years will be to try and secure funding for additional personnel during the nesting season, and to have them be assigned to the northernmost five miles of the beach, so that park rangers can focus on operations within the park limits.

One factor that compounded the exchange of information between CCC research teams and National Park staff was severe problems with the radio communication system in operation at the station. Repeatedly throughout the 2007 Green Turtle Program researchers were unable to report suspicious events to the authorities due to lack of reception at certain parts of the beach. At times the RAs commented a sense of insecurity while conducting research activities in isolated parts of the beach, especially when accompanied by volunteer participants. The safety and security of research personnel is paramount to the program and this issue should be addressed with the highest priority before the start of the 2008 programs.

The jaguars continue to kill nesting green turtles within the park, 12 green turtles were reported in 2007. Fortunately the number of individuals killed remains a very small percentage of the population, and so this predation does not pose a significant threat to the Tortuguero green turtles. The data from the weekly track surveys, however, provides a minimum estimate of the number of turtles predated by jaguars and it would be interesting to conduct further investigation to calculate more precisely the level of jaguar predation, and to determine temporal and spatial patterns of predation.

4.2.2 Hawksbill turtles

Whilst the weekly track surveys seemed to indicate that the decreasing trend in hawksbill nesting at Tortuguero seemed to continue throughout the 2007 season (with only two nests recorded), the daily track surveys of the northernmost five miles of beach suggested a more encouraging situation, with 15 nests observed between June and the end of October. The lack of hawksbill nests observed on the weekly surveys could be the result of the fact that during the peak of the nesting season it is likely that smaller hawksbill tracks will be 'lost' amongst the numerous green turtle tracks, especially in sections of the beach with highest nesting density. Furthermore, if a hawksbill female is encountered by a night patrol they will erase the track, and so the surveyor would not see signs of the nesting attempt.

Given the low nesting density of this species at Tortuguero it is important to stress to all research personnel the significance of guarding the female until she returns to the sea, and completely erasing the track to minimize the risk of poaching. Also, it is important to try and mark all hawksbills nest, to gain a better understanding of their survival rates and hatching success. In addition, it is proposed that this species is not shown to tourists, to allow research teams the opportunity to collect all the necessary data from each individual, and not allow any potential negative impacts that could result as a consequence of tourist visitation.

4.2.3 Leatherback turtles

Whilst a comprehensive discussion of leatherback nesting at Tortuguero in 2007 can be found in Nolasco *et al.* (2008), it is interesting to note that nesting during the 2007 leatherback season was at a higher density than that observed in 2006, although the trend would still appear to be decreasing. Considerable movement between nesting beaches along the Caribbean coast of Costa Rica and Panama has been documented, and it is vital to further develop data exchange between all the conservation and monitoring projects in the region to establish the true status of this globally important leatherback population.

4.3 Tagging of Nesting Sea Turtles

4.3.1 Green turtles

The goal of 1,000 newly tagged green turtles was successfully achieved in September 2007. As in previous years efforts were focused on the peak of the season, to ensure that 1,000 new females were tagged, and so very few new turtles were tagged at the end of the program. To determine the number of new turtles that could be tagged a survey was conducted throughout October to record the number of individuals encountered without tags during night patrols; 931 turtles were recorded. As the non-inclusion of these late nesting individuals might have an influence on the data gathered during the course of the season it is suggested to expand tagging efforts to include October in future years, which might involve the purchase of additional tags.

Large numbers of previously tagged green turtles ($n = 669$) were recorded during the night patrols in 2007. These individuals are very important for they allow the estimation of between season tag loss and annual survival probabilities. In 2007 it was encouraging to observe 75 females that had originally been tagged more than 10 years previously returning to nest again, indicating that they are surviving during their migrations to feeding grounds away from Tortuguero. Most interesting amongst these were two turtles that had first been tagged in 1982, 26 years previously; this is a new record for the longest nesting history for a green turtle at Tortuguero.

A small number of turtles ($n = 21$) were encountered that had been tagged at nesting beaches other than

Tortuguero; the majority were from Cano Palma (the research project just north of the Tortuguero river mouth) whilst the remainder were from nesting beaches in southern Costa Rica. Typically green turtles have strong site fidelity, and return to their natal beach to nest; what these encounters demonstrate is that there is some, albeit limited, movement between nesting beaches for this species. Such data emphasize the need for communication and data exchange between the projects working on turtle nesting beaches in the region, so that conservation efforts can be better organized to improve the survival of turtles at all sites they are utilizing throughout their life. With this goal, CCC needs to remain an active member of the National Marine Turtle Network in Costa Rica.

In addition to the turtles encountered with tags from other projects within Costa Rica, there were several other interesting tags discovered during 2007. One of the most significant was possibly the female with tags that had originally been applied by Drs Anne and Peter Meylan as part of their in-water project in Bocas del Toro, Panama. Data indicate that this turtle was tagged as a juvenile in 1995, and this encounter in Tortuguero provides the first record for their project of a turtle captured as a juvenile subsequently being encountered as a sexually mature female on a nesting beach. As such it stresses the need for international cooperation in turtle conservation initiatives, as it proves that at various stages of the turtle's life cycle there is movement between essential habitats in Panama and Costa Rica.

There was also a tag that was found by park rangers in a turtle that had been killed by a jaguar, which had an address from Cuba. Unfortunately despite several attempts to determine more details about when and where this turtle was originally tagged no information has been forthcoming from Cuban turtle researchers.

Another turtle had tags that from the data base were believed to have been distributed for use in Ascension Island during 1997. Once again, desperate attempts to determine the origin and history of this tag proved futile, due to the limited availability of tagging records from Ascension Island. This finding highlights several very important facts; 1) it is vital that researchers when encountering a turtle with tags take every care to ensure that they record the number accurately, and that for any 'unusual' number sequences they note the address on the back of the tag to aid in identification of the tagging project; 2) it is important to maintain detailed records of all tags issued to a project, and to list the fate of each tag (for example, if they were used for tagging practice, applied to a turtle, lost or destroyed); 3) tagging data provide a historical record for the project, and so there should be a single person dedicated to updating the database. Unfortunately for this particular tag, as no definitive answer was received from research personnel who had been connected with the tagging project in Ascension Island, the number could not be confirmed and so the data are effectively 'lost'; a more probable explanation is that the number of the tag was mis-read and that in fact it was from a series that had been used during a previous nesting season at Tortuguero. With effective training such errors can be minimized, with considerable care being taken to explain to all research personnel the importance of accurate data collection on the beach, especially during night patrols where there are many compounding factors to complicate the situation, such as poor visibility, extreme weather conditions or even extreme fatigue.

Overall within-season tag loss was low in 2007, at 2.6%. As is often observed, tag loss varied between researchers and declined towards the end of the program, when everyone had more experience; in August and September tag loss was around 1.0%. The low overall tag loss signifies that the RAs were receiving adequate training in tagging procedures during the first couple of weeks of the program; as stated previously, at the start of the season, when nesting density is very low, it is often difficult to conduct supervised tagging practice and as a matter of course the FCs should ensure that they are overseeing the work of the RAs until they feel confident to conduct patrols unsupervised. They should also continue to monitor the RAs throughout the program, to ensure that the monitoring protocols are

being followed and that data are being accurately collected. To assist in the accurate and effective tagging of turtles all equipment should be inspected and cleaned on a daily basis; any malfunctioning equipment should be replaced immediately.

Given that 2007 was a high nesting year, the tagging efficiency of the research teams working in the northernmost five miles of beach was high; on average they encountered 9.2% of all turtles emerging each night from June to October.

4.3.2 Hawksbill turtles

It was encouraging to observe that the trend for hawksbill encounters continues to increase, more hawksbills were encountered during patrols in 2007 than were observed in 2006 (11 compared to 9, respectively); accounting for 73% of all nests of this species recorded during track surveys for the same time period. Obviously, the number of hawksbills nesting at Tortuguero remains very low, but in spite of this a remigrant female was observed; she was originally tagged in Tortuguero in 2005. These returning individuals are vitally important to determine the survival probability of reproductive females. As has been suggested in previous years, all efforts should be made to try and increase encounters with nesting hawksbills, by increasing vigilance in areas where hawksbill tracks are observed 14 - 16 days after the initial sighting. Any hawksbill encounter will provide additional information about this species, and the nesting population in Tortuguero.

4.3.3 Leatherback turtles

Nolasco *et al.* (2008) includes a detailed review of the tagging of leatherback turtles at Tortuguero in 2007. However, it is worth noting that during the 2007 Green Turtle Program an interesting remigrant leatherback was encountered. This female was fitted with a satellite transmitter in 2003 and then was subsequently observed nesting in Parismina in 2005, with the harness still attached. The transmitter harness had caused some damage to her carapace and shoulders, which was described in detail in Troëng *et al.* (2006). In 2005 critics were quick to condemn the team responsible for attaching the harness, citing incorrect attachment procedures, but the return of this female in 2007 would seem to indicate that she has suffered no long-term negative effects from the transmitter attachment process. Indeed, her encounters since 2003 show that she has completed two entire migration cycles and returned to nest successfully in 2007 (the nest had an emerging success of 72.7%, which is considerably higher than average). Furthermore, the Scientific Director (who happened to be on the patrol in June when she was encountered, and who had also been part of the original transmitter deployment team in 2003) did a thorough visual inspection of the turtle once she observed the indentation on the central ridge which she believed could have been the result of a satellite transmitter; very careful attention was given to the areas where the transmitter harness lies (the shoulder and belly regions) and no other visible scarring was evident, indicating that the wounds observed in 2003 had completely healed.

4.3.3 Loggerhead turtles

Only one loggerhead turtle was encountered during the 2007 Green Turtle Program. This species is an incredibly infrequent visitor to the Tortuguero nesting beach; one individual was observed in 2001 and she was recorded again in 2004. The turtle encountered in 2007 was a different female, as she did not have tags. Researchers were incredibly lucky to observe this turtle as she was making a non-nesting emergence when she was found, and so they barely had time to tag her and collect biometric data before she returned to the sea.

4.4 Biometric Data Collection

4.4.1 Green turtles

The overall mean curved carapace length (CCLmin) was 105.1cm and the mean straight carapace length (SCLmax) was 99.1cm. Both these measurements are similar to those obtained for the Tortuguero green turtle population in recent years. As observed previously, newly tagged females without evidence of old tags were slightly smaller than those females with tags, or with evidence of having been previously tagged.

Research Assistants showed a greater degree of precision than volunteer participants for both CCLmin and SCLmax measurements, that would indicate that the training provided by the FCs at the start of the program was effective, although care should be taken to ensure that the volunteer participants are adequately supervised during the collection of carapace length data. Furthermore, there was considerable variability in the measurements taken for the same females that were seen on more than one occasion during the nesting season (up to 10cm difference), which would suggest that there is some individual differentiation as to the end points of the measurements, particularly for the curved length which is taken from where the carapace meets the skin. It is imperative during the practical training sessions that all RAs are taking the measurements from the same start/end points, to minimize the potential for erroneous data. As mentioned in previous years, a useful training tool for the RAs and volunteers participants might be a video with detailed explanation of the correct positioning of the tape measure and calipers for the carapace measurements.

For green turtles measured on two or more occasions, SCLmax had greater precision than the CCLmin measurements. SCLmax should remain the standard Tortuguero green turtle carapace measurement, although unfortunately researchers often have most difficulty learning how to take this measurement efficiently, especially if the turtle has started to camouflage the nest site and is moving around. It is very important therefore that if volunteer participants are taking this measurement that the RAs provide assistance and adequate supervision.

4.4.2 Hawksbill turtles

Carapace measurements obtained for hawksbill turtles during the 2007 Green Turtle Program were within the range observed in previous years, although in 2007 previously tagged females were slightly larger than newly tagged individuals, which was the reverse of what has been observed in the past.

The CCLmin and SCLmax measurements for hawksbills were both slightly less precise than for green turtles.

4.4.3 Leatherback turtles

Nolasco *et al.* (2008) contains information about biometric data collection from leatherback turtles nesting in Tortuguero during the 2007 Leatherback Program. For those individuals observed during the 2007 Green Turtle Program the mean carapace length (CCLmin) was slightly larger than that calculated for earlier in the season (154.0cm compared to 152.1cm, respectively), although the sample size was obviously much smaller. It would be interesting to analyze the size data to determine if there is any temporal variability in size of individuals arriving at different times during the nesting season.

4.4.3 Loggerhead turtles

The loggerhead female measured 98.8cm (CCLmin) and 93.7cm (SCLmax). The precision of the SCLmax was greater than that of the CCLmin measurements; 0.3cm compared to 0.7cm, respectively.

4.5 Fibropapilloma Assessment

Of the subsample of green turtle females examined for the presence of fibropapilloma tumors in 2007, only 1.9% was recorded as being affected. This is a considerable decline from the percentage of turtles that were recorded with tumors in 2006 (9.4%), though is in accordance to the low levels of this disease that has previously been observed in the Tortuguero population. Due to the high percentage of turtles recorded with fibropapilloma tumors in 2006, extra emphasis was given to the training of RAs in 2007 to ensure that they were able to correctly identify the disease and visually distinguish a fibropapilloma tumor from other skin lesions and growths that can be observed on turtles. It would appear, therefore, that the extremely high numbers of turtles recorded with fibropapilloma in 2006 could have been an overestimation of the prevalence of this disease due to mis-identification by research personnel.

Fibropapilloma is definitely present in the green turtle population nesting in Tortuguero, and individuals with large tumors have been observed (growths up to 14cm in diameter were seen in 2007). It is important therefore to continue to monitor the presence of this disease in future programs, and to pay particular attention to the training of RAs in its identification, so that any real increase in its prevalence can be monitored immediately.

4.6 Determination of Nest Survivorship and Hatching Success

4.6.1 Green turtles

Only 125 green turtle nests were marked during the 2007 Green Turtle Program, considerably less than in 2006. However, of these 110 were monitored on a daily basis and the fate of the nest was accurately determined upon excavation. Over 75% of nests were undisturbed during the incubation period; poaching however accounted for the loss of 6.4% of all marked nests, signifying that there is still a problem with illegal take even within the limits of the National Park. Predation, primarily by dogs, resulted in the destruction of 2.7% of the marked nests. This problem has been seen to increase in recent years with the explosion in the population of dogs within the community of Tortuguero. Frequently during morning track surveys the research patrols would report seeing large groups of dogs on the beach. Unfortunately, the majority of these dogs have owners, but they are not acting in a responsible manner and so allow their animals to roam freely throughout the village and onto the beach, where they can easily cause damage to turtle nests. Dogs seemed to target nests that contained hatchlings within the nest chamber, just prior to their emergence. It is possible that when the hatchlings break the egg they release a fluid into the sand that might be attracting the dogs to the nest, for it seemed that dogs were not necessarily digging up fresh nests, as might have been expected from evidence of natural predators of turtle nests.

Overall hatching success of marked nests was 74.8% and emerging success was 67%; this is considerably lower than that observed in 2006 (which was over 80%), but within the range calculated in recent years. While the hatching success rate was quite high it would appear that a considerable number of hatchlings were dying within the nest chamber during the few days that they remain within the nest once they have hatched from the egg. It is possible that adverse tidal conditions or excessive rain could have caused the nest chambers to be flooded, or that predators such as crabs were responsible for the death of hatchlings within the nest. There was no increase in the number of deformed hatchlings found during excavations, which might have offered an explanation to the increase in the number of dead hatchlings found in the nest chamber, due to their physical inability to emerge from the nest. It will be interesting to observe in future years the changes in the hatching and emerging success of green turtle nests, to see if any trends emerge.

It was found that nests laid in the border zone (those in which there was partial shading during the day from surrounding vegetation) were more likely to be disturbed (either by another turtle or predators) than those nests laid in the open or vegetation zones. Also the majority of unhatched nests were found to have been laid in this zone.

Daily monitoring of marked nests is vital, to ensure that all incidents of disturbance (either natural or artificial) can be immediately recorded. In 2007 the FCs and RAs were able to determine accurately the fate of the majority of marked nests; only eight nests were classified as unknown of the 125 originally marked. For future programs it is important to try and mark and monitor as many nests as possible throughout the season, so that any trends in hatching and emerging success can be identified.

There was a sharp rise in the frequency with which albino, twin and deformed embryos were encountered during nest excavations in 2007. Most importantly the proportion of deformed embryos, those with cranial, carapace or limb malformations, increased dramatically from levels observed in previous programs. In 2007, 0.16% of embryos showed a deformation, compared to just 0.03% in 2006 and 0.07% in 2005. This is a very worrying trend, as such deformities might be caused by the presence of toxic compounds in the sand or be the result of genetic malformation resulting from chemicals ingested by the female turtle; either scenario represents a degradation of a vital sea turtle habitat. This is an area of potential future study at Tortuguero, to ascertain whether potentially toxic compounds are present in the sand, and if so, at what levels. If it were possible to identify the compound and so ascertain its origin, it would allow for its potential control to limit further negative impacts on nesting turtles and their hatchlings.

4.6.2 Hawksbill turtles

Hatching and emerging success of the hawksbill nests marked during the 2007 Green Turtle Program was much lower than that typically observed for this species in Tortuguero (36% and 32.9%, respectively). Of the seven nests that were marked only three were undisturbed; one was poached (despite efforts by the research team to disguise the nest site and erase the tracks), one was dug up by another turtle and another was invaded by roots. Of the undisturbed nests, one showed signs of predation within the nest chamber (from either crabs or ants). It is discouraging to observe such a low success rate for this critically endangered species which is nesting at a very low density at this beach. All attempts to improve the survival of hawksbill nests should be taken, and daily monitoring should pay particular attention to marked nests of this species.

In 2007 one hawksbill nest was relocated at the time of laying due to pressure placed on research personnel by several tour guides that were present. The guides were concerned that the location of the nest (in front of the village) significantly increased its chances of being poached, and so they wanted to do something to improve its chances of remaining undisturbed. While the relocation of nests is not condoned, as it is not within the CCC monitoring protocol or stipulated in the investigation permit, in this instance the researcher took the decision to perform the relocation (having had experience of the procedure) as they were under the assumption that the guides were going to relocate the nest (without experience), and so they could at least minimize the risks to the eggs by moving them in the correct manner. The relocated nest was marked and monitored throughout the incubation period; excavation revealed it to have had a hatching success of 46.8% and an emerging success of 42.5% (higher than the *in situ* nests). The subject of nest relocation is always contentious, and it should be discussed prior to the start of the 2008 nesting season with the relevant authorities in Tortuguero and the tour guide association, to come to an accord between all interested parties.

4.6.3 Leatherback turtles

A discussion of leatherback nest survivorship and hatching success in Tortuguero during 2007 can be found in Nolasco *et al.* (2008).

4.7 Physical Data Collection

4.7.1 Rainfall

Rainfall patterns throughout 2007 were quite typical for Tortuguero, with increased rainfall in June, and July. August, which is often a month with high rainfall, was exceptionally dry as was September and October. As in previous years, heavy rains were recorded in November, which is typically the end of the nesting season but the peak of hatching for green turtles. The continuation of the collection of physical data as part of the CCC monitoring protocol is essential to evaluate changes in environmental conditions in Tortuguero that could arise due to global climatic changes. As such the possible negative impacts on nesting turtles in the area could be assessed and potential management strategies developed to deal with changing nesting habitats. One obvious impact that could result from changing rainfall patterns during the nesting season would be a change in sand temperature; this in turn could have significant impact on the sex ratio of hatchlings being produced in Tortuguero. As such the historical baseline data that CCC has been collecting could prove invaluable to sea turtle conservationists in the region facing the inevitable threats of climate change in the Caribbean.

4.7.2 Air temperature

Given the pattern of rainfall observed at Tortuguero in 2007, the air temperature data were not surprising; August (one of the driest months) had correspondingly high temperatures. The overall range in air temperature was 20°C - 33°C, although the average difference between minimum and maximum temperatures over a 24 hour period was 4.4°C. It was interesting to note that despite high rainfall in June and July, the mean maximum temperature remained above 28°C. As for the rainfall data, the air temperature data that have been recorded over the last 10 years at Tortuguero can provide valuable information on emerging temperature trends in the region.

4.7.3 Sand temperature

Fortunately the data loggers 'stolen' in 2006 were replaced during 2007; only one was missing for the first six months of the year; this permitted a more comprehensive collection of data regarding sand temperature in all three zones of the beach, and at different depths relating to the three species nesting at Tortuguero.

As mentioned above, sand temperatures will be influenced by the level of rainfall, and so the precipitation experienced in 2007 will have likely had a direct effect on the sand temperature. Throughout August, September and October temperatures above 30°C were recorded in the open zone; a similar increase in temperature was also observed in the border zone, though only in October were temperatures above 30°C recorded. Sand temperature in the vegetation zone remained relatively stable throughout the months of the program. These data highlight the importance of the beach vegetation in providing shading for turtle nests, to ensure that the eggs are not subject to lethal temperatures which can cause embryonic death. Fortunately, the majority of the nesting beach in Tortuguero is protected by a buffer of vegetation, which not only helps to provide valuable shading and so helps control excess temperature within the nest, but this vegetation also provides shading from artificial lights behind the nesting beach.

The high sand temperatures observed during the peak of the green turtle nesting season would suggest that, as observed in previous years, if the data are related to the sex ratio of hatchlings incubated at these temperatures, then the majority of green turtle hatchlings produced at Tortuguero in 2007 were likely to be female.

And, as for the monitoring of rainfall and air temperature, the collection of data on sand temperatures from the Tortuguero nesting beach is an important component of the protocol, and should continue in future programs. That the green turtle nesting population at Tortuguero is one of the most important globally, and is definitively the largest in the Caribbean basin; the effect of any changes in sex ratios as a result of changes in sand temperatures will have considerable implications for the survival of this species on a regional scale.

4.8 Collection of Human Impact Data

4.8.1 Visitors to Tortuguero

There was a decline in tourist visitation at the CCC Visitor Center in 2007; over 2,500 fewer visitors were recorded. As has been suggested in previous years it is increasingly evident that the Visitor Center needs an extensive overhaul; a new information video needs to be produced, to incorporate changes in the CCC research and conservation activities. There is also the need for new displays, such as an examination of the development of the community of Tortuguero and its role in turtle conservation, or an introduction to some of the environmental issues facing Tortuguero National Park, such as solid waste management. In addition, a review of the range and type of merchandise offered in the gift shop is important, to ensure that tourists can select from a choice of products that are unique, of high quality, made from environmentally sustainable materials and that are, preferably, locally or at least nationally manufactured. These changes will help ensure that the Visitor Centre will be able to fulfill its dual function as an environmental education center for the community and visitors to Tortuguero, and as a potentially important source of income for CCC. In the future priority should be given to securing funds to facilitate these necessary improvements.

In contrast, the number of visitors paying the entrance fee to Tortuguero National Park increased once again in 2007, continuing the trend observed for many years; over 15,000 more visitors were recorded than in 2006. It was interesting to note that this increase in visitation was true for both foreign and national visitors. From park entrance fees alone MINAE generated over \$600,000 in 2007; it is unfortunate that all of this money cannot be given directly to TNP in order to fund personnel and to purchase necessary equipment that would ensure that the park could be adequately protected. CCC maintains a close relationship with TNP staff and should continue to support them, and also search for possible funding sources that would allow additional rangers to be contracted to specifically focus on the protection of turtles and nests during the nesting season.

4.8.2 Capacity of hotels and cabinas

2007 saw a slight decline in the capacity of the hotels and cabinas in Tortuguero; although there were still almost 1,400 beds available to tourists in the small village cabinas and the larger lodges along the canals. Some of the cabinas continue to rent exclusively to locals, and there has been no expansion at the lodges, although a new lodge was under construction at the end of 2007. CCC should continue to monitor the growth of development in Tortuguero, with specific focus on the potential negative impacts of tourist activities on not just sea turtles but all the flora and fauna of TNP.

4.8.3 Turtle tours

2007 saw another increase in the number of visitors to Tortuguero who participated in turtle tours;

43,065 compared to 35,662 in 2006. With tourism on the beach regulated by the Turtle Spotter Program, there are reduced risks of turtles being disturbed by tour groups. However, it is extremely worrying that MINAE does not appear to have set a carrying capacity limit for the beach, ie. a maximum number of people who can participate in tours per night. This is surprising as all other tourist activities within TNP are conducted within such limits; for example, there are limits to the number of boats that can enter a canal at a given time, or the number of people who can be walking on a trail. Prior to the implementation of the TSP there was a limit of 400 tourists per night on the beach, and one of the justifications of the new system was that there was potential for this number to be increased. However, since 2004 no new maximum limit has been discussed or implemented, and if the 2007 season is any indication, no limits will be imposed on the guides. Given that the average number of tourists per night was over 500 in August, reaching up to 682 people, there is an urgent need for some kind of limits to be set to ensure that the positive benefits of the TSP (reduced impacts of tourism) are not negated by the sheer numbers of people on the beach, resulting in a lack of control. On several occasions during the 2007 season CCC research groups witnessed more than 50 people around a single turtle; something was supposed to have been eliminated by the TSP. Whilst the TSP has shown many benefits, not least in minimizing impacts on nesting females, there are still areas in which its activities can be improved. A priority for 2008 will be to set a feasible carrying capacity for the beach. It would be very interesting to conduct research projects looking at different impacts of tourism on turtles, such as changes in nesting behavior in the presence of tourists, or differential hatching success as a result of sand compaction caused by people walking over the nest. Data from such studies might provide sufficient evidence to warrant the implementation of stricter controls over how many people are permitted on the beach per night. CCC has the responsibility to protect the sea turtles nesting in Tortuguero, while at the same time permitting manageable tourist activities.

The new funding system for the TSP was incredibly success; more than \$100,000 were raised through the brochure/sticker sales. This money was more than sufficient to cover all of the TSP expenses from July - October, and it was the first year in which the TSP could be continued until the end of the official green turtle season (31 October). The collaboration of the larger lodges was key to this success, and it was disappointing to observe that there was minimal participation on the part of the local guides. In future years there should be a concerted effort to try and improve the percentage of tourists who are purchasing the sticker. It will be necessary to conduct a widespread awareness campaign of the importance of the TSP, and how money from the brochure/sticker will go directly to support the program. The surplus funds will be used initially to consolidate the program, by improving infrastructure and contracting additional personnel (such as a coordinator of the spotters). Ultimately it is hoped that additional funds will be used to support TNP and community-based projects, by way of a grants program. The success of this funding system should be disseminated as widely as possible, it should be viewed as a model for other turtle nesting beaches where tourist activities occur, as a potential means of generating funds to support turtle conservation activities.

The TSP is having positive benefits for turtles nesting in Tortuguero, and it should definitely be continued in the future. However, there are several issues that need to be urgently addressed, such as the number of tourists permitted on the beach each night. It is vital that the welfare of the turtles is placed above the desires of the tourist, or the hoteliers or travel agencies. To ensure that this occurs CCC needs to remain an integral part of the committee governing the evaluation and development of the program in coming years.

4.8.4 Artificial lights

Unfortunately the issue of light pollution in front of the village, and near to several of the lodges continued in 2007. This problem is one that should be given a high priority for future years, especially in the light of the increasing development of Tortuguero, with the potential for more lights being

visible on the beach. The involvement of the electricity company (ICE) is important, as a large number of the potentially problematic lights are the street lights maintained by ICE. In previous years they have been supportive of efforts to try and reduce the problem, and will hopefully continued to be so in the future. A suggestion for 2008 would be a community initiative to approach the owners of the houses, cabinas, lodges or other buildings that have lights visible from the beach, and to inform them of the problems that their lights can cause for turtles or hatchlings; and to provide them with ideas for possible solutions, such as shades or different light bulbs.

4.8.5 Hatchling orientation and disorientation

Data on hatchling orientation were collected in 2007 and represents important baseline information. As in previous years, some differences were observed between green and leatherback hatchlings. Unfortunately two cases of hatchling disorientation were also observed; one was in front of the village and the other was close to Mawamba Lodge. As artificial lights remain a problem on the nesting beach there should be increased efforts to try and monitor any disorientation events, and if possible record the light source responsible. Efforts should be focused close to the village where there are more lights visible at night on the beach. Such data would provide additional support when approaching residents to request that they switch off unnecessary lights or have them shaded during nesting and hatching season.

4.9 Environmental Education Activities

Numerous environmental education activities were conducted by the RAs and FCs during the 2007 Green Turtle Program. More than 150 students from the kindergarten, school and high school participated in these events. Due to the close relationship developed by the FCs with the directors and teachers of all the education establishments in Tortuguero and San Francisco, the program of events was much more structured, with incredible interest from everyone involved.

For the first time the FC were able to develop two workshops; one for high school students, the second at the request of the teachers who wanted to know more about the work of the CCC. Both workshops had good support, and participants completed theoretical and practical sessions, including night patrols with CCC researchers to get hands-on experience of the monitoring activities. It was very encouraging to see that activities involved not just the younger generations but also adults from both Tortuguero and San Francisco.

It was evident throughout the 2007 season that the employment of an additional FC greatly improved the frequency with which educational activities could be conducted in the village. Having someone dedicated to establish a program of community events allowed was extremely beneficial, and also provided a point of contact at the station for anyone from the village who was interested in gaining information about the work of CCC or participating in one of the monitoring patrols. It is strongly recommended that two FCs be employed in the future, with one focused on environmental education and community awareness. One suggestion would be to determine a specific theme at the start of each turtle program, and let RAs develop a series of activities related to that theme; as a group the RAs would be responsible for producing necessary materials and running the activity, under the supervision and guidance of the FC. A manual of activities that are conducted should be maintained at the station, for reference by future groups.

4.10 Independent Research Projects

Data collection for two independent research projects was conducted during the 2007 Green Turtle Program; a stable isotope study of adult green turtles, and an investigation of the level of multiple

paternity in the Tortuguero green turtle population. Both students, on arrival in Tortuguero and having assessed the logistics of collecting data, found that they required an assistant to ensure either their safety during night-time beach patrols or to comply with the stipulations of their study protocol. For future research students wishing to conduct studies at Tortuguero it would be advisable to fully explain the logistical situation at this particular site, and to have them address such issues as safety or implementation of monitoring protocol prior to their arrival.

Students obviously are working under the CCC research permit and any study that involves a protocol that is not included within the remits of this permit will be assessed on an individual basis, to determine whether it warrants requesting an addition to the permit.

At the end of the 2007 Green Turtle Program a decision was made by the Scientific Director to not allow RAs to also conduct their own research in the future unless the data could be collected either during regular CCC monitoring activities or with minimal additional effort during the person's free time. This was so that their personal data collection did not cause either a disruption to the regular RA work schedule or result in the person being unable to fulfill their responsibilities as an RA. This decision was made following several problems with one of the research students, who was working simultaneously as an RA whilst also collecting data for their own study.

Independent research projects should be encouraged, as not only do they provide the opportunity for CCC to be involved in novel research, or to conduct additional studies that require data that are not collected during regular monitoring activities, but they provide a potential source of income from students paying to use the field station facilities.

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6. Appendices

Appendix 1. Nightly sea turtle encounters for the 2007 Green Turtle Program

Date	Green Turtle				Leatherback				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
8-Jun				0				0				0
9-Jun				0				0				0
10-Jun				0				0				0
11-Jun				0		1		1				0
12-Jun				0				1				0
13-Jun				0			1	2				0
14-Jun				0		1		3				0
15-Jun	1			1		1		4				0
16-Jun				1				4	1			1
17-Jun				1				4				1
18-Jun				1		1	1	6				1
19-Jun	2			3				6	1			2
20-Jun	2			5				6				2
21-Jun	2	1		8				6				2
22-Jun	2			10			1	7				2
23-Jun	1	3		14				7				2
24-Jun	3	1		18			1	8				2
25-Jun	1			19		1		9				2
26-Jun	3			22				9	1			3
27-Jun	2			24				9				3
28-Jun	1	1		26				9				3
29-Jun	3	3		32				9				3
30-Jun	5	4		41				9				3
1-Jul	2	2		45				9			1	4
2-Jul	3	5		53			1	10				4
3-Jul	5	4		62				10				4
4-Jul	1	1	1	65			1	11				4
5-Jul	4		1	70				11				4
6-Jul	1		1	72				11				4
7-Jul ¹	3	7	1	83				11				4
8-Jul	4	3		90				11				4
9-Jul	3	5		98				11				4
10-Jul	3	7		108				11				4
11-Jul	7			115				11				4
12-Jul	3	1		119				11				4
13-Jul	5	5	1	130				11				4
14-Jul	8	5	2	145				11				4

Appendix 1. Continued

Date	Green Turtle				Leatherback				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
15-Jul	8	8	1	162				11				4
16-Jul	10	5		177				11				4
17-Jul	14	6		197				11				4
18-Jul	6	9	1	213				11	1			5
19-Jul	4	8	4	229				11				5
20-Jul	7	7		243				11				5
21-Jul	9	8	1	261				11				5
22-Jul	10	8	2	281				11				5
23-Jul	11	11	1	304				11				5
24-Jul	10	5	2	321				11				5
25-Jul	17	6	2	346				11				5
26-Jul	21	9	2	378				11				5
27-Jul	11	8	6	403				11				5
28-Jul	20	9	3	435				11				5
29-Jul	13	7	1	456				11	2			7
30-Jul	19	8	4	487				11				7
31-Jul	21	13	1	522				11				7
1-Aug	15	9	8	554				11		1		8
2-Aug	22	13	5	594				11				8
3-Aug	21	7	2	624				11				8
4-Aug	15	8	1	648				11				8
5-Aug	10	7	2	667				11				8
6-Aug	15	10	6	698				11				8
7-Aug	14	15	6	733				11				8
8-Aug	11	6	1	751				11				8
9-Aug	15	5	6	777				11				8
10-Aug	12	7	10	806				11				8
11-Aug	17	7	4	834				11				8
12-Aug	11	4	5	854				11				8
13-Aug	15	7	6	882				11				8
14-Aug	9	5	4	900				11				8
15-Aug	9	7		916				11				8
16-Aug	18	5	9	948				11				8
17-Aug	18	14	9	989				11				8
18-Aug	6	7	6	1008				11				8
19-Aug	9	5	3	1025				11				8
20-Aug	26	6	9	1066				11				8
21-Aug	13	6	6	1091				11				8

Appendix 1. Continued

Date	Green Turtle				Leatherback				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
22-Aug	11	6	4	1112				11				8
23-Aug	11	3	2	1128				11				8
24-Aug	17	6	4	1155				11				8
25-Aug	21	4	5	1185				11				8
26-Aug	20	12	2	1219				11				8
27-Aug	25	9	6	1259				11				8
28-Aug	25	9	11	1304				11				8
29-Aug	14	9	8	1335				11				8
30-Aug	28	14	7	1384				11				8
31-Aug	23	10	3	1420				11				8
1-Sep	17	5	3	1445				11				8
2-Sep	9	6	4	1464				11				8
3-Sep	17	9	7	1497				11				8
4-Sep	21	6	5	1529				11				8
5-Sep	22	10	3	1564				11				8
6-Sep	10	6	9	1589				11				8
7-Sep	11	3	5	1608				11				8
8-Sep	18	4	5	1635				11				8
9-Sep	7	1	6	1649				11				8
10-Sep	14	9	8	1680				11				8
11-Sep	6	1	6	1693				11				8
12-Sep	18	5	7	1723				11				8
13-Sep	20	4	9	1756				11				8
14-Sep	15	8	7	1786				11				8
15-Sep	13	5	8	1812				11				8
16-Sep	8	5	4	1829				11				8
17-Sep	10	4	8	1851				11				8
18-Sep	13	6	5	1875				11				8
19-Sep	14	12	9	1910				11				8
20-Sep	6	8	9	1933				11				8
21-Sep	8	2	4	1947				11				8
22-Sep	5	1	1	1954				11				8
23-Sep		4	6	1964				11				8
24-Sep	2	6	9	1981				11				8
25-Sep		3	8	1992				11	1			9
26-Sep	2	3	8	2005				11				9
27-Sep		5	6	2016				11				9
28-Sep	1	4	13	2034				11				9

Appendix 1. Continued

Date	Green Turtle				Leatherback				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
29-Sep	1	6	5	2046				11				9
30-Sep	1	4	2	2053				11				9
1-Oct	1	6	7	2067				11				9
2-Oct		4	5	2076				11				9
3-Oct		2	8	2086				11				9
4-Oct		2	8	2096				11				9
5-Oct		4	5	2105				11				9
6-Oct		2	10	2117				11				9
7-Oct		3	4	2124				11				9
8-Oct		1	6	2131				11				9
9-Oct		13	11	2155				11				9
10-Oct		2	6	2163				11				9
11-Oct				2163				11				9
12-Oct				2163				11				9
13-Oct			4	2167				11				9
14-Oct		4	1	2172				11				9
15-Oct		2	7	2181				11				9
16-Oct		4	2	2187				11				9
17-Oct		4	6	2197				11				9
18-Oct		3	7	2207				11	1			10
19-Oct		2	3	2212				11				10
20-Oct		3	1	2216				11				10
21-Oct		5	3	2224				11				10
22-Oct		4	7	2235				11				10
23-Oct		2		2237				11				10
24-Oct			2	2239				11				10
25-Oct		2	2	2243				11				10
26-Oct		1		2244				11				10
27-Oct			3	2247				11				10
28-Oct		1	1	2249				11				10
29-Oct		1	1	2251				11				10
30-Oct		2	1	2254				11				10
31-Oct				2254				11				10
Total	1077	669	508	2254	0	5	6	11	8	1	1	10

¹ 7 July - 1 newly tagged loggerhead encountered

Key to table

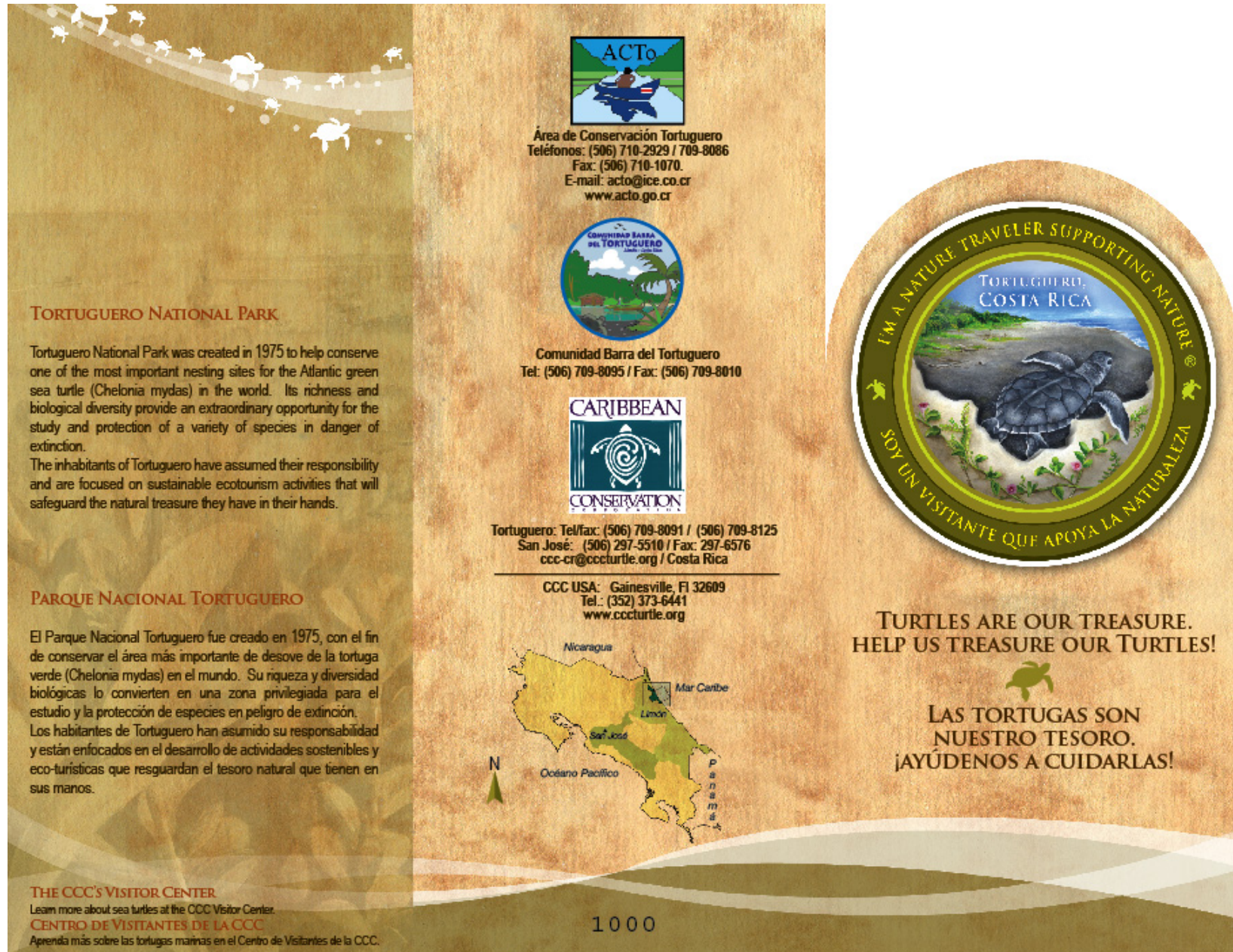
New – Turtles that had no tags on first encounter in 2007

REM – Remigrant turtles that had tags from previous years/other projects on first encounter in 2007

REN – Renester turtles that were encountered on more than one occasion during 2007

Appendix 2. Information brochure produced for the Turtle Spotter Program

a) Exterior view



Appendix 2 Continued

b) Interior view

THE TURTLES NEED YOUR DONATION SO THE PROGRAM CAN CONTINUE.

Now this committee has joined together to give you, the turtles' guests on the beach, the opportunity to help support this program with a donation. In return you will have earned the right to wear this sticker. Please wear it proudly when you are on the beach. If you see visitors on the beach without these stickers encourage them to get one.

IF THERE ARE TOO MANY PEOPLE ON THE BEACH THE TURTLES RETURN TO THE OCEAN WITHOUT LAYING THEIR EGGS.

How can we protect the turtles and yet accommodate the 35 657 visitors a year who come to Tortuguero to witness the nesting?

THE ANSWER IS SPOTTERS

For the past 3 years a committee made up of representatives from Tortuguero National Park, the Caribbean Conservation Corporation, the local community and the hotel industry has implemented a program of turtle spotters. Instead of having the visitor on the beach searching for nesting turtles, professional spotters from the village of Tortuguero find the turtles and radio their position back to the guides. This allows the visitors to walk directly to the turtles. Unfortunately, the funding for this program has run out.

DURANTE EL DESOVE, SI HAY MUCHA GENTE CAMINANDO EN LA PLAYA, LAS TORTUGAS REGRESAN AL MAR SIN DEPOSITAR SUS HUEVOS.

¿Cómo podemos proteger a las tortugas y al mismo tiempo, darles la oportunidad a los 35,657 visitantes que durante el año llegan a Tortuguero para observar el proceso de anidación?




LA RESPUESTA ES LOS RASTREADORES DE TORTUGAS.

En los últimos 3 años un comité conformado por representantes del Parque Nacional Tortuguero, Caribbean Conservation Corporation, la comunidad local y la industria hotelera han implementado el Programa de Rastreadores.

Para evitar que los visitantes caminen por la playa en búsqueda de tortugas durante el desove, rastreadores profesionales del pueblo de Tortuguero localizan las tortugas que están desovando y comunican por radio a los guías turísticos la ubicación exacta, para su observación. Lamentablemente, el presupuesto de este programa se ha terminado.

LAS TORTUGAS NECESITAN SU CONTRIBUCIÓN PARA QUE ESTE PROGRAMA CONTINÚE.

El comité ha unido esfuerzos para permitir que ustedes, como invitados de las tortugas en su playa, tengan la oportunidad de apoyar este programa con una donación. Con su contribución, usted adquiere el derecho de usar esta calcomanía. Llévela con orgullo cuando camine por la playa y motive a otros visitantes para que la adquieran.



Appendix 3. Photographs of Environmental Education Workshops Conducted During the 2007 Green Turtle Program

1) Scientific Workshop on Sea Turtles and Their Ecosystems



Some of the workshop participants receiving a lecture at the CCC field station



Students from Tortuguero high school participating in workshop activities

Appendix 3 Continued

2) Pro² Tortugas – Profesores Protegiendo Tortugas (Teachers Protecting Turtles)



Some of the workshop participants preparing to conduct a night patrol with FC Dagnia Nolasco



Workshop participants receiving their certificates from FCs Dagnia Nolasco and Xavier Debadé