REPORT ON

THE 2003 GREEN TURTLE PROGRAM

AT TORTUGUERO, COSTA RICA

Submitted to
Caribbean Conservation Corporation and
the Ministry of Environment and Energy of Costa Rica.
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by

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EXECUTIVE SUMMARY

Monitoring and Research Activities Conducted

1. During 2003, a total of 53 track surveys were conducted along the entire 18 miles of beach between Tortuguero river mouth and Jalova lagoon.
2. Nesting was observed between 13 April and 3 December, 2003, with peak nesting recorded on 24 August when 1,575 green turtle nests were counted. A total of 13.7% of all green turtle nests recorded during track surveys were deposited between Tortuguero river mouth (mile –3/8) and mile 5, where most night patrols occur.
3. A total of 14 green turtles and 147 nests were poached, between April and November. Poaching levels were low, 1-2 green turtles/night, although 6 turtles were taken on 18 September.
4. Jaguar predation continued, with a minimum of 28 turtles killed during the 2003 Green Turtle Program.
5. Hawksbill nesting density was very low throughout the season, with 0-2 nests/night recorded between May and November.
6. A total of 1,264 green turtles were newly tagged, 433 green turtles with tags from previous years and 582 renesters were recorded during 2,034 team hours of night patrols between 16 June and 30 October.
7. Three green turtles from other projects were encountered nesting in 2003; one was tagged in-water in Mexico and two were tagged on the beach in Pacuare Nature Reserve in Costa Rica.
8. Overall probability of within-season tag loss from first to last encounter was low 0.025, although there was considerable variation between taggers and months.
9. Newly tagged green turtles had evidence of old tag holes or notches in at least one front flipper in 14% of cases.
10. Tagging efficiency for night patrols varied from 0%-100%, with a mean of 9%, for nights preceding track surveys (n = 20).
11. The majority of green turtle nests were deposited in the open zone 47.6% of cases (n = 1,006), with 43.9% (n = 928) located in the border zone and just 8.4% (n = 178) in the vegetation zone.
12. Eight hawksbill turtles were newly tagged, four hawksbills with tags from previous years, and four renesters were encountered during the 2003 Green Turtle Program.
13. Tissue samples from 15 hawksbill turtles were collected and exported (with CITES permits) to Dr. Peter Dutton of the National Marine Fisheries Service.
14. Most hawksbill nests were laid in the border zone, 71.4% (n = 10).
15. Five leatherback turtles were encountered during the 2003 Green Turtle Program; one newly tagged, two with tags from previous years and two renesters.
16. Mean carapace length for newly tagged green turtle females without evidence of previous tagging was 104.2cm (CCLmin) and 98.4cm (SCLmax); for newly tagged green turtle females with old tag holes or notches 105.3 cm (CCLmin) and 99.5cm (SCLmax), and for previously tagged tagged females 105.8cm (CCLmin) and 99.6cm (SCLmax). Mean clutch size for the same groups of females was 107 eggs, 116 eggs and 110 eggs, respectively.
17. Measurement precision of green turtles was higher for CCLmin than for SCLmax within a single encounter. Between 2-5 encounters SCLmax measurements were more precise.

18. Mean carapace length for newly tagged hawksbill turtles was 89.4 cm (CCLmin) and 85.2 cm (SCLmax) and for previously tagged turtles was 88.8 cm (CCLmin) and 83.9 cm (SCLmax). Mean clutch size of newly tagged turtles was 179 eggs.
19. Mean carapace length of newly tagged and previously tagged leatherbacks was 153.3 cm (CCLmin).
20. A total of two green turtles representing 0.8% of 238 carefully examined individuals were recorded as having fibropapilloma tumors. In both turtles the tumors were found in the shoulder area of the front flippers.
21. A total of 195 green turtle nests were marked and the fate of 164 determined. Overall hatching success was 68.8% (12,960 empty shells from 18,832 eggs) and overall emerging success was 68.0% (12,815 emerged hatchlings from 18,832 eggs). Mean clutch size for undisturbed nests was 112.2 eggs.
22. The biggest cause of nest loss was depredation (10.5%), with other nesting females destroying a further 16 (9.8%) nests. Poaching resulted in the loss of 9 nests (5.5%).
23. Comparison between egg counts at excavation and the moment of oviposition showed a mean difference of 1.7 more eggs counted at the time of laying.
24. Mean depth for undisturbed green turtle nests (n=96) at excavation was 56 cm from the sand surface to the top egg and 72 cm from the sand surface to the bottom of the egg chamber.
25. The mean incubation period for undisturbed green turtle nests (n=36) was 56 days.
26. A total of twelve albino, twin and deformed embryos were observed in unhatched eggs in undisturbed nests, nests dug up by guides and unhatched nests, accounting for 0.1% of all eggs.
27. A total of 27 undisturbed green turtle nests were included in the hatchling orientation study. The mean angular range of hatchling tracks was 37º and the mean angular range including all outliers was 50º.
28. Eleven hawksbill nests were monitored and their fate determined. Overall hatching success was 64.7 % (1,117 empty shells from 1,727 eggs) and overall emerging success was 64.4 % (1,112 emerged hatchlings from 1,727 eggs). Mean clutch size for undisturbed nests was 155.7 eggs
29. Six of the marked hawksbill nests were undisturbed (54.5%), three were depredated (27.3%) and two were poached (18.2%).
30. Mean depth for undisturbed hawksbill nests (n=6) at excavation was 34 cm from the sand surface to the top egg and 46 cm from the sand surface to the bottom of the egg chamber.
31. July was the wettest month of the 2003 Green Turtle Program (721.6 mm) and September was the month with least rain (282.4 mm).
32. During the 2003 Green Turtle Program several of the sand temperature data loggers failed, probably due to excessive humidity, thus the data are incomplete. However, mean monthly sand temperatures were highest in September, at all depths and in all three beach zones. The lowest temperatures were recorded in July and November.
33. Ground water levels were undetectable in the tubes throughout the Program.
34. A total of 29,103 persons visited the CCC Natural History and Visitors Center in 2003.
35. Tourist visitation to Tortuguero National Park (TNP) increased in 2003, to 67,669 people. Entrance fees to Tortuguero Conservation Area (TNP and Barra del Colorado Wildlife Refuge) raised a total of ¢143,715,204 (~ US$335,000).

36. The capacity of hotels and cabinas in the Tortuguero area increased to 512 rooms (1,169 beds) in 2003.
37. A total of 32,854 tourists were issued permits to go on guided turtle walks in 2003.
38. Many artificial lights are still visible on the beach. The majority of lights are from the village, between mile 2 3/8 – 3 3/8. Some lights are also visible from several of the bigger hotels located north of Tortuguero village.

Conclusions

1. The majority of green turtle nests (99.5%) recorded during track surveys were laid between 15 June and 31 October.
2. Peak green turtle nesting density occurred on 24 August, 2003 when 1,575 nests were laid.
3. Poaching of green turtle nests was recorded at low levels from June - November.
4. Jaguar predation was observed at low levels, and at present does not represent a significant impact on nesting turtles.
5. Nesting of hawksbill turtles occurred at low density, although more females were encountered during night patrols than in recent years.
6. The three green turtles tagged outside of Costa Rica and encountered on the beach in 2003 emphasize the importance of maintaining high effort beach patrols during the nesting season.
7. The probability of within-season tag loss was low (0.025) as a result of the diligence of the Field Coordinator and the RAs in ensuring that tags were properly attached.
8. Low tag loss observed for Inconel tags should decrease the proportion of females returning with evidence of old tag holes and notches but without tags.
9. CCLmin measurements were more precise than SCLmax measurements during the same encounter. Between encounters SCLmax measurements showed a higher level of precision.
10. Incidence of fibropapilloma tumours in green turtles was very low (0.8%).
11. Depredation was the major factor reducing nest survivor ship and hatching success in 2003. Human disturbance resulted in the loss of 7.3% of nests.
12. Hatching success of undisturbed green turtle nests was very high (89.8%), and overall hatching success (68.8%) was within the range observed during the past five years.
13. Undisturbed hawksbill nests had extremely high hatching success (94.8%).
14. Lower than average rainfall in November resulted in few nests being inundated.
15. Visitation to Tortuguero continued to increase in 2003, with more visitors recorded at the CCC visitor centre and Tortuguero National Park than in previous years.
16. Increased visitation and increased capacity of hotels and cabinas mean that more people benefit economically from tourism in the Tortuguero area.

Recommendations

1. The implementation of a structured environmental education program at both the school and the high school would greatly facilitate collaboration with the Tortuguero community.
2. Following the introduction of the new sea turtle law in November 2002 the focus needs to be on enforcement of this law, by increasing park patrols on the beach and ensuring

that those people detained are charged under this new law. Helping to secure additional funding for park personnel would aid this endeavor.

3. It would be highly desirable to establish an incentive mechanism by which a larger part of the fees raised by the Tortuguero Conservation Area are returned to cover operative costs incurred by the Conservation Area in managing Tortuguero National Park.
4. The introduction of a comprehensive study of the general health status of the nesting green turtle population would provide valuable information on the incidence of fibropapilloma.
5. Studies to determine the presence of pesticides in the Tortuguero beach and waterways and the impact such chemicals may have on flora and fauna should be encouraged.
6. TidBit (Onset Computer Corp.) data loggers with protective casing should be bought whenever temperature data loggers need to be replaced.

INTRODUCTION

Studies of green turtles (*Chelonia mydas*) in Tortuguero were initiated by Dr. Archie Carr in 1954 (*Carr et al.* 1978). Since 1959, the Caribbean Conservation Corporation (CCC) has implemented an annual green turtle program. CCC staff and the Scientific Advisory Committee revised the Green Turtle Program monitoring protocol in preparation for the 1998 nesting season. The new protocol states 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 2003 Green Turtle Program represents the sixth consecutive year of implementing the revised monitoring protocol.

The objectives of this report are to summarize and discuss the 2003 Green Turtle Program results and provide recommendations for future sea turtle programs, conservation efforts and research activities in Tortuguero.

2. METHODS

2.1 Preparations

Following the arrival of the research assistants (RA's) in Tortuguero on 16 June, 2003, there commenced a week-long training program. This included theoretical sessions on sea turtle biology and nesting behavior, and a comprehensive review of the monitoring protocol. These lectures were supported by practical training sessions in nest marking, tagging and biometric data collection during daytime and night-time patrols between the Tortuguero river mouth and the mile 5 marker.

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 during the 2003 Leatherback Program.

The RA's were familiarized with the village, and relevant people from the local community, including the school director and teachers. They were also introduced to personnel at the park ranger station at Cuatro Esquinas, to facilitate co-operation whilst working on the beach at night.

2.2 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 in the afternoon. Only tracks from the previous night were recorded and for each track the following information was recorded: species, mile section, nest or false crawl, if the nest or turtle was poached or 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.

2.3 Tagging of Nesting Sea Turtles

Tagging teams patrolled the beach every night between 16 June – 30 October (except for 18, 22 June and 18 October). The northern part of the beach was divided into two sections: mile -3/8 to the field station (at mile 2 5/8) and 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 station residents allowed. Additional night patrols were occasionally conducted between mile 5 and 8 by teams working 8pm-4am.

Every turtle encountered after she had finished egg-laying was checked for old tags. Turtles without old tags were tagged in each front flipper, axillary, proximal to the first scale. Species, mile section, tagger, nest zone (open, border, vegetation, or did not lay) and special characteristics or injuries were noted for each tagged turtle.

Tags used during the 2003 Green Turtle Program include National Band&Tag Company (NBTC) Inconel #681 tags no. 95007-95025, 95036-95050, 95066-97996 and Monel #49 tags no. VA2094-VA2095, VA2874-2875.

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. However, in some cases, it was not possible to remove the Monel tag and so a new 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.

2.3.2 Hawksbill turtles

Hawksbill turtles (*Eretmochelys imbricata*) were tagged with Inconel #681 tags. A disposable sterile scalpel or a biopsy punch was used to collect tissue samples from all

hawksbills encountered, when possible. The samples were kept in ethanol at the field station until a CITES permit was obtained and the samples could be sent for analysis to Dr. Peter Dutton of the National Marine Fisheries Service. The tagging team always remained with the hawksbill until it had returned to the sea and then they thoroughly erased its track afterwards.

2.3.3 Leatherback turtles

Leatherback turtles (*Dermochelys coriacea*) 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 or two clutches per night as the eggs were laid. The person counting the eggs wore a plastic glove so as not to contaminate the nest. Eggs were counted using an egg counter.

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 measuring tape. 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 cm between the longest and the shortest of the three measurements.

2.4.2 Hawksbill turtles

CCLmin and SCLmax measurements were taken for all hawksbills encountered during nightly tagging work. As for green turtles, the same observer measured the turtle three times for each measurement, to allow the precision to be calculated. The clutch was counted, if the hawksbill had not already started to lay eggs at the time of encounter.

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

2.5.1 Green turtles

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 absence or presence of fibropapillomas, location and size of fibropapilloma tumors, and the names of the persons examining the turtle were recorded.

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. The distance from the centre of the egg chamber to each of these tapes was measured, to the nearest cm, whilst the turtle was still laying eggs. When it was time to excavate the nest, triangulation of these three measurements was used to indicate the location of the egg chamber, at the site where the three lines crossed. 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 the nest was marked.

Marked nests were inspected daily at 6:00am. It was recorded if the nest was poached, predated (if possible, the type of animal was identified), dug up by another turtle or lost due to beach erosion. After 55 days the nest was measured and a "V" of small sticks was placed on the sand behind the site where the three lines intersected. This aided researchers in locating the nest to observe signs of imminent hatching, either a depression or hatchling tracks. 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 approximately 65 days. Daily inspection was terminated and the marker tapes were removed from those nests when it was determined with certainty that it had been poached, completely depredated or dug-up, or that had washed away. Monitoring of partially depredated or dug-up nests continued as normal until they were excavated, though the date of disturbance was recorded.

After 65 days, or sooner if signs of emergence had been recorded, the nests were 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. Nests were not excavated if the excavator 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 excavated nest the name of excavators, nest code, mile section, date laid, date hatched (if available), date excavated, distance from sand surface to top egg, distance from sand surface to bottom of egg chamber were documented. To determine hatching and emergence success the number of empty shells (if it was more than 50% of the egg), live hatchlings, dead hatchlings, unhatched eggs with no embryo, unhatched eggs with visible embryo (all stages before fully developed), unhatched eggs with full embryo (ready to hatch but not yet pipped), pipped eggs, depredated eggs, destroyed eggs and yolkless eggs were also recorded.

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 bodypit were encountered where the 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. If human footprints and digging was observed at the location of the nest, the nest was considered dug-up by tour guides. Nests for which the fate could not be determined with certainty were excluded from the sample.

2.7 Physical Data Collection

2.7.1 Rainfall

Rainfall (to the closest mm) was recorded daily at 9:00am at John H. Phipps Biological Field Station.

2.7.2 Air temperature

Air temperature (current, minimum and maximum) was recorded daily at 9:00am at John H. Phipps Biological Field Station.

2.7.3 Sand temperature

Sand temperature was measured using data-loggers located at 30, 50 and 70 cm depth in the open, border and vegetation zones of the beach in front of the field station. These data-loggers recorded sand temperatures once an hour. They were set on 20 June 2003 and the data was retrieved on 8 September and 30 November, 2003.

2.7.4 Ground water level

The level of the ground water was measured daily at 9:00am. The ground water level was determined from the water level in three PVC pipes (8.5 cm x 160 cm) dug down in front of the John H. Phipps Biological Field Station, at 5, 10 and 15 m distance from the high tide line (as of 1 July 2002).

2.8 Collection of Human Impact Data

2.8.1 Visitors to Tortuguero

The number of visitors to the CCC Natural History and Visitors Center was estimated from the number of paying tourists that entered the center. The number of tourists visiting

Tortuguero National Park was estimated from the number of visitors that paid the entrance fee at the National Park offices at Cuatro Esquinas and Jalova.

2.8.2 Capacity of hotels and cabinas

CCC Station Manager Sergio Campos and Scientific Director Sebastian Troëng requested information on the room and bed capacity from cabina owners and hotel managers in Tortuguero during the Green Turtle Program 2003.

2.8.3 Turtle walks

The number of tourists going on guided turtle walks during the Green Turtle Program was estimated from the permits issued to tour guides by Tortuguero Conservation Area (ACTo). The Tortuguero Tour Guide Association recorded the money raised from the voluntary contributions from tour guides, money that is designated for use in community projects in the village.

2.8.4 Artificial lights

The presence of artificial lights on Tortuguero beach was monitored along the northern 5 2/8 miles of beach, from the Tortuguero river mouth to the mile 5 marker. Once a month light surveys were conducted on nights close to the new moon, when natural light was minimal. The date and name of observers were recorded, as was the mile section, light source (if possible to determine) and location (beach side or river side) for each artificial light visible from the beach.

2.8.5 Hatchling orientation

Hatchling orientation was determined for a sample of nests from which hatchlings were known to have emerged the previous night. For each nest the observer, mile section, distance from the nest to the most recent high tide line (m) and the approximate number of tracks were recorded. In addition, at a distance of 10m from the nest, the angular range of all tracks (^{o}), the angular range of tracks minus any outliers (^{o}) and the modal direction of tracks were determined using a compass held at waist-height above the nest.

2.9 Environmental Education Activities

Talks and slide shows about sea turtle biology, conservation and environmental economics were given opportunistically to groups staying at or passing by the John H. Phipps Biological Station. In addition, researchers implemented a series of environmental education activities at the Tortuguero village school, involving 4th, 5th and 6th grade students.

3. RESULTS

3.1 Track Surveys

3.1.1 Green turtles

Nesting of green turtles was observed from March - December, with more than 34 nests/night recorded between 15 June - 31 October (See Figure 1). From the weekly track surveys, peak nesting was observed on 24 August, 2003, when 1,575 nests were recorded in

a single night (See Figure 1). Using the methodology of Troëng and Rankin (In press) 93,436 nests were estimated to have been laid in 2003 (See Figure 10b). Using the mean clutch frequency estimates of 2.8 per season (Carr *et al*, 1978) and six per season (Bjorndal *et al*, 1999), this equates to between 15,573 - 33,370 females nesting in 2003.

As has been observed in previous years, nesting density was found to be highest in the centre of the beach, between miles 6 - 12, with the highest density occurring in mile 9 (See Figure 2). Those nests laid between the Tortuguero river mouth and mile 5 marker, where night-time beach patrols were regularly conducted, made up 13.7% of nests laid on the entire beach (Figure 2).

On seven separate occasions in May, July, September and November, the track surveyor reported that nesting green turtles had been poached, with a total of 14 individuals taken (Figure 3). In addition to these turtles that were taken, from eight other track surveys a total of 147 green turtle nests were also recorded as poached.

Between May and October the track surveyor reported a total of 16 freshly killed green turtles (Figure 4). Further to these, park rangers and research assistants reported another twelve green turtles killed by jaguars throughout 2003. Two teams of research assistants also observed jaguars on the beach during night patrols on 25 and 29 September.

3.1.2 Hawksbill turtles

Very low levels of hawksbill nesting activity were recorded between May – November, with peak nesting occurring from May - July (See Figure 5). A hawksbill turtle was reported killed by a jaguar by research assistants on 7 May, 2003, although the body was not found and was presumed to have been taken by poachers that encountered it freshly killed in the vegetation.

3.1.3 Leatherback turtles

Leatherback nesting as recorded from track surveys was observed from February - June, with peak nesting occurring on 22 May, 2003 when 16 nests were noted (See Figure 6).

3.2 Tagging of Nesting Sea Turtles

3.2.1 Green turtles

A total of 1,264 newly tagged, 433 previously tagged and 582 renesting green turtles were encountered by researchers during 2,034 hours of night patrols from 16 June – 30 October, 2003 (Appendices 1 and 2).

Three green turtles tagged by other research projects were encountered during the 2003 Green Turtle Program. Green turtle AM709 was observed nesting at mile 3 5/8 on 14 September 2003 and was originally tagged by researchers at Isla Mujeres, Quintana Roo, Mexico between 23 May 1996 and May 1997 (R. Marquez, pers. comm.). Green turtles V3106/V3107 seen at mile 3 5/8 on 18 July 2003, and V3408/V3409 observed at mile 3 6/8 on 17 October 2003 were both tagged in the Pacuare Nature Reserve, located south of Tortuguero National Park.

Of 1,262 newly tagged green turtles, 181 (14%) showed evidence that they had been tagged previously, exhibiting either old tag holes or notches in at least one front flipper when encountered.

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 = 20) ranged from 0% to 100% with a mean of 9%.

Green turtle nests recorded during night patrols were located in the open beach zone in 47.6% of cases (n = 1,006), 43.9% (n = 928) were located in the border zone and 8.4% (n = 178) in the vegetation zone. 6.7% of turtles were encountered during a false crawl (n = 152).

3.2.2 Hawksbill turtles

Twelve different hawksbill turtles were encountered during the 2003 Green Turtle Program; eight (75%) were newly tagged, four (25%) had tags from previous years, and four of these twelve individuals were observed on more than one occasion during the season (See Appendix 1). Only one of the eight (12.5%) newly tagged hawksbill turtles showed evidence of previous tags.

Tissue samples from 15 hawksbill turtles were sent to Dr. Peter Dutton of the National Marine Fisheries Service (USA) for mtDNA analysis. These samples were collected during both the 2003 Leatherback and Green Turtle Programs. All the necessary CITES and Ministry of Environment and Energy permits were acquired prior to the collection and export of these samples.

Most of the hawksbill nests recorded during night patrols were located in the border zone of the beach (71.4%, n = 10), the others were laid in the open zone (28.6%, n = 4).

3.2.3 Leatherback turtles

A total of five leatherback encounters were logged at the beginning of the 2003 Green Turtle Program; one was newly tagged, two were previously tagged and two were renesting individuals encountered during the 2003 Green Program. The last leatherback turtle was recorded on the 7 July, 2003 (See Appendix 1). All leatherback nests observed during night patrols were deposited in the open zone (n = 4).

3.2.4 Determination of within-season tag loss for green turtles

Using data from green turtles tagged with two Inconel #681 it was possible to determine the probability of within-season tag loss, by recording the presence of either one or both tags on subsequent encounters of the same individual throughout the nesting season.

From Table 1 it can be seen that of 248 turtles that were observed on more than one occasion, only twelve were reported to have lost one tag on the subsequent encounter, giving a within-season probability of tag loss of 2.5%. There were considerable differences in the probability of tag loss between researchers, ranging from 0% to 20%. Differences

were also observed between months, with the lowest tag loss observed in June and October, and the highest in July (0% and 5% respectively).

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

a) By tagger

Tagger	r_{di}	r_{si}	$1\text{-}K_i \pm 95\%$ CL
FC	19	0	0 ± 0
SD	7	0	0 ± 0
RA1	16	0	0 ± 0
RA2	15	0	0 ± 0
RA3	15	0	0 ± 0
RA4	14	0	0 ± 0
RA5	14	0	0 ± 0
RA6	9	0	0 ± 0
RA7	7	0	0 ± 0
RA8	6	0	0 ± 0
RA9	24	1	0.020 ± 0.041
RA10	21	1	0.023 ± 0.046
RA11	20	1	0.024 ± 0.049
RA12	9	1	0.053 ± 0.105
RA13	21	3	0.067 ± 0.077
RA14	10	2	0.091 ± 0.128
RA15	6	3	0.200 ± 0.226
Mixed taggers	3	0	0 ± 0
TOTAL	**236**	**12**	**0.025 ± 0.014**

b) By month

Month	r_{di}	r_{si}	$1\text{-}K_i \pm 95\%$ CL
June	6	0	0 ± 0
July	67	7	0.050 ± 0.037
August	76	2	0.013 ± 0.018
September	73	3	0.020 ± 0.023
October	14	0	0 ± 0
TOTAL	**236**	**12**	**0.025 ± 0.014**

FC = Field Coordinator, SD = Scientific Director, RA = Research Assistant, Mixed taggers = Two RA's tagged the same turtle
r_{di} = Number of green turtles encountered with two tags, r_{si} = Number of green turtles encountered with one tag, $1\text{-}K_i$ = Probability of tag loss, 95% CL = 95% confidence limits

3.3 Biometric Data Collection

3.3.1 Green turtles

Table 2 shows the mean carapace length of green turtle females. It can be seen that the mean carapace length of newly tagged individuals with no evidence of previous tagging was

slightly smaller than the mean carapace length of newly tagged females with old tag holes or notches, and that of previously tagged individuals.

Newly tagged females with no signs of previous tagging laid smaller clutches than either previously tagged females or newly tagged individuals with evidence of previous tags (See Table 2).

Table 2. Mean carapace length and clutch size of green turtle females

Sample	CCLmin (cm)		SCLmax (cm)		Clutch size (eggs)	
	n	$\bar{x}$ ± ST.D.	n	$\bar{x}$ ± ST.D.	n	$\bar{x}$ ± ST.D.
Newly tagged - no OTH/OTN	1070	104.2 ± 4.8	868	98.4 ± 4.4	92	107 ± 28
Newly tagged - with OTH/OTN	178	105.3 ± 5.1	156	99.5 ± 4.9	19	116 ± 17
Previously tagged	395	105.8 ± 4.8	360	99.6 ± 4.5	43	110 ± 20

OTH = Old tag hole, OTN = Old tag notch

The carapace measurements of green turtles, both curved carapace length (CCLmin) and straight carapace length (SCLmax), were taken with a higher degree of precision by research assistants than by volunteer participants (See Table 3a). For research assistants, the CCLmin was more precise than the SCLmax measurement, no difference was observed for volunteer participants (See Table 3a). For individuals encountered more than once during the season the SCLmax measurements showed a higher level of precision than the CCLmin measurements, irrespective of the number of times the turtle was observed (See Table 3b).

Table 3. Precision of carapace measurements for green turtle females

a) During the same encounter

Observer	CCLmin (cm)			SCLmax (cm)		
	n	$\bar{x}$ ± ST.D.	Range	n	$\bar{x}$ ± ST.D.	Range
Research Assistants	1536	0.2 ± 0.2	0 - 1.5	1320	0.3 ± 0.2	0 - 1.7
Participants	641	0.4 ± 0.3	0 - 2.0	571	0.4 ± 0.3	0 - 4.8
TOTAL	**2177**	0.3 ± 0.2	**0 - 2.0**	**1891**	0.3 ± 0.2	**0 - 4.8**

b) Between encounters

Encounters	CCLmin (cm)			SCLmax (cm)		
	n	$\bar{x}$ ± ST.D.	Range	n	$\bar{x}$ ± ST.D.	Range
2	281	1.2 ± 1.0	0.1 - 8.0	256	1.0 ± 0.9	0.2 - 10.0
3	83	1.7 ± 1.1	0.3 - 6.9	69	1.5 ± 1.1	0.5 - 6.0
4	17	1.8 ± 1.0	0.4 - 4.2	17	1.6 ± 1.1	0.6 - 4.9
5	5	3.5 ± 2.3	2.1 - 7.6	5	1.6 ± 0.7	0.7 - 2.7
6	1	2.4 ± N/A	N/A	1	0.5 ± N/A	N/A

3.3.2 Hawksbill turtles

The mean carapace length of newly tagged hawksbill females was greater than that of previously tagged individuals, for both CCLmin and SCLmax measurements (See Table 4).

Only clutches of newly tagged females were counted and the mean number of eggs laid was 179 (See Table 4).

The CCLmin measurements of hawksbill females showed a greater level of precision than SCLmax measurements (See Table 5). The precision of CCLmin measurements was the same for green and hawksbill turtles ($\bar{x}$ = 0.3cm), but the precision of SCLmax measurements of hawksbills was lower than that of green turtles ($\bar{x}$ = 0.6cm compared to $\bar{x}$ = 0.3cm respectively; See Table 3a and Table 5).

Table 4. Mean carapace length and clutch size of hawksbill females

	CCLmin (cm)		SCLmax (cm)		Clutch size (eggs)	
Sample	**n**	**$\bar{x}$ ± ST.D.**	**n**	**$\bar{x}$ ± ST.D.**	**n**	**$\bar{x}$ ± ST.D.**
Newly tagged - no OTH/OTN	6	89.4 ± 3.7	6	85.2 ± 2.5	4	179 ± 13
Previously tagged	2	88.8 ± 3.1	1	83.9 ± N/A	0	N/A

Table 5. Precision of carapace measurements for hawksbill females

	CCLmin (cm)			SCLmax (cm)		
Sample	**n**	**$\bar{x}$**	**Range**	**n**	**$\bar{x}$**	**Range**
Females	12	0.3	0.1-1.0	10	0.6	0-2.5

3.3.3 Leatherback turtles

The mean carapace length (CCLmin) of the five leatherback turtles encountered during the 2003 Green Turtle Program was 153.3cm (See Table 6). No clutches were counted for any of these individuals. See Harrison *et al*. (2003) for an analysis of the precision of CCLmin measurements for leatherbacks turtles.

Table 6. Mean carapace length of leatherbacks

		CCLmin (cm)
Sample	**n**	**$\bar{x}$ ± ST.D.**
Newly and previously tagged	5	153.3 ± 9.8

3.4 Fibropapilloma Assessment

3.4.1 Green turtles

A total of 238 green turtles were subject to a thorough examination for the presence of fibropapilloma tumors; just two individuals (0.8%) were found to be infected. In both cases it was the shoulder area of the front flippers that was affected, with the number of tumors ranging from one to three per turtle. Both the affected turtles were newly tagged and neither had evidence of old tag holes or notches.

3.5 Determination of Nest Survivorship and Hatching Success

Several mammal predators were observed disturbing nests or taking hatchlings during the 2003 Green Turtle Program, including coatis (*Nasua narica*), domestic dogs (*Canis familiaris*) and humans (*Homo sapiens sapiens*).

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. Another bird seen taking hatchlings as they crossed the beach was the common black hawk (*Buteogallus anthracinus*).

In addition, fly larvae (*Megaselia scalaris*) were observed depredating eggs, pipped hatchlings and hatchlings in the nest. Tropical fire ants (*Solenopsis geminata)* were also observed depredating eggs, pipped hatchlings and live hatchlings, both in the nest and in the vicinity of the nest.

3.5.1 Green turtles

A total of 195 green turtle nests were marked during the course of the 2003 Green Turtle Program. Of these, all three marker tapes were lost for three nests, one nest still contained hatchlings at the end of the Program, the fate of 21 nests could not be determined with certainty and new nests deposited near to marked nests prevented the excavation of six nests. These 31 nests were excluded from subsequent analysis, leaving a sample of 164 green turtle nests monitored from the date of oviposition until their fates could be determined (See Table 7).

From the data in Table 7 it can be seen that almost 60% of nests remained undisturbed during incubation (n = 98). Of those that were disturbed, depredation accounted for 10.5% of disturbances and nesting turtles destroyed another 9.8% of nests. Human disturbance, either from poaching or tour guides excavating nests, resulted in the loss of a further 15 nests (9.1%). Figure 7 shows the location of all marked nests that were poached. There were three areas where poaching occurred, all of which were outside of Tortuguero National Park. One area was between miles 7/8 – 1 1/8, close to the airport, the second was between miles 1 7/8 – 2 1/8, and the third was closer to Tortuguero village, between miles 2 3/8 – 3 3/8 (which marks the northern limit to Tortuguero National Park).

Natural loss of nests, due to beach erosion, was limited (n = 5), but occurred mainly in the beach section between Tortuguero village and the river mouth. Only two nests failed to hatch. Both non-human and human depredation occurred at higher levels outside of the national park limits, in the sector to the north of Tortuguero village (See Table 7 and Figure 7).

The results of the excavations of the 164 green turtle nests monitored through incubation are shown in Tables 8a and 8b. Overall hatching and emerging success was calculated, based on the assumption of a mean number of 112.2 eggs per marked nests unless the fate category indicated otherwise (Table 8b). The estimated total number of eggs in monitored nests

equals 18,832 eggs (162 nests x 112.2 eggs + 2 nests x 103.5 eggs + 4 nests x 112.2 eggs to account for nests that were dug up together with other nests – fate category 7). Overall hatching success is estimated at 68.8% (12,960 empty shells from 18,832 eggs) and overall emerging success at 68.0% (12,815 hatchlings from 18,832 eggs).

Table 7. Fate of marked green turtle nests

Fate	Public n	Park n	Total n	% of total
Undisturbed				
1. Undisturbed	55	43	98	59.8
Disturbed				
2a. Poached	9	0	9	5.5
2b. Empty egg chamber	3	0	3	1.8
3. Dug up by dogs after hatching	0	1	1	0.6
4. Dug up by guide after hatching	2	1	3	1.8
5. Depredated	13	4	17	10.4
6. Dug up by nesting turtle	11	5	16	9.8
7. Two nests together	2	2	4	2.4
8. Washed out	4	1	5	3.0
9. Invaded by roots	2	4	6	3.7
10. Unhatched	0	2	2	1.2
TOTAL	**101**	**63**	**164**	**100**
Not included in analysis				
11. Hatchlings still in nest on 1 December	1	0	1	
12. All three marker tapes lost	2	1	3	
13. Undetermined	12	9	21	
14. Other nest on top prevented excavation	4	2	6	

Table 8. Results of green turtle nest excavations

a) Raw data from excavations

				Hatchlings		Unhatched eggs				
Fate	n	Empty shells	Pipped eggs	Live	Dead	No embryo	Embryo	Full embryo	Depredated	Destroyed
1	98	9889	81	48	30	564	233	24	203	0
2a	9	62	2	0	1	1	0	0	2	0
2b	3	8	0	0	0	8	4	0	6	0
3	1	85	2	2	1	3	1	0	0	0
4	3	209	0	2	0	6	7	1	1	0
5	17	981	20	11	28	95	34	1	190	0
6	16	511	3	6	13	47	20	9	7	14
7	4	708	0	2	0	16	5	0	47	0
8	5	0	0	0	0	0	0	0	0	0
9	6	506	1	0	0	8	8	1	38	0
10	2	1	0	1	0	185	15	0	6	0
ALL	**164**	**12960**	**109**	**72**	**73**	**933**	**327**	**36**	**500**	**14**

For fate categories see Table 7

b) Hatching and emerging success of excavated green turtle nests

Fate	n	$\bar{x}$ clutch size	Hatching success (%)	Emerging success (%)
1	98	112.2	89.9	89.2
2a	9	N/A	6.1[a]	6.0[a]
2b	3	N/A	2.4[a]	2.4[a]
3	1	N/A	75.8[a]	73.1[a, b]
4	3	N/A	62.1[a]	61.5[a, b]
5	17	N/A	51.4[a]	49.4[a]
6	16	N/A	28.5[a]	27.4[a]
7	4	N/A	78.9[a]	78.7[a]
8	5	N/A	0[a]	0[a]
9	6	N/A	75.2[a]	75.2[a]
10	2	103.5	0.5	0
Total	**164**	**N/A**	**68.8**	**68.0**

For fate categories see Table 7

[a]Assuming a mean clutch of 112.2 eggs

[b]Assuming that all hatchlings not accounted for emerged before depredation

Most of the marked green turtle nests were deposited either in the open (n = 78), or border zones (n = 75), and very few were laid in the vegetation (n = 10). When eggs were laid in the vegetation they were more likely to be disturbed than if they were laid in the border or open zones (70% compared to 45% and 31%, respectively).

A comparison between egg counts at the time of oviposition and at excavation for a sample of undisturbed nests (n = 79) shows a mean of 1.7 more eggs (range: +57 to -146 eggs, st.dev. = 22 eggs) counted at the time of oviposition.

The distance between the sand surface and the top eggshell at the time of excavation for undisturbed nests (n = 96) ranged between 29 and 90 cm with a mean of 58 cm. The distance between the sand surface and the bottom of the egg chamber for the same nests varied between 41 and 100 cm with a mean of 72 cm.

The incubation period for undisturbed nests for which emerging was observed (n = 36) ranged from 51 to 65 days with a mean of 56 days.

Unhatched eggs that contained albino and deformed embryos accounted for 0.1 % of eggs in undisturbed nests, nests dug up by guides and unhatched nests (See Table 9).

Table 9. Incidence of albinism, twins and deformed embryos in green turtle nests

	n	% of total eggs
Albinos	5	0.04
Twins	0	0.00
Deformed embryos	7	0.06
TOTAL	**12**	**0.10**

3.5.2 Hawksbill turtles

A total of eleven hawksbill nests were marked at the time of oviposition, and the results of the excavations of these nests are shown in Table 10. Of these eleven nests, six were undisturbed (54.5%), two were poached (18.2%) and three were depredated (27.3%).

Table 10. Results of hawksbill nest excavations

				Hatchlings		Unhatched eggs					Hatching success	Emerging success
Fate	n	Empty shells	Pipped eggs	Live	Dead	No embryo	Embryo	Full embryo	Depred.	Total eggs	(%)	(%)
1	6	885	0	1	4	28	12	2	7	934	94.8	94.2
2a	2	83	0	0	0	0	0	0	0	83	26.7[a]	26.7[a]
5	3	149	0	0	0	24	21	40	248	482	30.9	30.9
ALL	**11**	**1,117**	**0**	**1**	**4**	**52**	**33**	**42**	**255**	**1,499**	**64.7**	**64.4**

For fate categories see Table 7

[a]Assuming mean nest size of 155.7 eggs (934 eggs ÷ 6 nests)

Hatching and emerging success of undisturbed hawksbill nest was very high (over 94%), but in those nests that had been disturbed by humans or animal predators, a substantial reduction in both hatching and emerging success was recorded (less than 31%). The nests that were categorized as poached contained some eggs when excavated (n = 83), and those that were depredated had lost over 51% of their eggs.

Overall hatching success for hawksbill nests (n = 11) was 64.7% (1,117 empty shells from 1,727 eggs) and emerging success was 64.4% (1,112 emerged hatchlings from 1,727 eggs). This is comparable to the hatching and emerging success of marked green turtle nests (See Table 8b).

The distance between the sand surface and the top eggshell at the time of excavation for undisturbed hawksbill nests (n = 6) ranged between 21 and 46 cm with a mean of 34 cm. The distance between the sand surface and the bottom of the egg chamber for the same nests varied between 30 and 64 cm with a mean of 46 cm. Hawksbill nest were shallower than those of green turtles, both with respect to depth to the first egg (34cm compared to 58cm, respectively) and depth to the bottom of the egg chamber (46cm compared to 72cm, respectively).

The incubation periods for the two hawksbill nests where hatchling tracks were observed were 60 and 64 days, giving a mean of 62 days. The mean hawksbill incubation time was approximately 6 days longer than that observed for marked green turtle nests (mean = 56 days)

3.5.3 Leatherback turtles

For more information about the leatherback hatching success in Tortuguero in 2003, please consult Harrison *et al*. (2003).

3.6 Physical Data Collection

3.6.1 Rainfall

During the 2003 Green Turtle Program, which ran from mid-June to the end of November, July was the wettest month, with 721.6mm of rain recorded for the month, with a mean of 23.3mm of rain per 24-hour period (See Table 11). September was the driest month of the Program with 282.4mm of rain recorded for the entire month, equating to 9.4mm per 24-hour period.

Table 11. Rainfall, January-December 2003

Month	Total rainfall (mm/month)	$\bar{x}$ rainfall (mm/24hrs)*
January	677.4	21.9
February	125.6	4.5
March	86.2	2.8
April	317	10.6
May	987.7	31.9
June	407.3	13.6
July	721.6	23.3
August	675.2	21.8
September	282.4	9.4
October	331.4	10.7
November	584.8	19.5
December	1219.2	39.3

*Data for 48 hours for 17-18 May, 7-8 June, 17-18 December

3.6.2 Air temperature

May and October had the highest minimum air temperature (25.3°C) and December was the coolest month (23.3°C) of 2003.

Table 12. Air temperature, January - December 2003

Month	$\bar{x}$ minimum temp. (^{o}C) *	$\bar{x}$ maximum temp. (^{o}C) *
January	23.7	28.2
February	24.9	31.0
March	25.8	32.8
April	24.1	32.3
May	25.3	31.2
June	24.8	30.7
July	24.8	30.0
August	24.7	30.4
September	25.1	31.8
October	25.3	30.2
November	24.7	29.5
December	23.3	28.6

*No data for 17 and 31 May, 17 June, 5 July, 29 August, 6 and 11 September, 31 October, 3 and 17 December

3.6.3 Sand temperature

The mean sand temperatures, as calculated from data recorded by the data loggers each hour, are shown in Table 13. Over the course of the year several of the data loggers failed, probably due to excessive humidity levels. These were subsequently replaced with a different style device that was held in a waterproof casing.

At all depths temperatures were greater in the open zone and lower in the vegetation zone (See Table 13). The month with the highest average sand temperature, at all depths, was September, which was also the driest month recorded for the Program (See Table 11). August (the wettest month of the Program) still showed elevated sand temperatures, above 25°C at all depths and in all zones.

Table 13. Mean monthly sand temperatures

Zone	Open $\bar{x}$ temp (°C)			Border $\bar{x}$ temp (°C)			Vegetation $\bar{x}$ temp (°C)		
Depth (cm)	***30***	***50*** [a]	***70***	***30***	***50*** [b]	***70***	***30*** [c]	***50*** [d]	***70*** [e]
January	27.5	FAIL	27.4	FAIL	26.5	26.5	24.7	FAIL	25.5
February	30.4	FAIL	28.5	FAIL	27.0	26.6	25.6	FAIL	25.4
March	32.0	FAIL	30.6	FAIL	28.5	28.1	FAIL	FAIL	27.0
Retrieval depth (cm) 6 March					48	65	*23*	*43*	63
Depth (cm)				*30*	*50*	*70*	*30*	*50*	*70*
April	32.2	FAIL	31.1	FAIL	28.3	28.2	FAIL	FAIL	27.4
May	29.1	FAIL	29.1	FAIL	27.4	27.5	FAIL	FAIL	26.5
June	30.6	FAIL	29.9	FAIL	28.2	28	FAIL	FAIL	26.8
Retrieval depth (cm) 20 June	*31*	*51*	*76*		*41*	*68*			*68*
Depth (cm)	*30*	*50*	*70*	*30*	*50*	*70*	*30*	*50*	*70*
July	28.7	28.9	28.7	FAIL	27.1	27.6	25.8	FAIL	26.4
August	30.3	29.5	28.8	FAIL	27.0	27.1	25.8	FAIL	26.1
September	32.0	31.7	30.8	FAIL	FAIL	28.5	FAIL	FAIL	27.2
Retrieval depth (cm) 8 Sept	*11.5*	*36*	*62.5*		*49*	*67*	*36*	*47*	*59.5*
Depth (cm)	*30*	*50*	*70*	*30*	*50*	*70*	*30*	*50*	*70*
October	30.9	31.0	30.5	FAIL	FAIL	28.7	FAIL	26.5	27.3
November	28.9	29.2	28.9	FAIL	FAIL	27.7	FAIL	25.7	26.5
Retrieval depth (cm) 30 Nov	*34*	*47*	*66*			*64*		*24*	*73*

[a] Data from 20 June onwards
[b] Data for 1 Jan - 4 Sep
[c] No data for 6 March - 19 June, 9 Sep - 31 Dec
[d] Data for 20 June - 22 July, 8 Sep - 30 Nov
[e] No data for 19 June

Figure 8a, 8b and 8c illustrate the mean sand temperatures for the months of the 2003 Green Turtle Program (mid-June to the end of November), in the open border and vegetation zones, respectively. Only included are data collected from a depth of 70cm, which corresponds to the mean depth of a green turtle nest. A similar pattern was observed for all three beach zones, with a dip in sand temperature towards the end of July, and then peaking in September. However, it is clear that there was much more variation in sand temperatures

in the open zone (which received no shading) than in the border and vegetation zones (which were partially and fully shaded with vegetation, respectively). In the open zone two things were apparent; the range of temperatures recorded was greater, between 26 - 31°C, and also higher temperatures were recorded, often over 30°C. In the border and vegetation zones temperatures were both lower and less variable, with a range of around 25 - 29°C during the season.

3.6.4 Ground water level

The ground water levels showed no detectable changes throughout the season.

3.7 Collection of Human Impact Data

3.7.1 Visitors to Tortuguero

The number of visitors paying to enter the CCC Natural History and Visitor Center in Tortuguero is shown in Table 14. There has been continuing increase in the number of people coming to the center over the past three years, from 22,605 in 2001 to 29,103 in 2003. There is a similar yearly pattern of visitation visible for all three years, with numbers rising through February and March before dropping drastically in May and June. Later in the year there is a high peak in August followed by lower months through to November when numbers increase again. Since 2001, peak visitation has occurred in August, with an average of 125 visitors per day throughout August in 2003.

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

	2001		2002		2003	
Month	**Total**	**$\bar{x}$ Per Day**	**Total**	**$\bar{x}$ Per Day**	**Total**	**$\bar{x}$ Per Day**
January	1846	60	1756	57	2220	72
February	2277	81	2108	75	2855	102
March	2301	74	2581	83	2921	94
April	2002	67	1738	58	2591	86
May	1208	39	1239	40	1410	45
June	1334	44	1463	49	1575	53
July	2720	88	2673	86	3272	106
August	2858	92	3419	110	3864	125
September	1440	48	2043	68	1779	59
October	1597	52	2104	68	1791	58
November	1550	52	2276	76	2453	82
December	1472	47	2124	69	2372	77
TOTAL	**22605**	**62**	**25524**	**70**	**29103**	**80**

The number of visitors entering Tortuguero National Park, both foreign tourists and Costa Rican nationals, continues to increase, reaching 67,669 visitors by the end of 2003, an increase of over 17,000 people from 2002 (See Table 15). In 2003 the income generated from the entrance fees to Tortuguero National Park and Barra del Colorado Wildlife Refuge totaled ¢143,715,204 (~ US$335,000). It is interesting to note that visitation to Barra del Colorado Wildlife Rufuge has declined dramatically since 1998, from over 23,000 visitors to less than 400 in 2003 (See Table 15).

Table 15. Number of paying visitors to Tortuguero National Park

Year	Tortuguero National Park			Barra del Colorado Wildlife Refuge	Tortuguero National Park and Barra del Colorado Wildlife Refuge
	CR Visitors	Foreign Visitors	Total Visitors	Total Visitors	Total Fees Raised
1996	1,287	7,766	9,053		
1997	2,274	10,757	13,031		
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

3.7.2 Capacity of hotels and cabinas

The number of hotels and cabinas available in Tortuguero continued to increase in 2003, and there are currently over 500 rooms for rent in the village and surrounding area, comprising a total of 1169 beds. Approximately 75% of the capacity is within the larger hotels and lodges, as opposed to the smaller cabinas in the village (See Table 16).

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

Hotels/Lodges	Rooms	Beds	Cabinas	Rooms	Beds
Caribe	3	5	All Rankin Lodge	6	22
Evergreen	20	43	Aracari	10	24
Hotel Vista del Mar	20	40	Casa Marbella	4	11
Ilan-Ilan	24	54	La Casona	-	-
Jungle	46	94	Chanu	5	17
Laguna	82	170	Ella y Yo	3	5
El Manati	10	20	Joruki	9	20
Mawamba	54	140	Meryscar	20	45
Pachira	60	124	Ms Miriam	14	42
Samoa Lodge*	19	44	Miss Junnie Hotel	12	30
Tortuga	26	60	Pisulin/Tropical Lodge**	6	12
Turtle Beach Lodge	18	39	Pancana***	-	-
			Sabina	27	58
			Tortuguero	7	18
			(CCC	7	32)
Total – Hotels	*382*	*833*	*Total – Cabinas*	*130*	*336*
			TOTAL	**512**	**1169**

* Previously called Caribbean Magic

** Will reopen in early 2004

*** Rooms rented out long-term to village residents instead of tourists

3.7.3 Turtle tours

A total of 32,854 tourists paid to go on a guided turtle tour during the official 2003 nesting season, which ran from March until the end of October (See Table 17). Peak tourist visitation coincided with peak nesting of green turtles in August (See Table 17 and Figure

1). Almost twice as many tourists used the public beach, north of mile 3 3/8, than the beach within the national park; 20,907 tourists compared to 11,947 tourists, respectively. The value "tour guide nights" illustrates the number of guides that received permits each month.

Table 17. Number of tourists paying to go on turtle tours in 2003

Month	Public beach (mile -3/8 to 3 3/8)	Park (mile 3 3/8 to 5)	Total	Tour guide nights
March	46	39	85	16
April	107	99	206	38
May	462	357	819	117
June	1521	520	2041	306
July	5491	3350	8841	1107
August	5845	4701	10546	1252
September	4254	1867	6121	805
October	3181	1014	4195	541
November	0	0	0	0
TOTAL	**20907**	**11947**	**32854**	**4182**

Data from ACTo

3.7.4 Artificial lights

Five light surveys were conducted during the 2003 Green Turtle Program, once a month from June to October (Table 18).

Table 18. Results of light surveys conducted from Tortuguero river mouth to mile 5

		Location of light		Months recorded during light survey				
Mile	Light source	Beach side	River side	Jun	Jul	Aug	Sept	Oct
6/8	Tortuga Lodge		X	X		X	X	
1 1/8	House		X		X		X	
1 2/8	Cabinas	X		X	X	X	X	
1 3/8	Laguna Lodge	X		X	X	X	X	X
1 4/8	Laguna Lodge	X		X	X	X	X	X
2 3/8	Mawamba Lodge	X		X	X	X	X	X
2 4/8	CCC Station	X			X	X	X	X
2 5/8	CCC Station	X		X	X	X	X	X
2 6/8	House and street lights	X			X	X	X	X
2 7/8	House and street lights	X			X	X	X	X
3	House and street lights	X		X	X	X	X	X
3 1/8	House and street lights	X		X	X	X	X	X
3 2/8	House and street lights	X		X	X	X	X	X
3 3/8	House and street lights	X				X		

Most of the lights visible on the beach were from house and street lights in Tortuguero village, between miles 2 6/8 – 3 3/8 (See Table 18). However, numerous lights from cabinas, lodges, houses and the CCC station that are north of the village were also visible (See Table 18). The majority of lights were located on the beach side of the river, although those of Tortuga Lodge were visible from the other side of the river.

3.7.5 Hatchling orientation

In total 27 undisturbed nests were included in the hatchling orientation study conducted in 2003 (See Table 19). A mean of 60 hatchling tracks per nest was calculated, although it should be noted that it was often difficult to accurately distinguish individual tracks, so this value should be taken as a minimum number.

The angular range of hatchling tracks was 37° ± 11°, but if outliers were included in the analysis the range increased to 50° ± 14° (See Table 19). Very few disorientated hatchlings were observed, less than one "circler" was observed per nest. Hatchlings were classified as "circlers" (and deemed disorientated as a result) if their track did not go directly to the sea, but made one or more circles. Sometimes disorientated hatchlings continued on to the sea, at other times their tracks went inland to the vegetation behind the beach.

Table 19. Results of hatchling orientation studies of green turtle nests

Fate of nest	n	No. hatchling tracks $\bar{x}$ ± ST.D.	Angular range (°) $\bar{x}$ ± ST.D.	Angular range including outliers (°) $\bar{x}$ ± ST.D.	No. of circlers $\bar{x}$ ± ST.D.
Undisturbed	27	60 ± 14	37 ± 11	50 ± 14	0.04 ± 0.20

3.8 Environmental Education Activities

Several activities were conducted with 4th, 5th and 6th grade students during the 2003 Green Turtle Program. These included a "Turtle Activity Day" hosted at the CCC station on 21 August, 2003. It was coordinated by the research assistants and a group of participants from the University of North Carolina, and incorporated a variety of different activities relating to sea turtle biology and the work of the CCC in Tortuguero. Another event focused on the importance of recycling – following a village clean-up session with the students, the aluminum cans collected were subsequently used to make trash bag holders for the school. In addition, several slide show presentations regarding the history of the CCC in Tortuguero were given to groups of students and other visitors to the CCC station.

4. DISCUSSION

4.1 Track Surveys

4.1.1 Green turtles

Green turtle nesting was observed from March to December with the majority of nests recorded between 15 June and 31 October (Figure 1). Green turtle nests recorded at track surveys before 15 June and after 1 November only amounted to 0.5 % of all registered green turtle nests in 2003.

As observed in previous years, the percentage of green turtle nests laid in the northernmost five miles of beach, between the Tortuguero river mouth and the mile 5 marker, where the

majority of night patrols were conducted, was quite small, just 13.7% of all nests recorded during track surveys (Figure 2).

Poaching of nesting green turtles was registered during track surveys in May, July, September and October (See Figure 3). The majority of these turtles were taken within Tortuguero National Park boundaries. The park guards received a new ATV at the start of the season, which enhanced the efficiency of their beach patrols. An increase in patrolling activity later in the season resulted in the arrest of eleven poachers within a 10-day period, all of whom will hopefully be charged under the more stringent sea turtle law that was brought into force in November 2002.

Track surveys revealed 16 green turtles that were killed by jaguars (See Figure 4), from May – November. Sightings were reported on several occasions throughout the season; track surveyor Enrique Vargas encountered a jaguar close to a dead turtle and on two nights in September researchers saw jaguars on the beach within the park. It would appear, therefore, that the jaguar population within the National Park is thriving and continuing to incorporate green turtles into their diet. An in-depth study of the relationship between jaguars and green turtles would highlight the impact that this predation may be having on the nesting population.

4.1.2 Hawksbill turtles

The nesting density of hawksbill turtles as identified by the weekly track survey was low, often less than one nest per night being recorded (See Figure 5), though it was comparable to that observed in recent years (Harrison *et al.*, 2003). Nesting was temporally disperse, with nests being recorded from April – October, although a distinct peak of nesting activity occurred around the beginning of May (See Figure 5).

With such low numbers of hawksbill females nesting in Tortuguero in 2003, it was very unfortunate to have recorded a hawksbill turtle that was predated by a jaguar, and even more regrettable that the body, undoubtedly for the carapace, was taken by poachers.

4.1.3 Leatherback turtles

A comprehensive discussion of leatherback nesting trends at Tortuguero in 2003 can be found in Harrison *et al.* (2003).

4.2 Tagging of Nesting Sea Turtles

4.2.1 Green turtles

The goal of 1,000 newly tagged green turtles was achieved quite late in the 2003 Green Turtle Program, due to a relatively low tagging efficiency in the northernmost five miles of beach close to the station, where the majority of night patrols are conducted. The target was accomplished primarily as a result of additional patrols working between miles 5 – 8 in September, an area of the park with high green turtle nesting activity and few previously tagged individuals.

The presence of turtles tagged at other research projects is always exciting, and it was interesting to encounter another green turtle that was originally tagged at Isla Mujeres, Mexico. This is the second consecutive year that turtles from that project have nested here in Tortuguero (Harrison *et al.*, 2003 b). The two turtles with tags from Pacuare Nature Reserve were also interesting as the project there is on another nesting beach, and not an in-water, hence these individuals are utilizing more than one beach for nesting. No further details are available from Pacuare as to whether the turtles were encountered nesting, or during false crawls. The implementation of the regional data base for the Caribbean coast, which is being initiated by all relevant turtle projects working in the area, would greatly facilitate the transfer of such information.

Overall tag loss was low (2.5%), but there was considerable variation between researchers, from 0 – 20%. This highlights the need for comprehensive training in tag application when new researchers arrive, to ensure that tags are correctly applied, to help minimize loss. Variability between months was also evident, with July and September showing higher tag loss than June, August or October. These differences are explainable by the fact that tagging skills improve over time, and researchers become more proficient over the course of the season; tags are better positioned and so less likely to be lost.

4.2.2 Hawksbill turtles

The 2003 Green Turtle Program recorded a higher number of hawksbill turtle encounters (16) than in 2002; indeed the very first encounter of the Program was a hawksbill. There were several weeks in July and August when numerous hawksbills were encountered, and on 3 August two individuals were recorded on the same night (See Appendix 1). What was very encouraging to observe, and that differed drastically from recent years, was that of the twelve individuals encountered, four had tags from previous years, thus suggesting that adult survivorship may be improving once they disperse from the nesting beach. Additionally, four turtles were observed on more than one occasion throughout the season.

4.2.3 Leatherback turtles

Harrison *et al*. (2003) includes a detailed review of the tagging of leatherback turtles at Tortuguero in 2003.

4.3 Biometric Data Collection

4.3.1 Green turtles

Mean carapace measurements of previously tagged females were greater than those of newly tagged individuals, both with or without evidence of old tags (See Table 2). For both research assistants and participants the precision of carapace measurements was high, varying less than 0.3m within an encounter. When the same turtle was encountered on more than one occasion the CCLmin was less precise than the SCLmax. This may result from greater individual variation in positioning the tape measure where the skin meets the carapace by the nuchal notch when taking the CCLmin measurements. In addition, new-style calipers were purchased for the 2003 Green Turtle Program; these were easier to use and improved the precision of SCLmax measurements from previous years (Harrison *et al.*, 2003).

Participants showed slightly lower precision than researchers for both CCLmin and SCLmax measurements. It is important, therefore, to ensure that everyone, but particularly participants, receives given adequate training prior to working with a turtle, and appropriate supervision whilst on the beach, to increase the accuracy of the data collected.

4.3.2 Hawksbill turtles

Newly tagged hawksbill females were found to be larger than previously tagged individuals, which is totally opposite to the situation found in green turtles. The precision of CCLmin measurements was equal to that of green turtles, but SCLmax measurements of hawksbills were slightly less precise than those of green turtles, which may have resulted if measurements were taken while the turtle was returning to the sea.

4.3.3 Leatherback turtles

Harrison *et al*. (2003) contains a full discussion of biometric data collection from leatherback turtles nesting in Tortuguero in 2003.

4.4 Fibropapilloma Assessment

4.4.1 Green turtles

The incidence of fibropapilloma was very low in 2003 (0.8%); just two females were found with tumors, of 238 individuals that were examined. All green turtles that are encountered are inspected for abnormalities, and any tumors are noted. Unfortunately no comprehensive study of fibropapilloma occurrence has been undertaken for the Tortuguero population, such research would be extremely worthwhile and should be contemplated for inclusion in future Green Turtle Programs.

4.5 Determination of Nest Survivorship and Hatching Success

4.5.1 Green turtles

Overall hatching and emergence success was within the range observed during recent years, around 68% (See Table 8b). Depredation was the single biggest threat to green turtle nests, both from natural predators such as coatis, or introduced predators, such as dogs (See Table 7). Disturbance of nests by dogs was particularly prevalent towards the end of the nesting season, when the majority of nests were hatching. Researchers frequently encountered groups of dogs on the beach in the early morning, searching for and excavating green turtle nests. The large numbers of feral dogs in Tortuguero village poses a potentially serious threat to both nests and hatchlings, and needs to be addressed, with the support of National Park personnel. A regular spaying and neutering program might be one possible solution to help reduce this particular problem. In August many dogs were deliberately killed by poisoning, and a smaller number were destroyed following a similar incident later in the season.

Few marked nests were poached (See Table 7), although this may belie the real levels of poaching of green turtle nests on the beach (See Appendix 3). All of the marked nests that

were poached were outside of the National Park limits, and close to the village and other easily accessible areas, such as the airstrip (See Figure 7).

In complete contrast to 2002, a very small number of nests were washed out by high tides. Throughout most of the season the beach suffered little from erosion. Ground water levels were also not high, so no nests were observed to have been inundated.

There was very little difference observed between egg counts at the time of oviposition and when the nest was excavated, a mean difference of 1.7 eggs was recorded, although the range was very large. Care must be taken to ensure that all personnel counting eggs are aware of the differences between yolked and yolkless eggs, to avoid confusion. Another factor to help reduce erroneous counts is to ensure that the count begins when oviposition commences, and not at a mid-way point when it is difficult to observe all eggs that have been laid. When excavating nests it is also important to remove the eggs with minimum disruption, to avoid splitting egg cases. This leads to a misrepresentation of the number of hatched eggs, as only shell fragments larger than 50% of an egg are counted.

The mean depth of green turtle nests was similar to that observed in previous years, and the average incubation period was also within the normal range.

The frequency of albinism, twins or deformed embryos was low in excavated nests (See Table 9), comparable to recent years. Any readily detectable increase in these types of defects should be monitored carefully, as they may indicate changes in chemical toxicity in the ocean, or on the beach.

4.5.2 Hawksbill turtles

A good proportion of the hawksbills observed were encountered prior to nesting and so the clutches were counted and the nests monitored. The mean number of eggs per clutch was considerably greater than that of green turtles (See Tables 8b and 10), and hawksbill nests took longer to incubate. Hatching and emerging success were similar for both species, although if only undisturbed nests were considered, hawksbills were far more successful (See Table 8b and 10). Predation, by ants and humans, was the only cause of loss of hawksbill nests.

4.5.3 Leatherback turtles

No leatherback nests were marked during the 2003 Green Turtle Program, however, a detailed review of leatherback nest survivorship and hatching success can be found in Harrison *et al*. (2003).

4.6 Physical Data Collection

4.6.1 Rainfall

As was observed in 2002, May was the wettest month of the year, and this may have negatively impacted leatherback nests laid at that time. However, for the 2003 Green Turtle Program, it was the months of July and August that showed the highest rainfall (See Tables 11 and 13). This appeared to have no significant effect on the fate of green turtle nests,

although there may have been an associated reduction in sand temperature, with resultant impacts on development time.

4.6.2 Air temperature

Despite high rainfall in May the mean monthly air temperature remained high, although in July and August, when high levels of rain were recorded there was an impact on air temperatures.

4.6.3 Sand temperature

Several problems were encountered due to the failure of the data loggers (See Table 15), and hence data were incomplete for all zones at each depth. Barring this complication, the heavy rains experienced in May, July and August resulted in lowering the sand temperatures.

It is hoped that the replacement of the old-style data loggers with TidBit (Onset Computer Corp.) models that are housed in a protective casing will reduce the effects of the extreme environmental conditions encountered on the beach.

4.6.4 Ground water level

Ground water levels were often not detectable in the tubes, suggesting that there would be no impact on green turtle nests. However, this result could in part be due to the location of the tubes on the beach, and it is suggested that they be moved to an area with a sloping incline in future years.

4.7 Collection of Human Impact Data

4.7.1 Visitors to Tortuguero

The trend that has been seen over the last few years, that of a huge increase in the number of visitors that annually come to Tortuguero National Park and the CCC visitor centre, continued throughout 2003 (See Tables 16 and 17). The revenue generated by the park entrance fees (~ US$335,000) is substantial. Unfortunately, however, this money does not remain within the Tortuguero Conservation Area, and so is not available to help finance the National Park. In addition, the continuing growth of tourism must be regulated to limit the negative impacts on the natural resources that the influx of such large numbers of people will create.

4.7.2 Capacity of hotels and cabinas

The capacity of the local lodges, hotels and cabinas increased in 2003, and Tortuguero can now accommodate over 1,000 visitors at any given time. During the 2003 Green Turtle Program many of the larger hotels were undergoing expansion and it is likely that there will be a further increase in capacity within the next year, once these projects have been completed. Again, such growth in capacity needs to be monitored, so that the economic benefits of tourism to the community are not negated by associated problems created by the additional volume of visitors.

4.7.3 Turtle tours

The popularity of turtle tours in Tortuguero continued to grow during 2003, with almost 33,000 visitors participating in guided walks on the beach (See Table 17). Almost 60% of all permits were issued in the months of July and August, coinciding with peak green turtle nesting (Figure 1). Many difficulties were encountered during the 2003 Green Turtle Program, with respect to the guiding system of the turtle tours. Principally these problems were related to the manner in which permits were issued to guides each day. At the start of the season the system was that which had been in place for several years; a list was posted at 6.00am each morning, on which guides who wanted permits for that night could write their name. At 5.00pm guides went to the National Park headquarters (Cuatro Esquinas) to obtain their permit. Because there was a limited number of permits granted per day, guides began arriving early to wait for the list to be posted at the information kiosk in the centre of the village. Over the course of several weeks guides starting arriving earlier each day until, in August, many people were sleeping in the kiosk to try and gain a place on the list. The situation quickly became unacceptable to National Park personnel, and a change in the system occurred. With the new system, the guides went to Cuatro Esquinas each day at 5.00pm and there was a lottery to award the permits. This was not seen as a permanent solution to the problem, and several meetings of the guide association in conjunction with ACTo personnel occurred to discuss alternative solutions which will hopefully be implemented for the 2004 green turtle season.

4.7.4 Artificial lights

Many lights are still visible on the beach, mainly street and house lights in the village, although lights from several of the larger hotels north of the CCC station can also be seen (See Table 18). Unfortunately, the shades of many of the street lights close to the beach, that had been installed by the Costa Rican Electricity Institute (ICE) in 2002, had either been lost or removed prior to the start of the 2003 Green Turtle Program, and so they once again created a light pollution issue on the beach in front of the village. It is important that the CCC sets a good example and covers all the remaining lights at the station prior to the start of the 2004 nesting season. Hotel owners, both of the lodges and the smaller cabinas in the village, should be approached with information about the lights which are visible from their particular establishments. In addition, a program of awareness within the community would alert homeowners to the problems created for nesting turtles that result from light pollution on the beach.

4.7.5 Hatchling orientation

A limited number of nests were included in the hatchling orientation study (See Table 19), however, only a very small number of disorientated hatchlings were recorded signifying that there is very little impact from the village lights.

4.8 Environmental Education Activities

The program of environmental education activities at the Tortuguero school was instigated in 2003, and so there were the inevitable problems associated with the introduction of any new system. These included limited communication with the director of the school, who lives outside of the village, and the somewhat erratic nature of the school timetable which was apt to change without prior warning before our scheduled visits. The implementation of

a more structured weekly session, planned at the start of the season would help alleviate such problems in the future. An extension of the scoop of these activities, to incorporate sessions with the high school, and lower grade students is also envisaged for future Programs. A more focused series of lessons, encompassing sea turtle biology, conservation theory and general principles in biology and ecology would be beneficial.

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Figure 1. Seasonal distribution of green turtle nesting activity as determined by track surveys from Tortuguero river mouth (mile -3/8) to Jalova lagoon (mile 18).

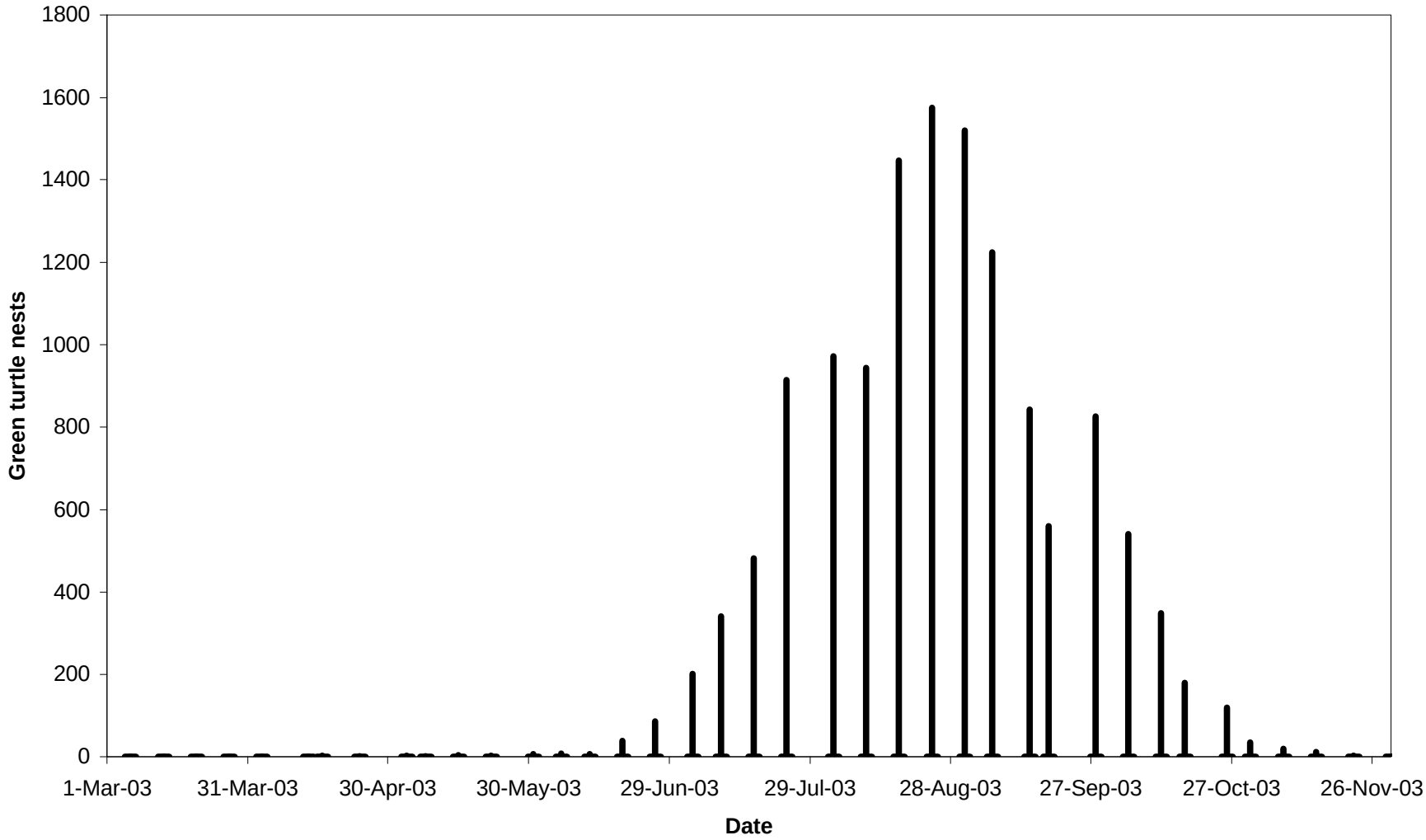


Figure 2. Spatial distribution of green turtle nesting activity as determined by track surveys from Tortuguero river mouth (mile -3/8) to Jalova lagoon (mile 18).

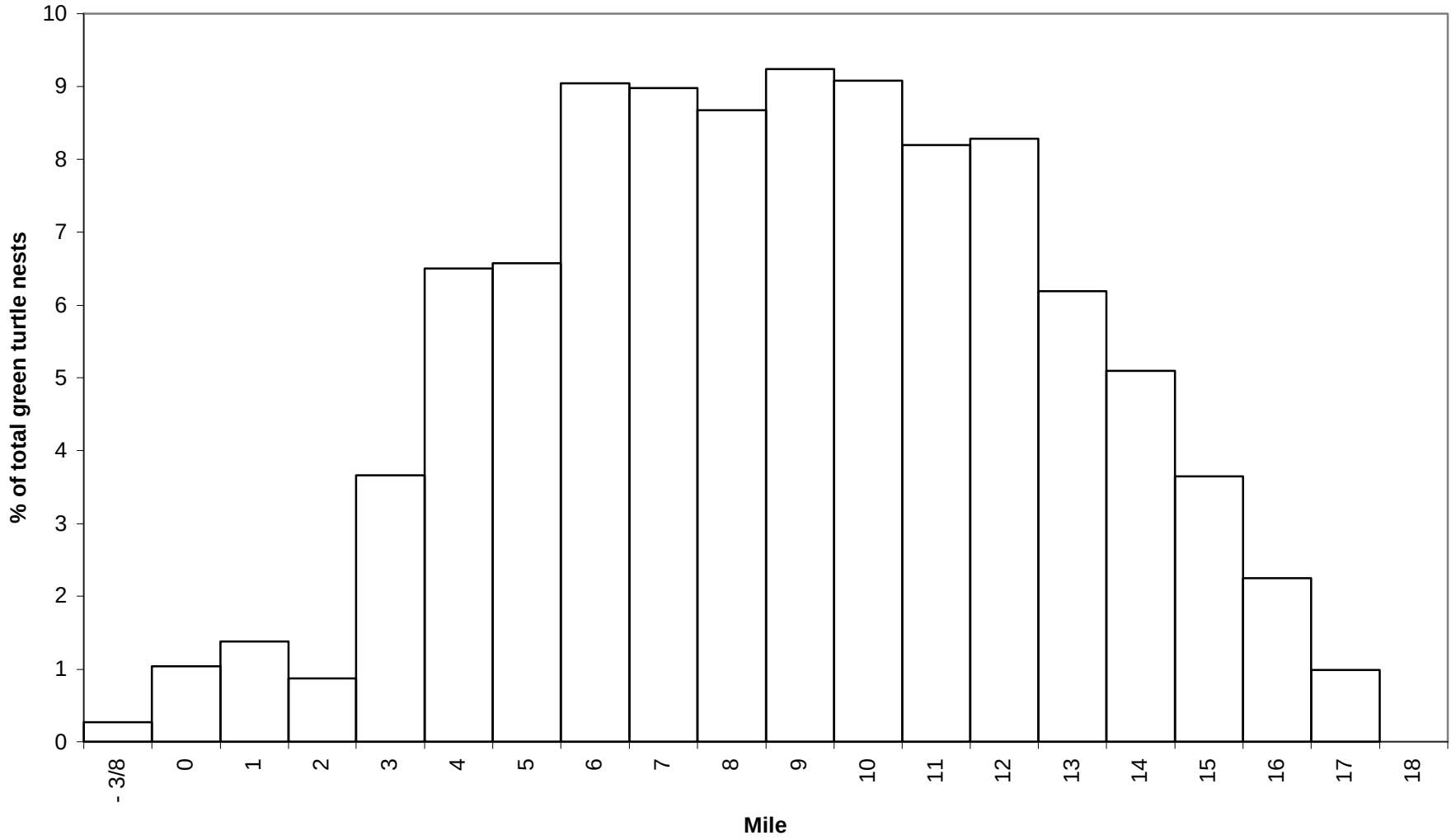


Figure 3. Illegal take of green turtles as determined by track surveys from Tortuguero river mouth (mile -3/8) to Jalova lagoon (mile 18).

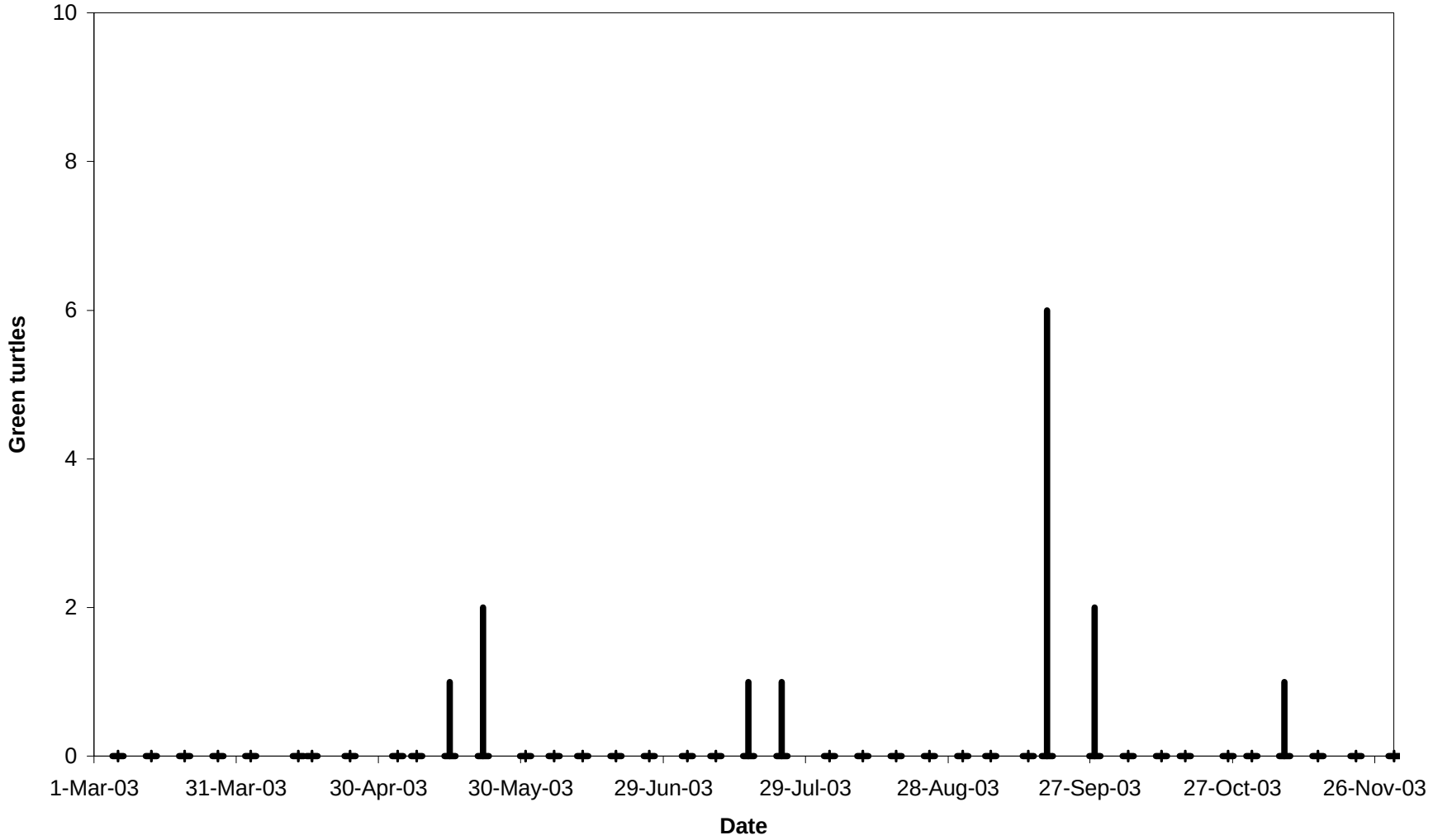


Figure 4. Green turtles killed by jaguars from Tortuguero river mouth (mile -3/8) to Jalova lagoon (mile 18).

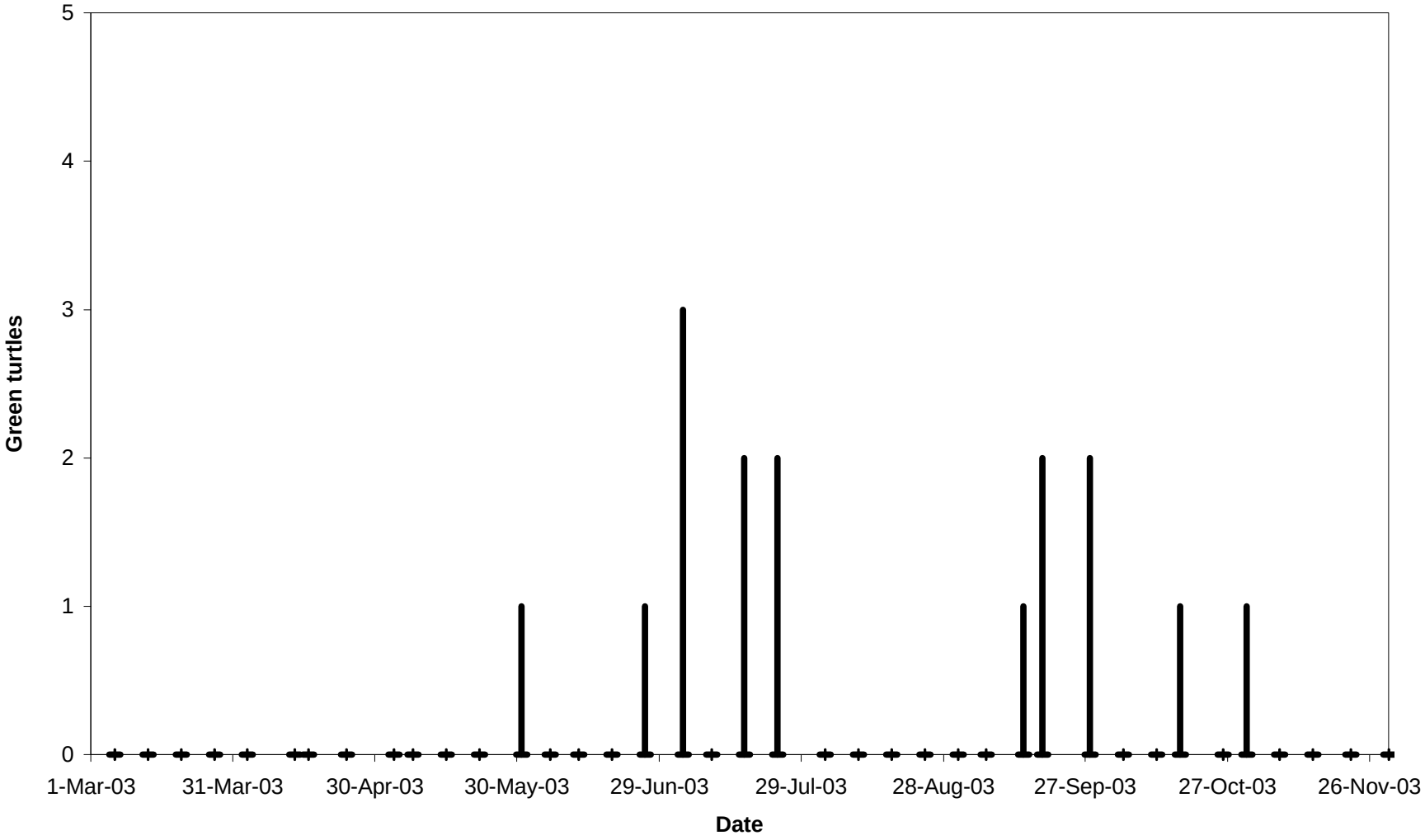


Figure 5. Seasonal distribution of hawksbill nesting activity as determined by track surveys from Tortuguero river mouth (mile -3/8) to Jalova lagoon (mile 18).

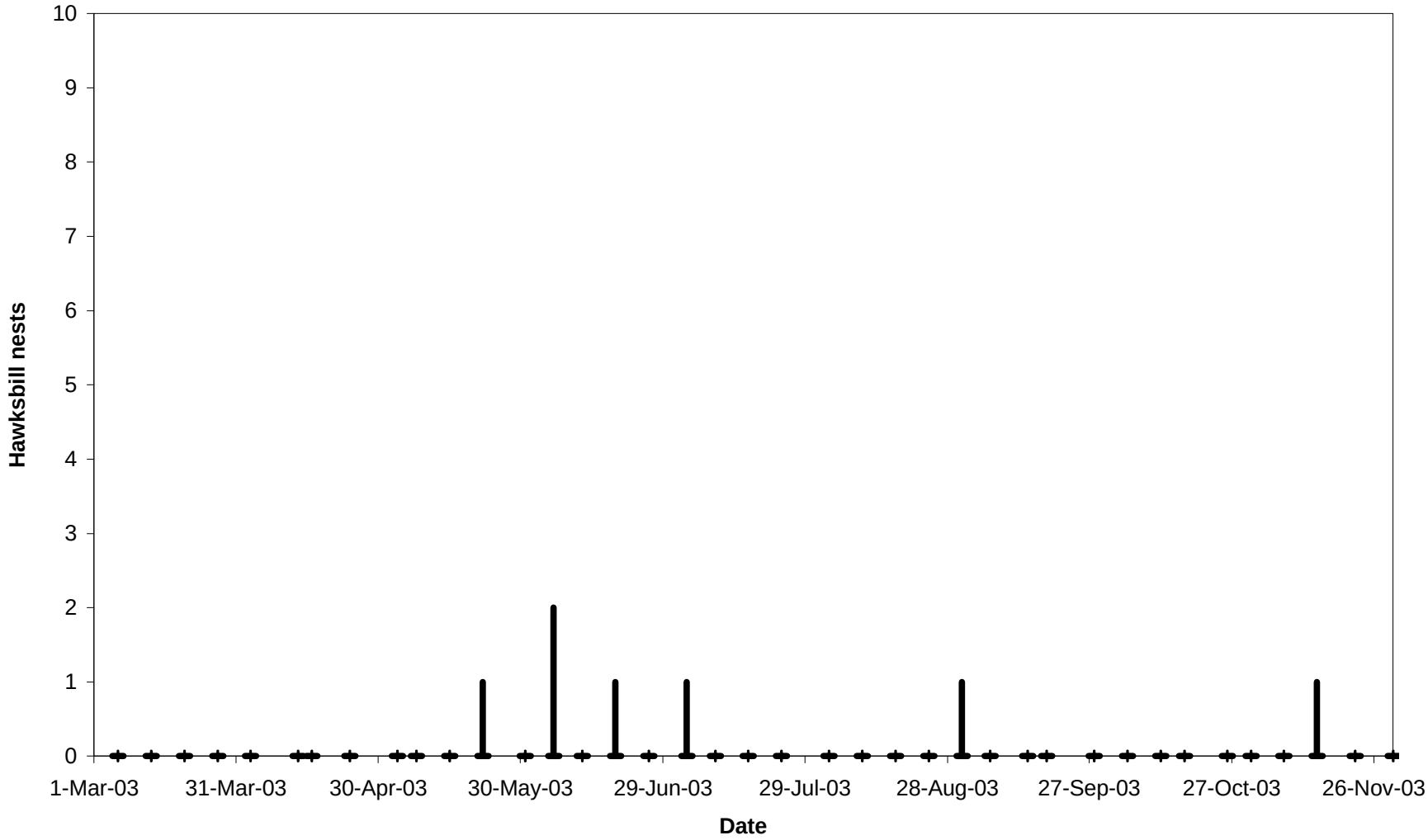


Figure 6. Seasonal distribution of leatherback nesting activity as determined by track surveys from Tortuguero river mouth (mile -3/8) to Jalova lagoon (mile 18).

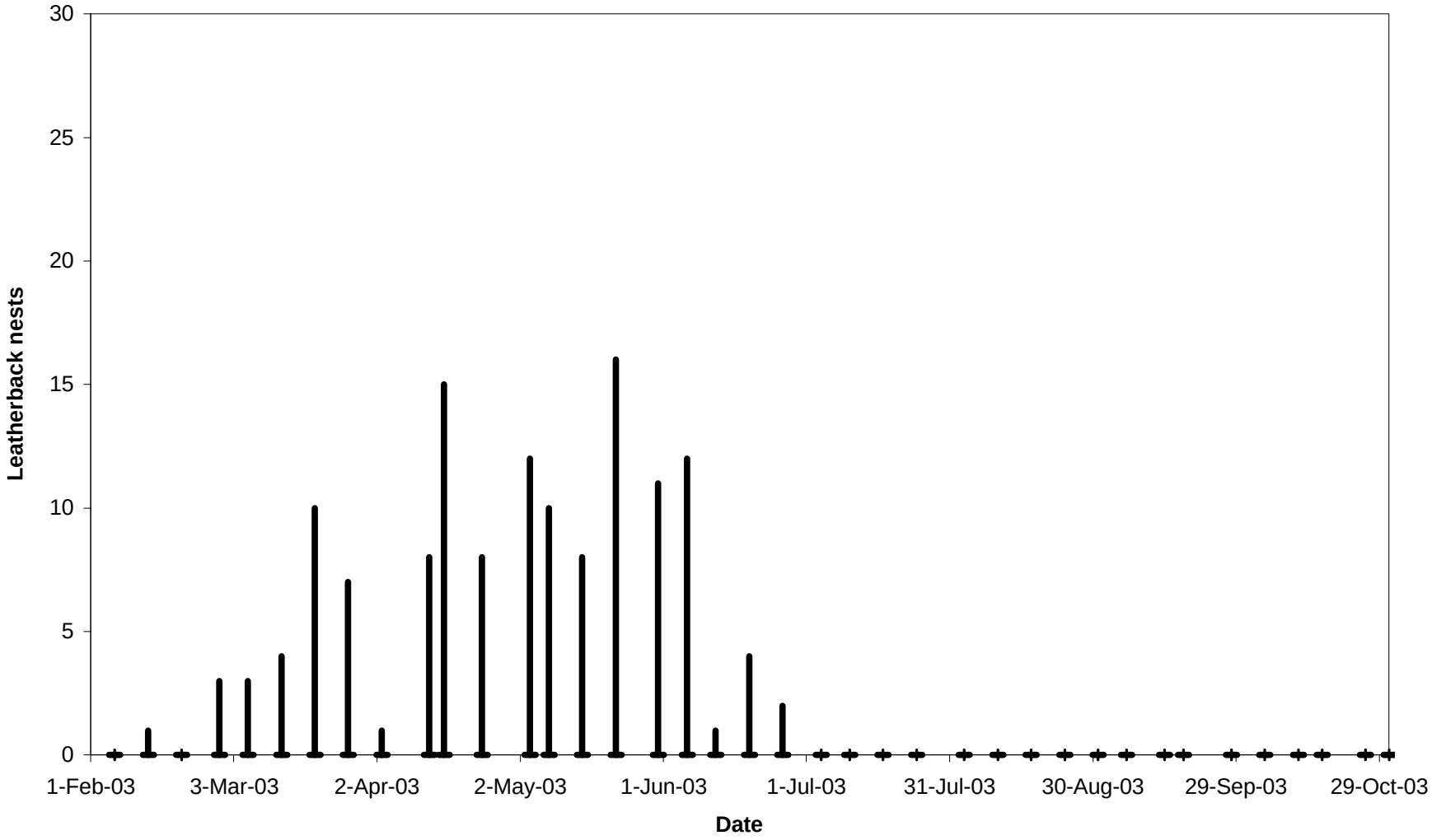


Figure 7. Spatial distribution of marked and subsequently poached nests.

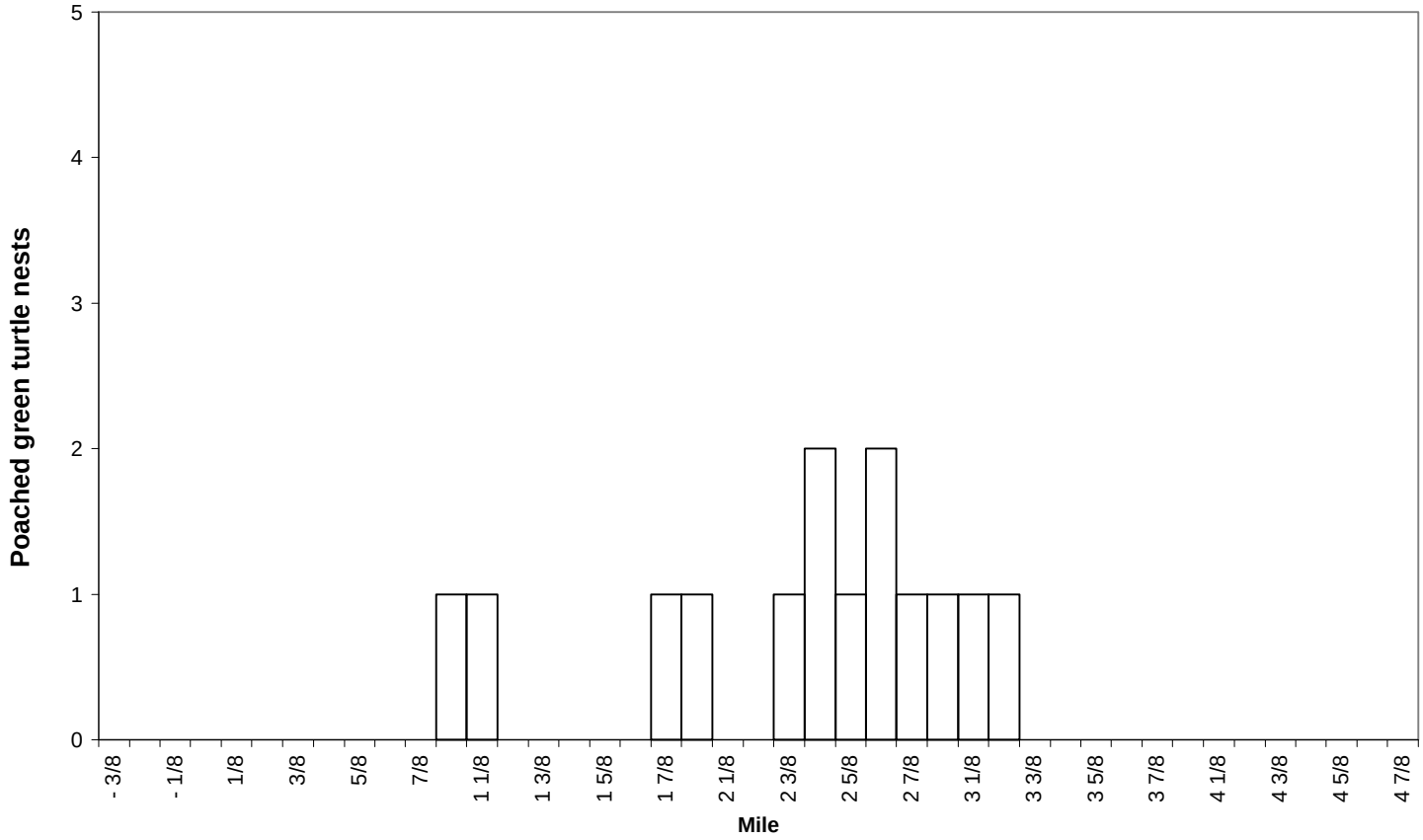


Figure 8. Sand temperatures.

Figure 8a. Sand temperature at 70 cm depth, open zone.

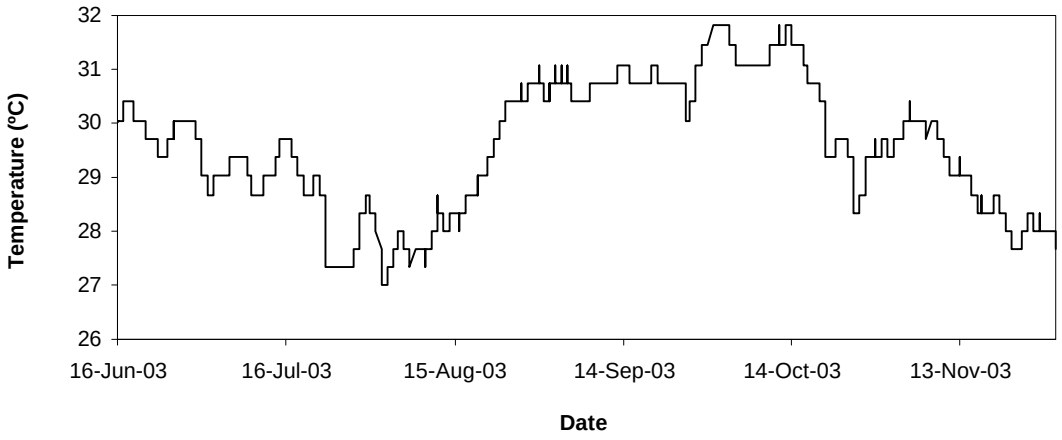


Figure 8b. Sand temperature at 70 cm depth, border zone.

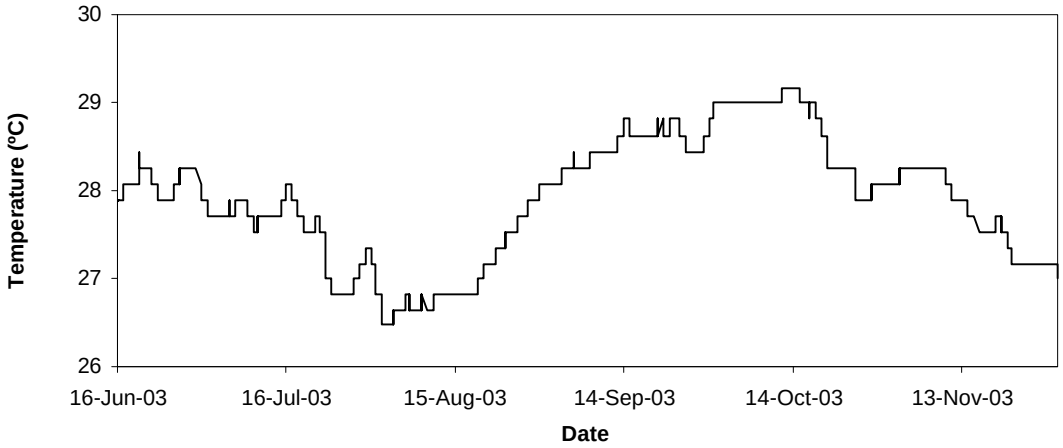


Figure 8c. Sand temperature at 70 cm depth, vegetation zone.

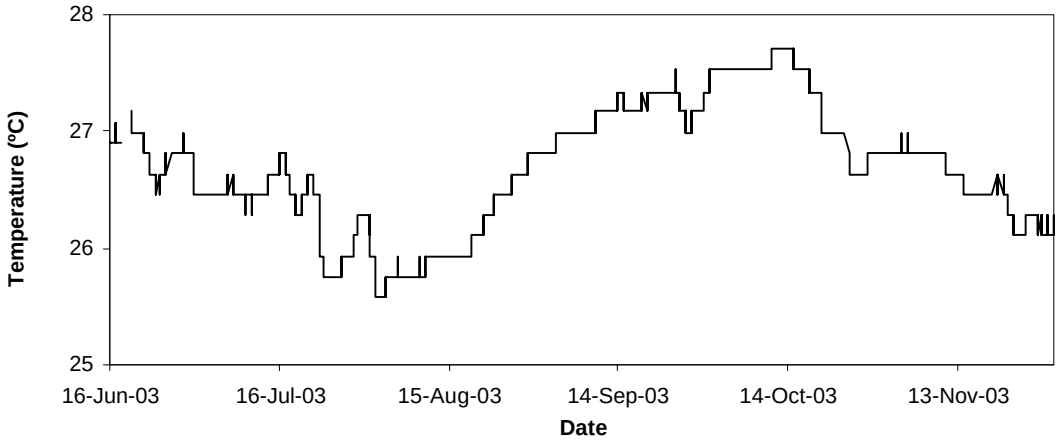


Figure 9. Recaptures of green turtles tagged at Tortuguero, by country.

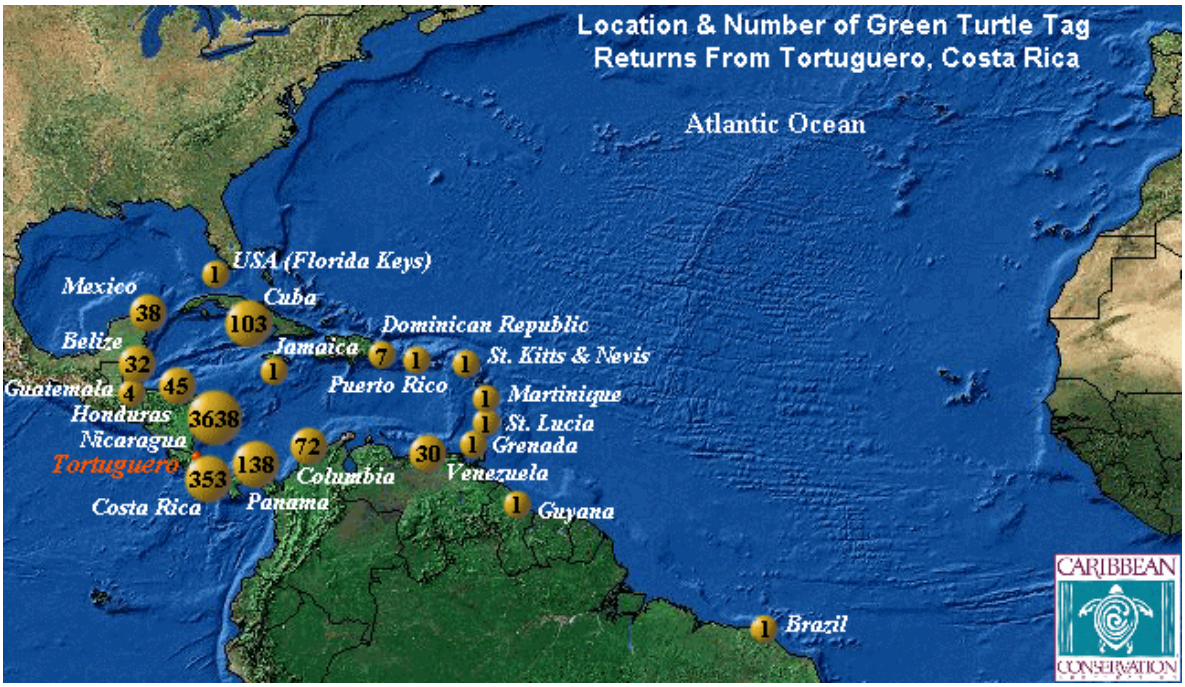
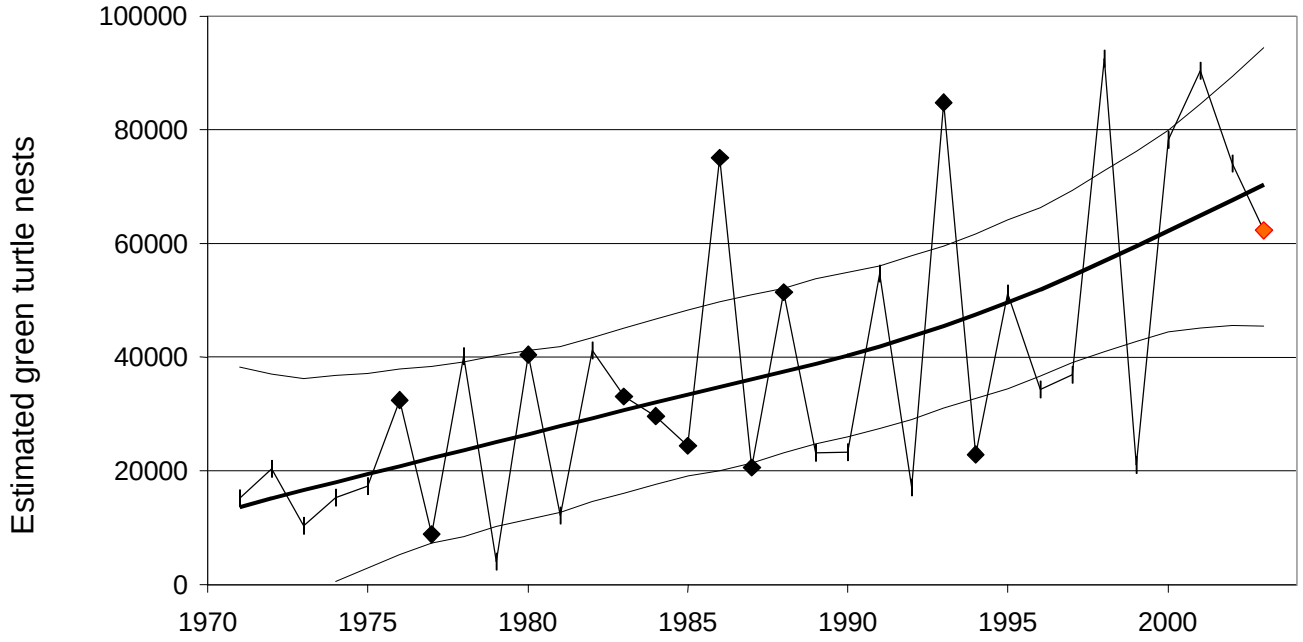


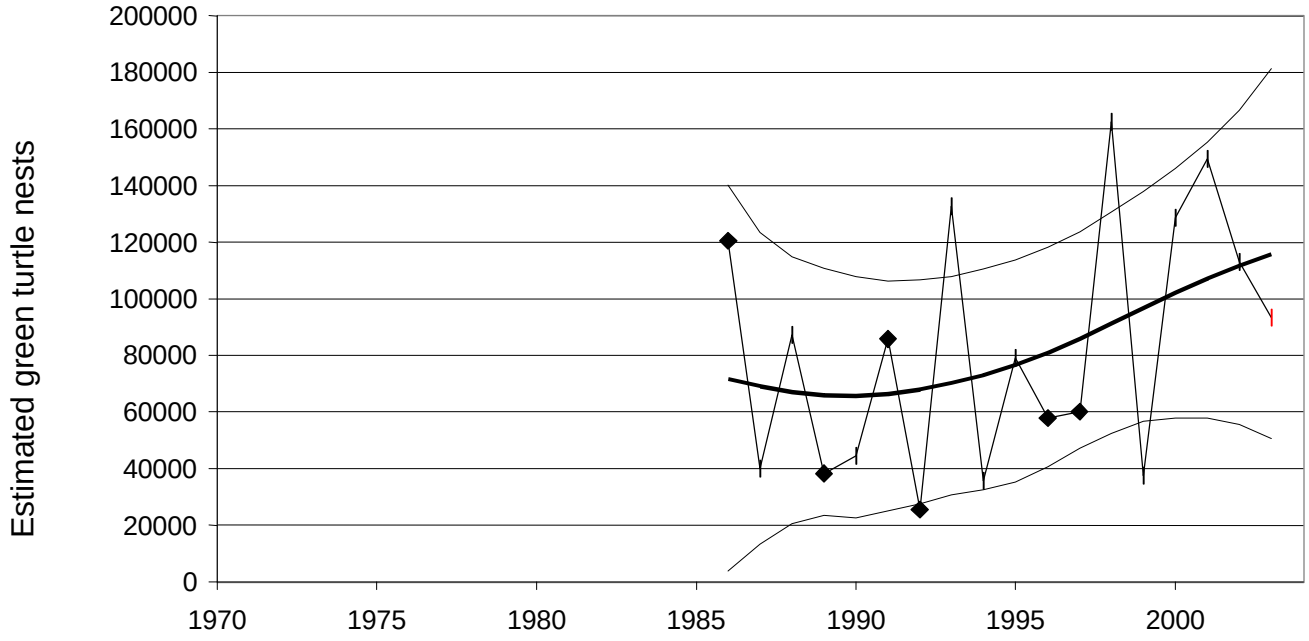
Figure 10. Green turtle nesting trend at Tortuguero.

For analysis methodology consult Troëng & Rankin (in press).

10a. Northern 18 km



10b. Entire beach



APPENDIX 1. Sea Turtle Encounters During Regular Night Patrols

	Leatherback turtles				Green turtles				Hawksbill turtles			
Date	Newly tagged	Previously tagged	Renester	Total	Newly tagged	Previously tagged	Renester	Total	Newly tagged	Previously tagged	Renester	Total
16-Jun-03				0				0		1		1
17-Jun-03				0				0				1
18-Jun-03				0				0				1
19-Jun-03				0				0				1
20-Jun-03				0	1		1	2	1			2
21-Jun-03				0				2				2
22-Jun-03				0				2				2
23-Jun-03				0	1	1		4				2
24-Jun-03		1		1	1	1		6				2
25-Jun-03		1		2	1			7				2
26-Jun-03				2	2	2		11			1	3
27-Jun-03			1	3		1		12				3
28-Jun-03				3	1	1	1	15				3
29-Jun-03	1			4	7	5		27				3
30-Jun-03				4		3	1	31		1		4
1-Jul-03				4	4	3	1	39	1			5
2-Jul-03				4	2	3		44		1		6
3-Jul-03				4	3	4		51				6
4-Jul-03				4	4	3	1	59	1			7
5-Jul-03				4	5	5	1	70				7
6-Jul-03				4	3	3		76				7
7-Jul-03			1	5	3	9	1	89				7
8-Jul-03				5	8		2	99				7
9-Jul-03				5	6	7		112				7
10-Jul-03				5	3	3		118				7
11-Jul-03				5	3	3	2	126				7
12-Jul-03				5	5	10	3	144				7
13-Jul-03				5	11	6	3	164				7
14-Jul-03				5	8	4	1	177				7
15-Jul-03				5	4	6	6	193				7
16-Jul-03				5	9	6	2	210				7
17-Jul-03				5	6	1	3	220				7
18-Jul-03				5	11	6	5	242				7
19-Jul-03				5	13	4	4	263				7
20-Jul-03				5	6	5	4	278				7
21-Jul-03				5	6	3		287				7
22-Jul-03				5	1		2	290				7
23-Jul-03				5	8	8	6	312				7
24-Jul-03				5	8	8	4	332				7
25-Jul-03				5	3	7	2	344				7
26-Jul-03				5	12	5	1	362				7
27-Jul-03				5	6	3	2	373				7
28-Jul-03				5	9	2	2	386				7
29-Jul-03				5	7	2	5	400				7
30-Jul-03				5	4	2	2	408				7
31-Jul-03				5	2	3	2	415				7

1-Aug-03		5	9	5	3	432			1	8
2-Aug-03		5	8	8	7	455				8
3-Aug-03		5	10	3	1	469	1		1	10
4-Aug-03		5	12	8	6	495	1			11
5-Aug-03		5	12	4	5	516				11
6-Aug-03		5	14	2	8	540				11
7-Aug-03		5	9	9	6	564				11
8-Aug-03		5	17	9	2	592				11
9-Aug-03		5	5	11	4	612				11
10-Aug-03		5	15	11	5	643				11
11-Aug-03		5	3	2	3	651				11
12-Aug-03		5	13	3	7	674				11
13-Aug-03		5	9	4	11	698				11
14-Aug-03		5	15	2	9	724				11
15-Aug-03		5	8	2	6	740				11
16-Aug-03		5	10	11	9	770				11
17-Aug-03		5	8	3	6	787	1			12
18-Aug-03		5	7	3	7	804				12
19-Aug-03		5	13	4	15	836				12
20-Aug-03		5	13	1	3	853				12
21-Aug-03		5	13	7	5	878		1		13
22-Aug-03		5	24	4	11	917				13
23-Aug-03		5	6	2		925				13
24-Aug-03		5	5	1	3	934				13
25-Aug-03		5	5	5	9	953				13
26-Aug-03		5	9	4		966				13
27-Aug-03		5	8	9	8	991				13
28-Aug-03		5	9	4	3	1007				13
29-Aug-03		5	6	3	3	1019				13
30-Aug-03		5	14	2	3	1038				13
31-Aug-03		5	9	5	9	1061				13
1-Sep-03		5	4		1	1066				13
2-Sep-03		5	7	1	7	1081				13
3-Sep-03		5	12	3	5	1101				13
4-Sep-03		5	12	4	7	1124				13
5-Sep-03		5	9	3	4	1140				13
6-Sep-03		5	18	10	10	1178			1	14
7-Sep-03		5	14	2	8	1202				14
8-Sep-03		5	18	7	9	1236				14
9-Sep-03		5	10	4	13	1263				14
10-Sep-03		5	18	4	10	1295				14
11-Sep-03		5	4	4	10	1313				14
12-Sep-03		5	9	3	1	1326	1			15
13-Sep-03		5	17	2	3	1348				15
14-Sep-03		5	28	7	11	1394				15
15-Sep-03		5	9	4	2	1409				15
16-Sep-03		5	4	4	10	1427	1			16
17-Sep-03		5	7	1	4	1439				16
18-Sep-03		5	10	1	4	1454				16
19-Sep-03		5	11	2	9	1476				16
20-Sep-03		5	16	2	8	1502				16
21-Sep-03		5	2		7	1511				16

22-Sep-03				5	12	1	5	1529			16
23-Sep-03				5	11	3	3	1546			16
24-Sep-03				5	22	1	9	1578			16
25-Sep-03				5	13	3	5	1599			16
26-Sep-03				5	13	3	9	1624			16
27-Sep-03				5	13	2	13	1652			16
28-Sep-03				5	15	1	7	1675			16
29-Sep-03				5	10		6	1691			16
30-Sep-03				5	16	3	5	1715			16
1-Oct-03				5	6	2	2	1725			16
2-Oct-03				5	9	4	8	1746			16
3-Oct-03				5	17	2	7	1772			16
4-Oct-03				5	13	1	4	1790			16
5-Oct-03				5	9	1	7	1807			16
6-Oct-03				5	14	1	3	1825			16
7-Oct-03				5	6	1	6	1838			16
8-Oct-03				5	5	1	5	1849			16
9-Oct-03				5	3	2	2	1856			16
10-Oct-03				5	16	2	9	1883			16
11-Oct-03				5	18	1	3	1905			16
12-Oct-03				5	17	2	5	1929			16
13-Oct-03				5	3	4	3	1939			16
14-Oct-03				5	3	1	13	1956			16
15-Oct-03				5	4	1	1	1962			16
16-Oct-03				5	3		6	1971			16
17-Oct-03				5	5	4	3	1983			16
18-Oct-03				5				1983			16
19-Oct-03				5	3		2	1988			16
20-Oct-03				5	5		2	1995			16
21-Oct-03				5	3	1	4	2003			16
22-Oct-03				5	5	1	5	2014			16
23-Oct-03				5	2		2	2018			16
24-Oct-03				5				2018			16
25-Oct-03				5	4	1	4	2027			16
26-Oct-03				5	2		4	2033			16
27-Oct-03				5	3		2	2038			16
28-Oct-03				5	1		1	2040			16
29-Oct-03				5	4		2	2046			16
30-Oct-03				5		1	1	2048			16
TOTAL	**1**	**2**	**2**	**5**	**1062**	**418**	**568**	**2048**	**8**	**4**	**16**

APPENDIX 2. Sea Turtle Encounters During Additional Night Patrols

Date	Section	Green Turtles			Total
		Newly tagged	Previously tagged	Renesters	
9-Sep-03	Mile 5-8	20	2	3	25
11-Sep-03	Mile 5-7	25	7	4	36
12-Sep-03	Mile 5-7	20	4	1	25
15-Sep-03	Mile 5-7	22		1	23
16-Sep-03	Mile 5-7 4/8	23	1	1	25
18-Sep-03	Mile 5-7 4/8	25		1	26
21-Sep-03	Mile 5-7	22	1	2	25
23-Sep-03	Mile 5-7 4/8	23		1	24
25-Sep-03	Mile 5-7	22			22
	TOTAL	**202**	**15**	**14**	**231**

APPENDIX 3. Notes and Anecdotal Information on Illegal Take of Turtles

CCC personnel recorded 47 poaching incidents from June to October 2003. Poaching or attempted poaching of 32 nests accounted for 26 records and the remaining 21 incidents involved poaching or attempted poaching of a total of 24 nesting green turtles. Four of the 24 green turtles were discovered alive and released by CCC research assistants, tour guides, park rangers or villagers. Poaching of three hawksbill turtles was also recorded; one of the three hawksbill turtles was released alive.

In addition, the CCC track surveyor recorded the poaching of 14 green turtles and 147 green turtle nests during the weekly 18-mile surveys.