

# **REPORT ON THE 2006 GREEN TURTLE PROGRAM AT TORTUGUERO, COSTA RICA**

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Caribbean Conservation Corporation  
and the Ministry of Environment and Energy of Costa Rica.  
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# Executive Summary

## Monitoring and Research Activities Conducted

- 1 During 2006, a total of 53 track surveys were conducted along the entire 18 miles of beach between Tortuguero river mouth and Jalova lagoon.
- 2 Green turtle nesting was observed between 19 March and 9 December, 2006, with peak nesting recorded on 5 August when 1,115 nests were counted.
- 3 An estimated 84,383 green turtle nests were laid during 2006.
- 4 A total of 10.2% 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 During daily track surveys conducted by research assistants between 15 June and 31 October, a total of 16,273 green turtle nests and 14,129 green turtle half-moons were recorded between the Tortuguero river mouth and the mile 5 marker.
- 6 The track surveyor recorded the illegal take of one nesting green turtle during a track survey in April, 2006. Green turtle nest poaching was recorded during five track surveys from March to October; 28 green turtle nests were recorded as poached, 14 of which were in one track survey in October.
- 7 Jaguars killed a minimum of 28 green and two hawksbill turtles in 2006.
- 8 Hawksbill nesting density was very low throughout the season, with 0-2 nests/night recorded between June and October.
- 9 A total of 1,059 green turtles were newly tagged, 573 green turtles with tags from previous years and 477 reneesters were recorded during 2,070 team hours of night patrols between 12 June and 29 October.
- 10 47 of the previously tagged turtles had been originally tagged more than 10 years ago; one turtle was first tagged in 1984, and was subsequently seen in 1988, 1998, 2001 and 2003. There was also one turtle seen in 2006 that was observed nesting in 2005.
- 11 Sixteen green turtles from other projects were encountered nesting in 2006; four were tagged on the beach in Pacuare Nature Reserve and 12 were tagged by researchers from Caño Palma, north of the Tortuguero river mouth.
- 12 Overall probability of within-season tag loss from first to last encounter was low at 2.2%, and there was considerable variation between taggers and between months.
- 13 Newly tagged green turtles had evidence of old tag holes or notches in at least one front flipper in 12.9% of cases.
- 14 Tagging efficiency for night patrols varied from 0 – 60%, with a mean of 6.9%, for nights preceding track surveys (n = 169).
- 15 Green turtles encountered during night patrols nested in the open zone in 33.9% of cases (n = 703), 45.9% (n = 953) were located in the border zone and 13.8% (n = 286) in the vegetation zone. 6.5% of turtles were encountered during a half-moon (n = 134).

- 16 Four hawksbill turtles were newly tagged, and five previously tagged hawksbills were encountered during the 2006 Green Turtle Program.
- 17 Three of the hawksbill nests were laid in the open zone, four nested in the border zone, one nested in the vegetation zone, and one hawksbill did not lay.
- 18 Six leatherback turtles were encountered during the 2006 Green Turtle Program; all were re-encounter females that had been seen during the 2006 Leatherback Program.
- 19 Mean carapace length for newly tagged green turtle females without evidence of previous tagging was 104.1cm (CCLmin) and 99.3cm (SCLmax); for newly tagged green turtle females with old tag holes or notches 104.5cm (CCLmin) and 98.9cm (SCLmax), and for previously tagged females 105.7cm (CCLmin) and 99.9cm (SCLmax). Mean clutch size for the same groups of females was 108 eggs, 119 eggs and 104 eggs, respectively.
- 20 Measurement precision of green turtles was the same for CCLmin than for SCLmax within a single encounter. For turtles encountered two to five times, the SCLmax measurements were more precise.
- 21 Mean carapace length for newly tagged hawksbill turtles was 91.9cm (CCLmin) and 86.4cm (SCLmax) and for previously tagged individuals 87.8cm (CCLmin) and 82.2cm (SCLmax).
- 22 Mean carapace length of previously tagged leatherbacks was 148.9cm (CCLmin).
- 23 A total of 15 green turtles representing 9.4% of 160 carefully examined individuals were recorded as having fibropapilloma tumors.
- 24 A total of 204 green turtle nests were marked and the fate was determined for 166 nests. Overall hatching success is estimated at 82.7% (15,834 empty shells from 19,155 eggs) and overall emerging success at 81.4% (15,584 hatchlings from 19,155 eggs).
- 25 The biggest cause of nest loss was other nesting females digging up nine nests (5.4%), depredation affecting seven nests (4.2%) and poaching affecting three nests (1.8%).
- 26 Comparison between egg counts at excavation and the moment of oviposition showed a mean difference of 5 more eggs counted at the time of laying.
- 27 Mean depth for undisturbed green turtle nests (n = 131) at excavation was 61.7cm from the sand surface to the top egg and 77.4cm to the bottom of the egg chamber.
- 28 The mean incubation period for undisturbed green turtle nests (n = 23) was 57 days.
- 29 A total of two albino, two twin, and four deformed embryos were observed in unhatched eggs in undisturbed nests, accounting for 0.06% of eggs.
- 30 Two hawksbill nests were monitored and their fate determined. Overall hatching success was 83.5% (167 empty shells from 200 eggs) and overall emerging success was 83.5% (167 emerged hatchlings from 200 eggs).
- 31 Mean depth for hawksbill nests (n = 2) at excavation was 40.5cm from the sand surface to the top egg and 55cm to the bottom of the egg chamber.
- 32 August was the wettest month of the 2006 Green Turtle Program (640.4mm) and October was the month with least rain (171.9 mm).

- 33 Mean minimum air temperature was lowest in January and November; mean maximum air temperature was highest in February.
- 34 Mean monthly sand temperatures were highest in June (open zone), October (border and vegetation zone) and lowest in November (all zones).
- 35 A total of 32,733 persons visited the CCC Natural History and Visitors Center in 2006.
- 36 Tourist visitation to Tortuguero National Park (TNP) increased significantly in 2006, to 101,344 paying visitors. Entrance fees to Tortuguero Conservation Area (TNP) and Barra del Colorado Wildlife Refuge) raised a total of ₡239,497,070 (~ US\$461,392).
- 37 The capacity of hotels and cabinas in the Tortuguero area increased to 658 rooms and bed capacity increased to 1,760 beds. This increase was due to the reopening of Manatus Lodge and Cabinas Sabina in Tortuguero village.
- 38 A total of 35,662 tourists were issued permits to go on guided turtle tours in 2006; an average of 224 tourists per night during the green turtle season (July – October).
- 39 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. Numerous lights from cabinas, lodges, houses and the CCC station that are located behind the beach, north of the village, were also visible as well as lights from houses and street lights in San Francisco, and Tortuga Lodge on the other side of the river.
- 40 The mean angular range of green turtle hatchlings crawling from nests (n = 46) was 40° if outliers were excluded and 53° if outliers were included. For leatherback nests (n = 10) the angular range of hatchlings was 33.6° (outliers excluded) and 43.4° degrees (outliers included).
- 41 Several environmental education activities were carried out during the 2006 Green Turtle Program including a workshop on lighting and the impact on turtles for the community of Tortuguero, training for researchers and turtle spotters, and turtle conservation presentations for students at the local school and high school.

## **Conclusions**

- 1 The vast majority of green turtle nesting was observed between July and October.
- 2 Daily track surveys conducted by the research assistants are essential to evaluate the effectiveness of the management actions aimed at reducing the impact of tourism visitation.
- 3 Daily track surveys showed that illegal take of green turtle females and nests continued throughout the nesting season, and was concentrated on a section of beach north of the airport.
- 4 The number of green turtles killed by jaguars is very small in comparison to the number of nesting green turtles and is not likely to represent a serious survival threat to the Tortuguero green turtle population.
- 5 For green turtles measured on two or more occasions, SCLmax had greater precision than the CCLmin measurements.
- 6 The frequency of albinism, twins, triplets and deformed embryos was very low in 2006.
- 7 The continued implementation of the new turtle-tour visitation system, which began as a pilot project in 2004, has been successful in reducing the impact on nesting turtles.

## Recommendations

- 1 It is strongly suggested that daily track surveys by the research assistants 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.
- 2 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.
- 3 To ensure increased hawksbill nesting in the future any action aimed at protecting nesting females and nests, or females in the inter-nesting habitat, should be encouraged. Efforts by researchers to ensure the survival of hawksbill nests on the beach should be continued.
- 4 CCC should conduct analyses to quantify tag loss and survival probabilities on an annual basis.
- 5 There is a need for increased coordination and data exchange between sea turtle conservation and monitoring projects being undertaken along the Caribbean coast of Costa Rica.
- 6 A training video might be an effective way of ensuring that all Research Assistants and volunteer participants. This could include a section on turtle nesting behavior to improve classification of the different stages of the process and all aspects of the monitoring protocol - tagging, carapace measurements and nest marking.
- 7 SCLmax should remain the standard Tortuguero green turtle carapace measurement.
- 8 Better training on identification of fibropapilloma tumors, including photographs of infected turtles, would ensure positive identification of this disease among the Tortuguero population.
- 9 Greater emphasis should be placed on ensuring that the fate of marked nests is determined, and to ensure that Research Assistants are adequately trained to identify poaching, predation, disturbance and also signs of nest emergence to reduce the number of nests of unknown fate, and to facilitate excavations soon after emergence of hatchlings.
- 10 Collection of physical data should be conducted on a daily basis throughout the year, to monitor changes in environmental conditions in Tortuguero.
- 11 The CCC Natural History and Visitors Center urgently needs new and more varied displays to attract more visitors.
- 12 It is suggested that the new turtle tour visitation system be continued and that monitoring to evaluate its success be maintained.
- 13 It would be desirable to establish a sustainable funding mechanism to ensure the new visitation system can be implemented throughout the green turtle nesting season, such as a fee for each person participating in the turtle-tours.
- 14 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.
- 15 It would be desirable to develop a more structured environmental education program for the school and high school in future programs, and to conduct similar activities in the school in San Francisco village.



# 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. In preparation for 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 2006 Green Turtle Program represents the ninth consecutive year of implementing the revised monitoring protocol.

The objectives of this report are to summarize and discuss the 2006 Green Turtle Program results and provide recommendations for future sea turtle programs, conservation efforts and research activities in Tortuguero.

## 2. Methods

### 2.1 Preparations

The research assistants (RAs) arrived in Tortuguero on 12 June, 2006. The Program commenced with a training week that included theoretical sessions on sea turtle biology and nesting behavior, and a comprehensive review of the monitoring protocol. There were also practical 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 at the start of the 2006 Leatherback Program.

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

### 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 section, nest or false crawl, if the nest and/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.

### **2.2.2 Daily track surveys**

In addition to the weekly track surveys of the entire 18 miles of nesting beach, between 15 June – 31 October, the Field Coordinator 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 marker, nest or false crawl, if the nest and/or turtle were poached, or if the turtle was depredated. Poaching or depredation criteria were the same as for the weekly track surveys.

Once a nest had been recorded a line was drawn through the track and two sticks were placed in a cross formation over the nest, 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 12 June – 29 October (except for 19 August, and 13, 14 and 26 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.

Every turtle encountered after she had finished egg-laying was checked for old tags. Turtles without old tags were double tagged with metal flipper tags in the front flipper, axillary, proximal to the first scale.

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 2006 Green Turtle Program include National Band & Tag Company (NBTC) Inconel #681 tags no. 104105-104113, 104123-104125, 104148-106992.

### **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.

### **2.3.2 Hawksbill turtles**

Hawksbill turtles (*Eretmochelys imbricata*) 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 are obtained and then the samples are sent for genetic analysis to Dr Peter Dutton of the National Marine Fisheries Service. The researchers always remained with the hawksbill until she returned to the sea and then they thoroughly erased the 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 clutch 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.

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 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 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

### **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 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. 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, dug-up or 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 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 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**

### **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**

Current and maximum/minimum air temperature (in degrees Centigrade) for the previous 24 hours were 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.

## **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 or Jalova.

### **2.8.2 Capacity of hotels and cabinas**

CCC Station Manager Sergio Campos, Field Coordinator Andrea de Haro and Visitor Center Administrator Jimmy Estrada requested information on the room and bed capacity from cabina owners and hotel managers in Tortuguero during the 2006 Green Turtle Program.

### **2.8.3 Turtle tours**

The number of tourists going on guided turtle walks during the 2006 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. In 2006, the Turtle Spotter Program, aimed at reducing the impact of tourism visitation on sea turtle nesting that was first implemented in 2004, was implemented for the entire northern five miles of beach (from the Tortuguero river mouth to the mile 5 marker) where tourism is permitted. Funds from hotel and cabina owners 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 groups of tourists waiting at designated sites behind the beach. When the turtle was close to laying eggs, guides led their tour group to her location using a path behind the beach, thus reducing the number of people walking along the beach.

### **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. 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)

### **2.8.5 Hatchling orientation**

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

## 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, the 2006 Green Turtle Program RAs implemented a series of environmental education activities at the Tortuguero village school and high school.

# 3. Results

## 3.1 Track Surveys

### 3.1.1 Weekly track surveys

Nesting of green turtles was observed from March – November, with peak nesting observed on 5 August when 1,115 nests were recorded in a single night (See Figure 1). Using the methodology of Troëng & Rankin (2005), it was estimated that 84,383 green turtle nests were laid during the 2006 nesting season (See Figure 2).

Green turtle nesting density was found to be highest in the centre of the beach, between miles 5 - 15, with the highest density occurring in mile 12 (See Figure 3). Those nests laid between the Tortuguero river mouth and mile 5 marker, where night-time beach patrols were regularly conducted, made up 10.2% of the nests laid on the entire beach (See Figure 3).

The track surveyor recorded illegal take of nesting green turtles during the track survey of 29 April, when one female green turtle was taken by poachers. Nest poaching was recorded during five track surveys between 25 March and 25 October. A total of 28 green turtle nests were recorded as poached, of which 50% were counted during a single track survey on 25 October.

Between 19 March and 4 November, the track surveyor reported a total of nine 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 2006. Only one hawksbill nest was observed, on 13 May.

Leatherback nesting was observed from March – June, with peak nesting occurring on 27 May when 8 nests were recorded. It was estimated that a total of 199 leatherback nests were laid in 2006 (See Figure 4). For a more detailed discussion of temporal and spatial distribution of leatherback nesting in 2006, and levels of illegal take, see de Haro *et al* (2007).

Figure 1. Temporal distribution of green turtle nesting at Tortuguero in 2006, as determined from weekly track surveys

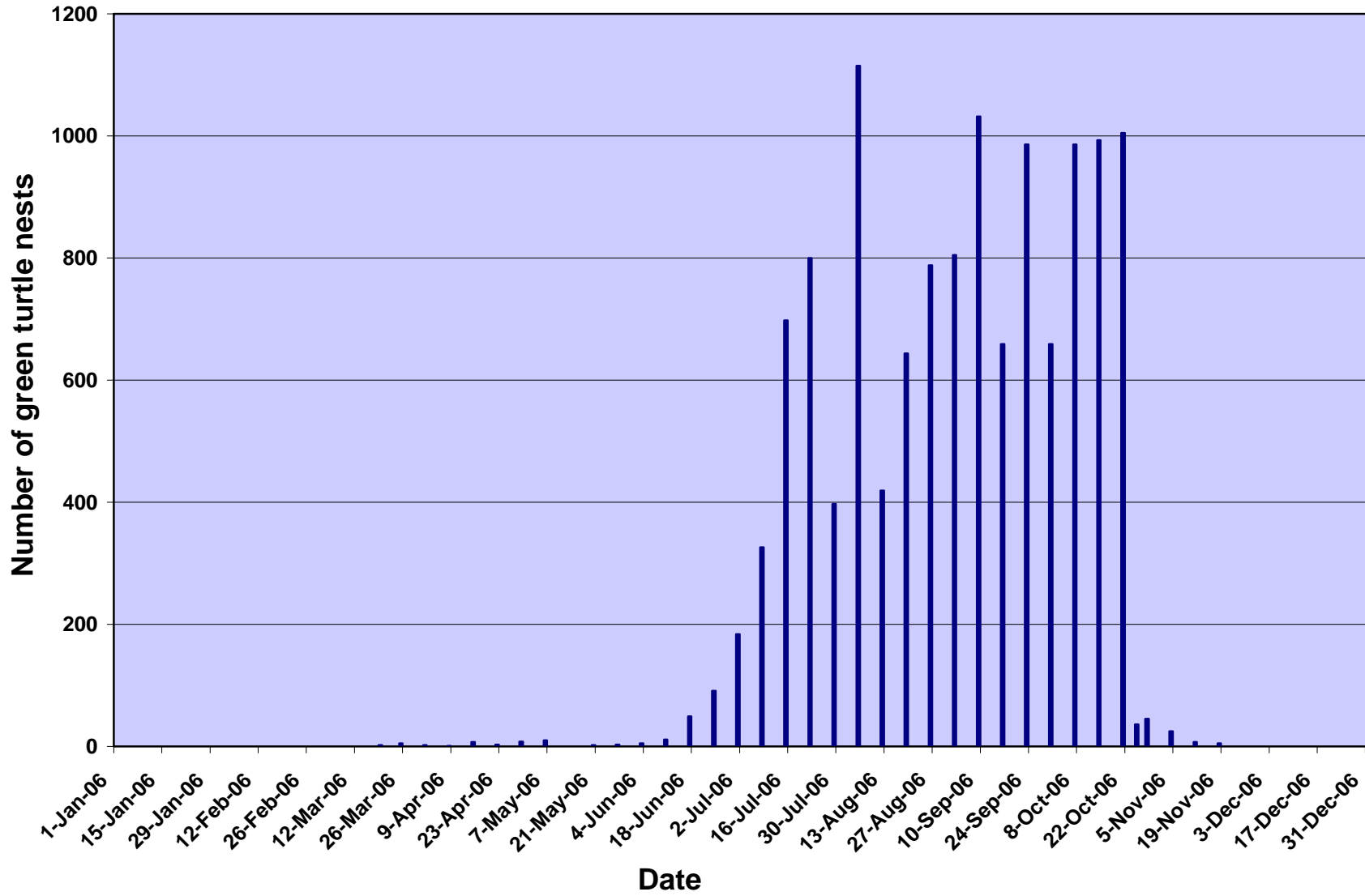




Figure 2. Green turtle nesting trend at Tortuguero, 1986 – 2006, as determined by weekly track surveys of the entire beach

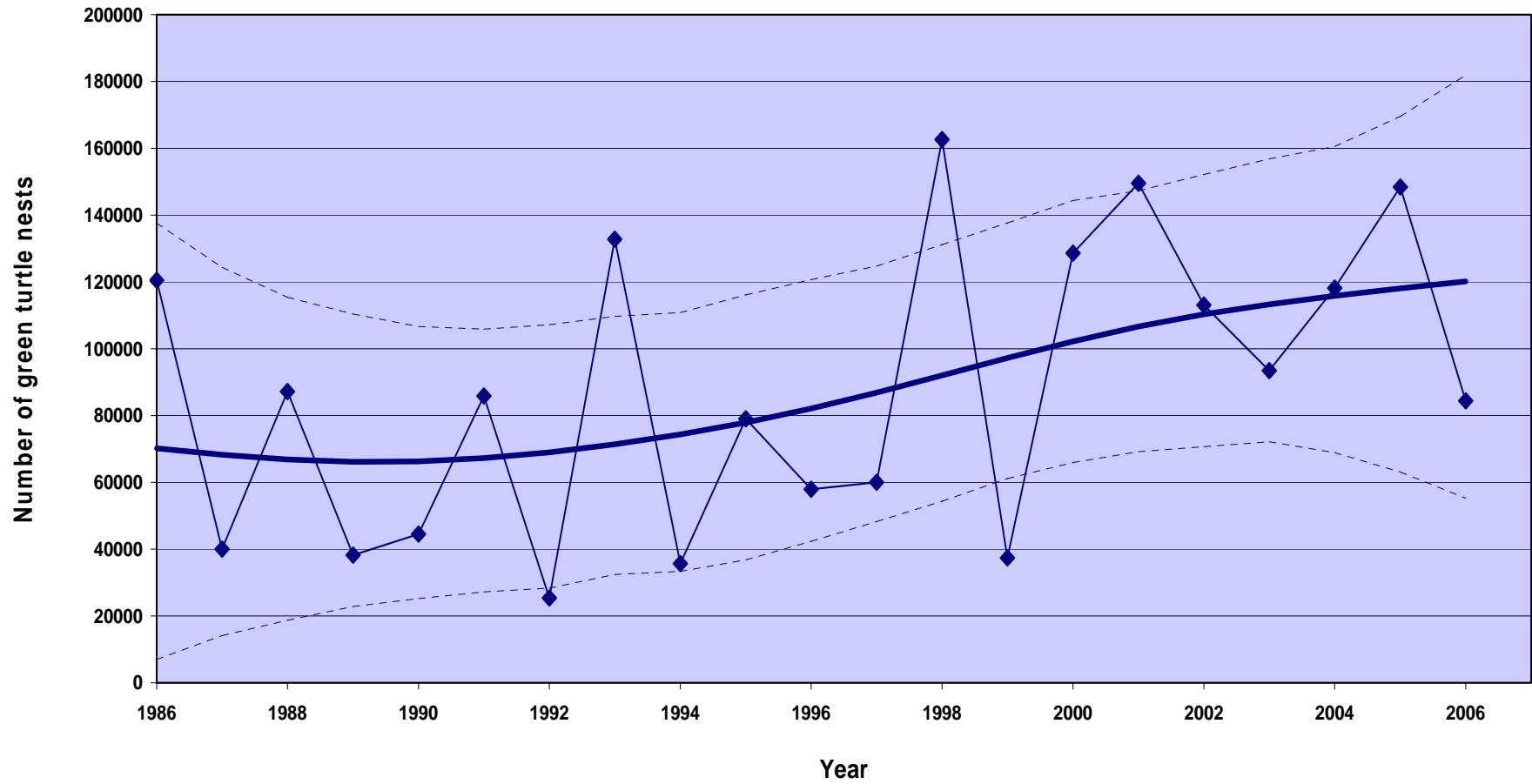
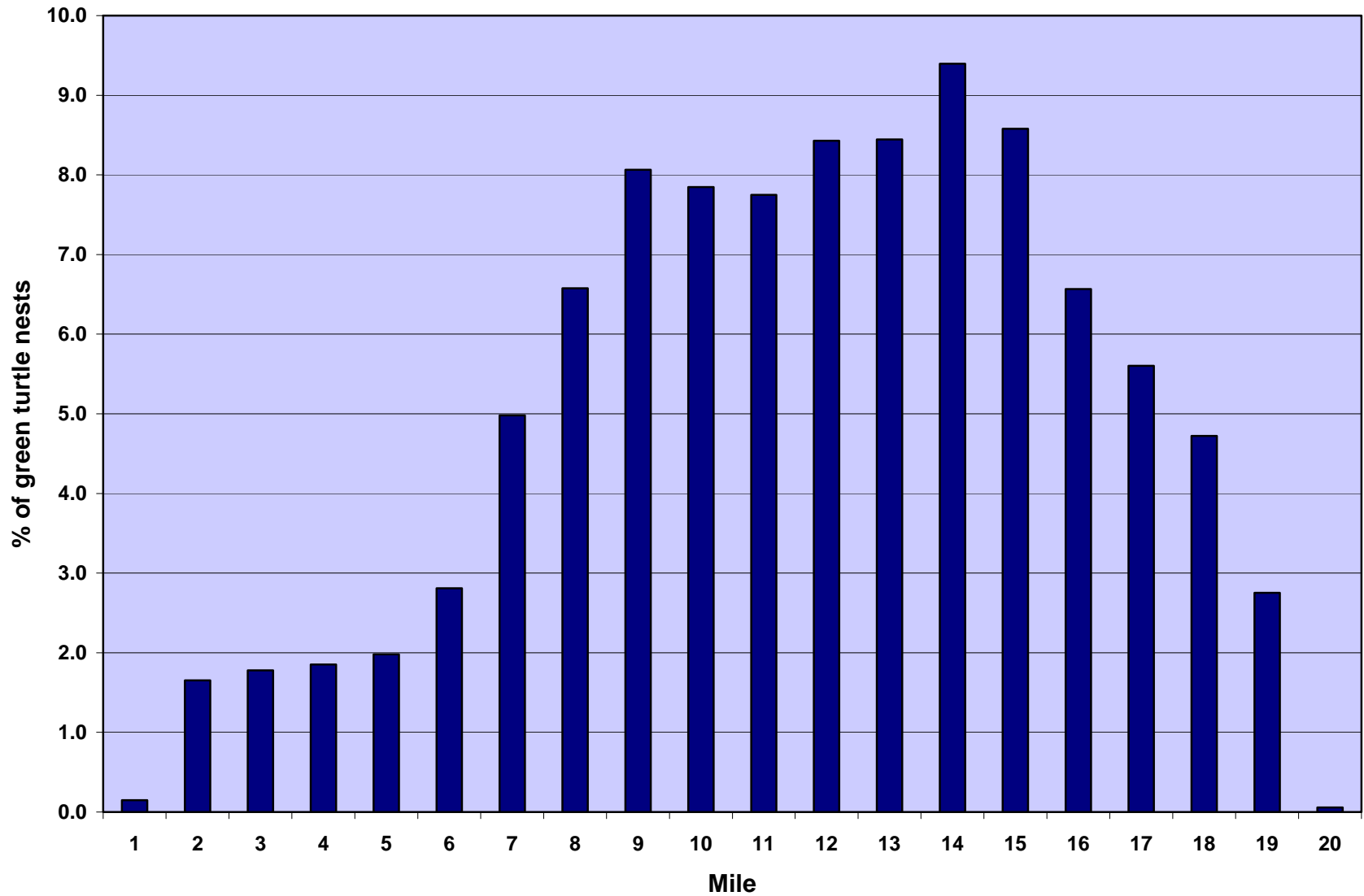
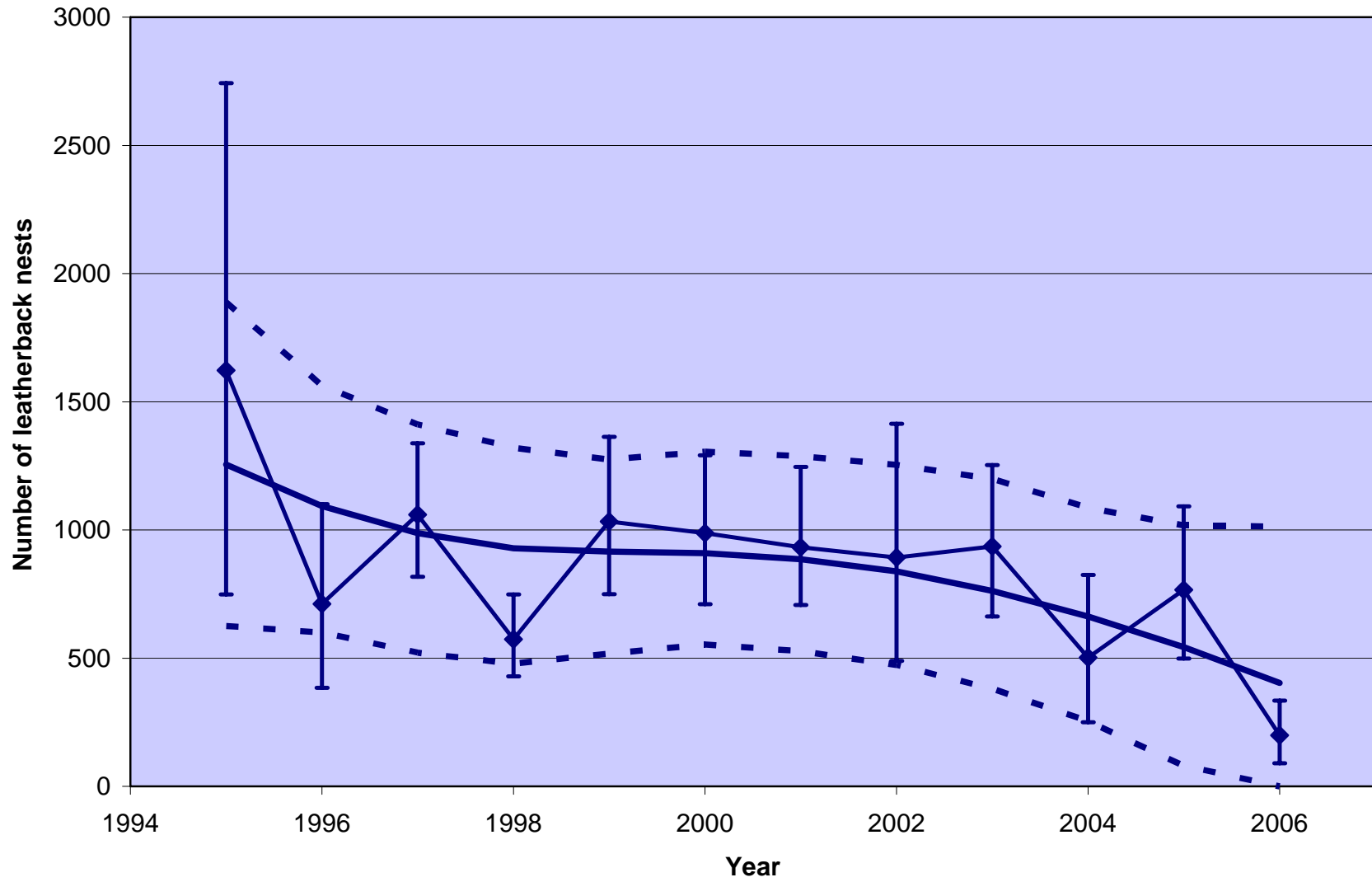


Figure 3. Spatial distribution of green turtle nesting at Tortuguero in 2006, as determined from weekly track surveys



**Figure 4. Leatherback nesting trend at Tortuguero, 1995 – 2006, as determined by weekly track surveys**



### 3.1.2 Daily track surveys

During daily track surveys conducted by the Field Coordinator and RAs between 15 June and 31 October, a total of 16,273 green turtle nests and 14,129 green turtle false crawls were recorded between the Tortuguero river mouth and the mile 5 marker (See Figure 5).

Figure 5a shows the spatial distribution of nests and false crawls for the northern 5 2/8 miles of beach. As observed in previous years, green turtle nesting density is greater within the National Park (past mile 3 3/8), and lowest in front of Tortuguero village (between miles 2 7/8 – 3 2/8).

The temporal distribution of green turtle nesting for the 2006 season is shown in Figure 5b. Peak nesting activity was recorded on 26 September, when 360 green turtle nests were counted from the previous night. Nesting activity was at least 50 nests/night during the period of 19 July – 15 October; even towards the end of October a low level of nesting was still recorded each night (less than 10 nests).

Five leatherback nests and five false crawls were counted during the same time period; the last nest was recorded on 3 July.

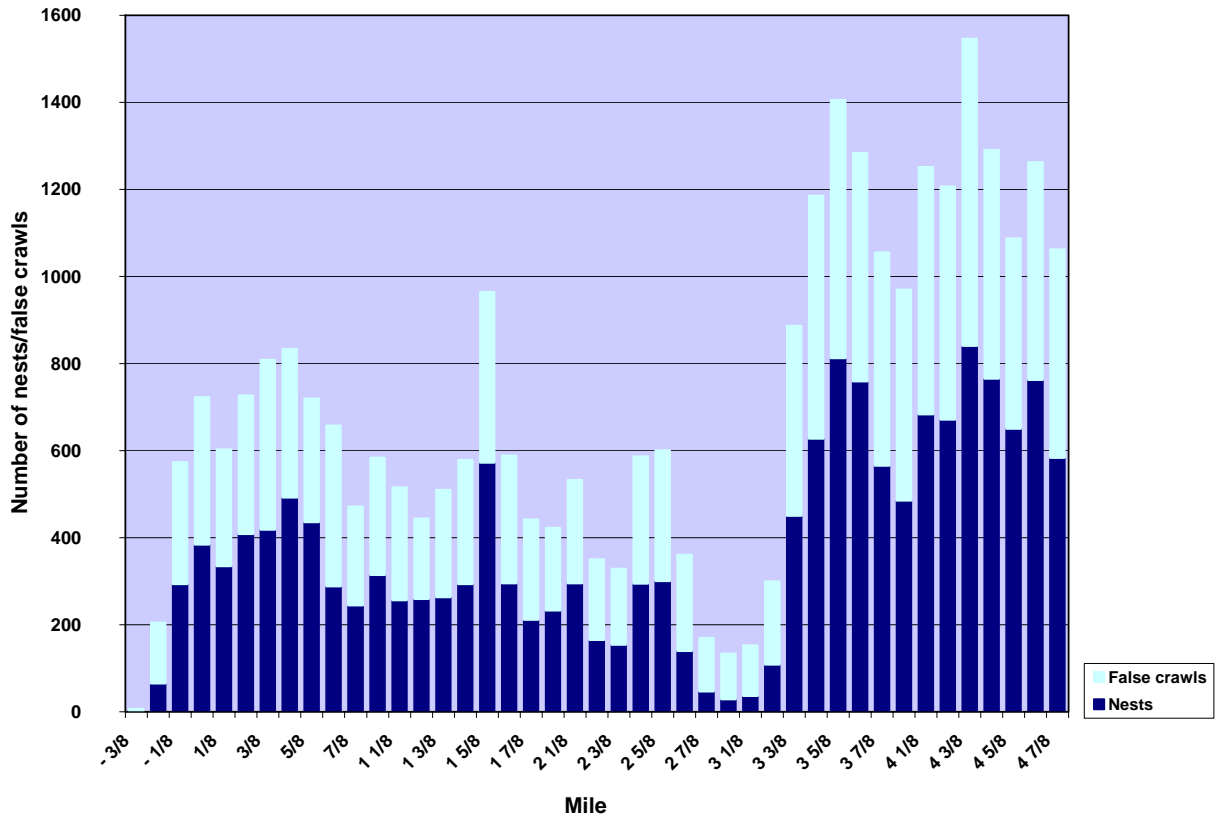
Hawksbill nesting activity was observed from June to September; with a total of 10 nests and 10 false crawls seen during track surveys. The last hawksbill nest was observed on 17 September.

During the daily track surveys researchers also noted the level of illegal take of both eggs and female turtles (See Figure 6). In total, 394 green turtle nests and 65 females were poached from June – October. Figure 6a shows the spatial distribution of poaching for the northern 5 2/8 miles of beach. It is very evident that the majority of the illegal take is occurring between the Tortuguero landing strip and the river mouth (from mile 6/8 -3/8); although another peak of poaching activity was seen just inside the northern limit of the National Park (mile 3 3/8 – 3 6/8).

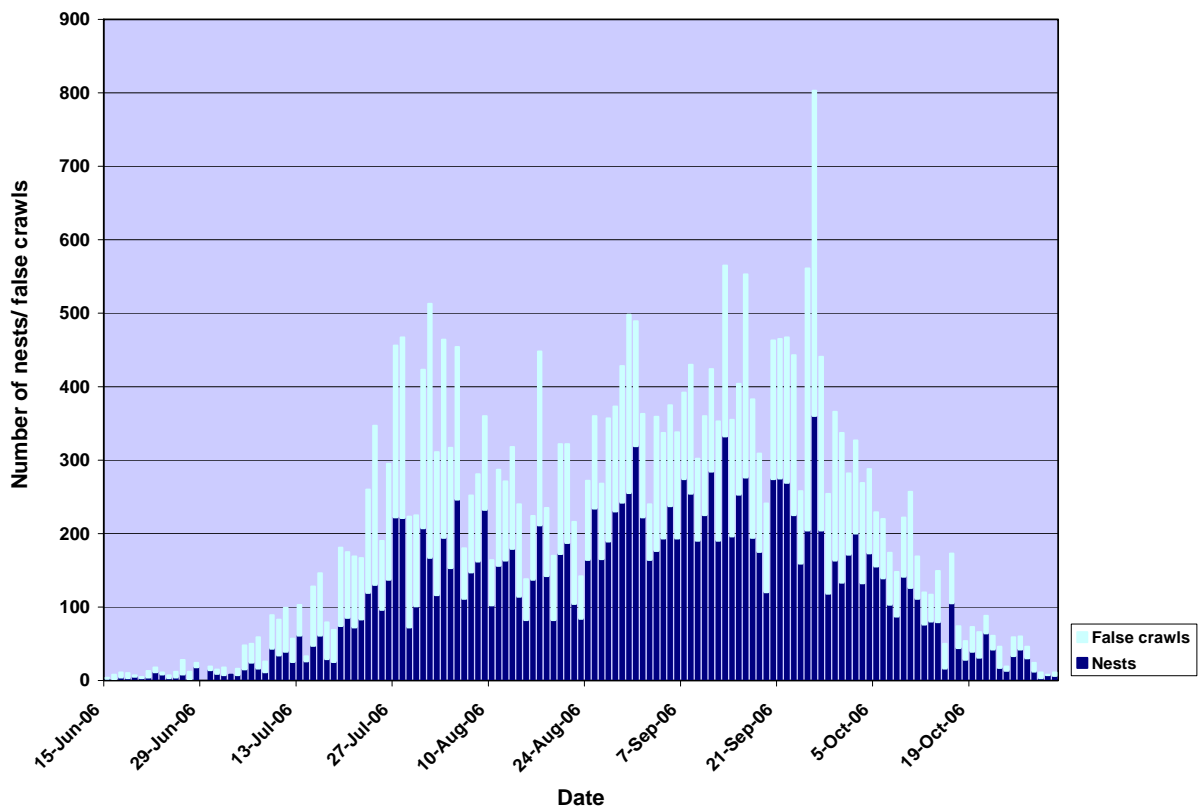
From 15 June – 31 October, poaching (of either nests or turtles) was observed during 98 of 139 (70.5%) track surveys (See Figure 6b); on 1 September, 28 green turtle nests were recorded as poached. Poaching levels were seen to increase during the latter part of the nesting season (August to October).

Figure 5. Results of daily track surveys of the northern 5 2/8 miles of beach in 2006

a) Spatial distribution

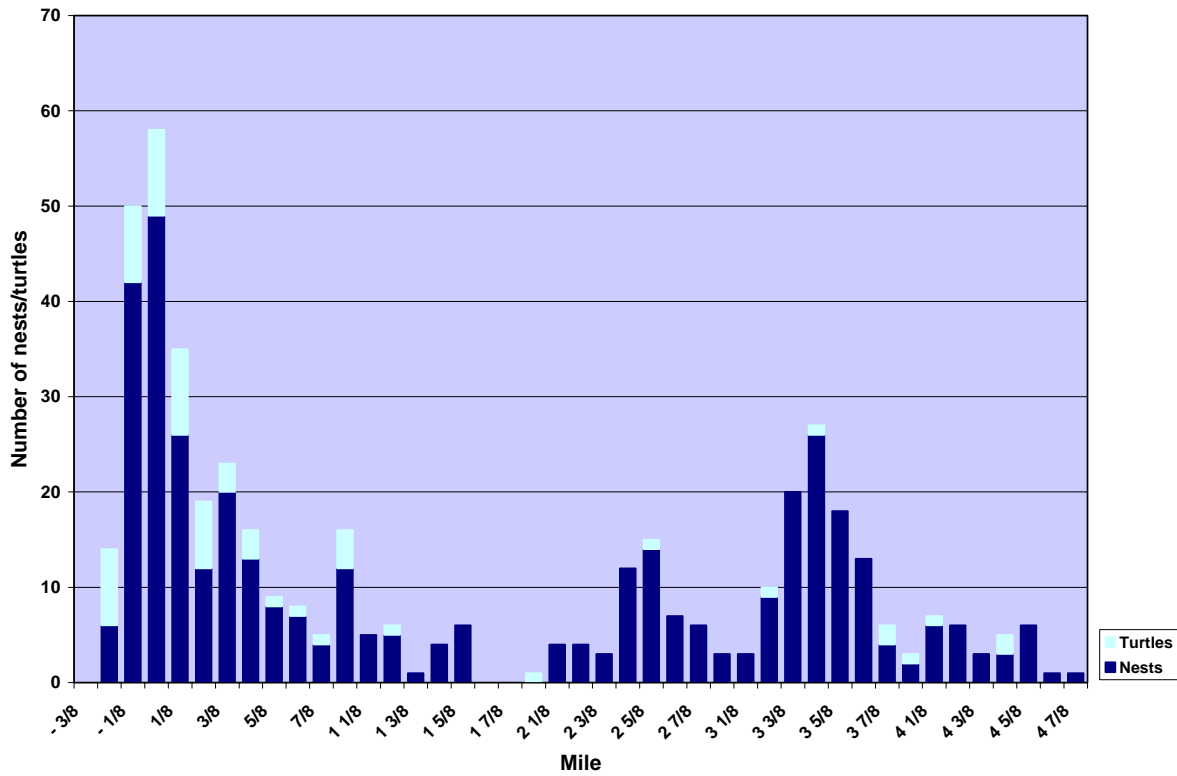


b) Temporal distribution

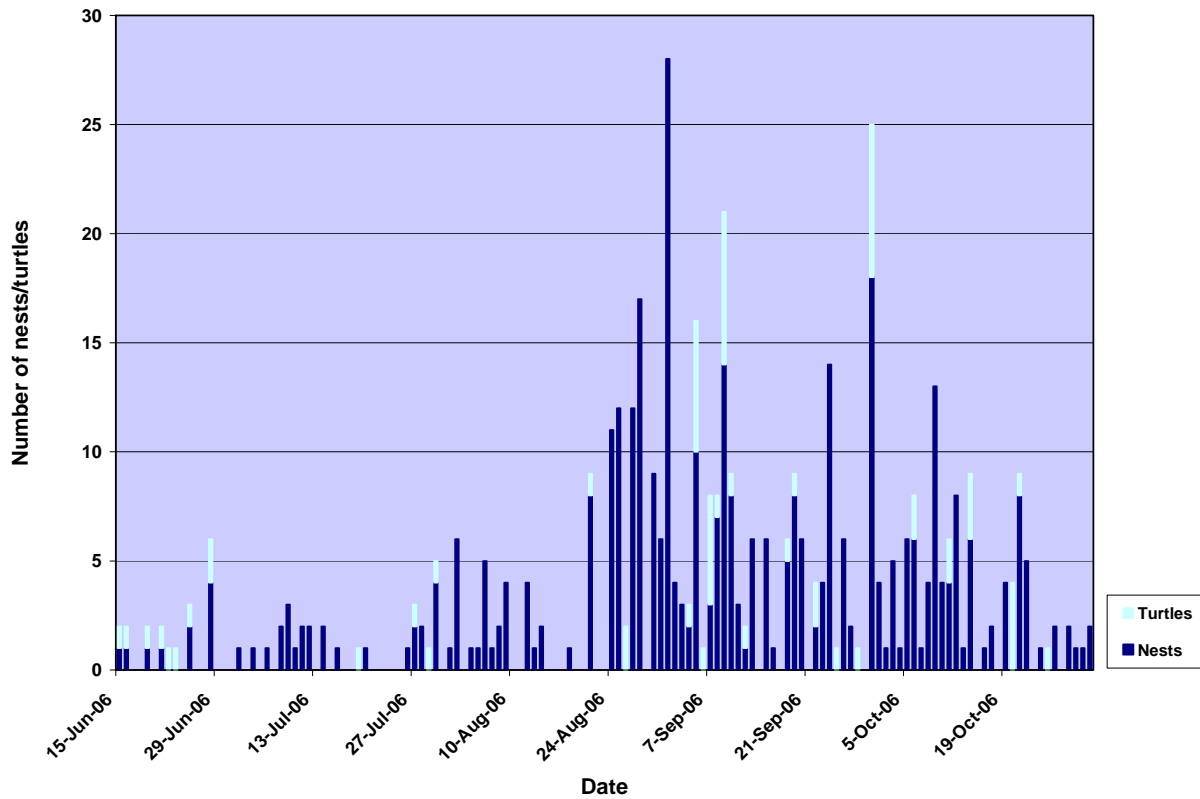


**Figure 6. Distribution of illegal take of green turtle nests and females in 2006, as determined from daily track surveys of the northern five miles of beach**

**a) Spatial distribution from the Tortuguero river mouth to mile 5**



**b) Temporal distribution from June – November**



## 3.2 Tagging of Nesting Sea Turtles

### 3.2.1 Green turtles

A total of 2,109 green turtle encounters were recorded during 2,070 team hours of night patrols between 12 June and 29 October 2006 (See Appendix 1). These encounters involved 1,632 individual females; 1,059 (64.9%) initially observed without tags and 573 (35.1%) who had tags. In addition, 477 encounters were with turtles observed more than once during the 2006 nesting season.

During the 2006 Green Turtle Program, 16 green turtles tagged at other nesting beach projects were encountered; 12 were tagged by researchers from the Caño Palma turtle monitoring project (which is based north of the Tortuguero river mouth) and four were tagged in the Pacuare Nature Reserve, south of Tortuguero National Park. All of these individuals had been tagged earlier in the 2006, indicating that they were utilizing more than one nesting beach during a single season.

Forty-seven green turtles that bore tags from Tortuguero were originally tagged more than 10 years previously. One of these females (Id #28817) was first tagged in 1984; she was seen nesting subsequently in 1988, 1998, 2001 and 2003. Of the others, three were tagged in 1986, five in 1988 and two in 1989. In addition, there was one female encountered in 2006 who had also been observed nesting in 2005.

Of 1,059 newly tagged green turtles, 137 (12.9%) were recorded as having evidence of old tag holes or notches in at least one front flipper when encountered for the first time during the 2006 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 = 139) ranged from 0% to 60%, with an overall mean of 6.9%.

Green turtles encountered during night patrols nested in the open beach zone in 33.9% of cases (n = 703), 45.9% (n = 953) were located in the border zone and 13.8% (n = 286) in the vegetation zone; 6.5% of turtles were encountered while making a false crawl (n = 134).

Of 209 turtles tagged with two tags and seen again during the 2006 Green Turtle Program, only 9 were reported to have lost one tag, resulting in a within-season probability of tag loss of 2.2%. Table 1a highlights the differences observed in tag loss between turtles tagged in different months; the lowest tag loss was observed in September and October (0%), and the highest in July (7.0%). There was also considerable variation in the probability of tag loss between researchers, ranging from 0% to 20% (See Table 1b).

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

**a) By month**

| Month        | r <sub>di</sub> | r <sub>si</sub> | 1-K <sub>i</sub> ± 95% CL |
|--------------|-----------------|-----------------|---------------------------|
| June         | 11              | 1               | 0.043 ± 0.091             |
| July         | 40              | 6               | 0.07 ± 0.061              |
| August       | 79              | 2               | 0.013 ± 0.018             |
| September    | 65              | 0               | 0 ± 0                     |
| October      | 5               | 0               | 0 ± 0                     |
| <b>Total</b> | <b>200</b>      | <b>9</b>        | <b>0.022 ± 0.015</b>      |

**Table 1. Continued**

**b) By tagger**

| <b>Tagger</b> | <b>r<sub>di</sub></b> | <b>r<sub>si</sub></b> | <b>1-K<sub>i</sub> ± 95% CL</b> |
|---------------|-----------------------|-----------------------|---------------------------------|
| RA1           | 17                    | 0                     | 0 ± 0                           |
| RA2           | 15                    | 0                     | 0 ± 0                           |
| RA3           | 13                    | 0                     | 0 ± 0                           |
| FC            | 12                    | 0                     | 0 ± 0                           |
| RA4           | 11                    | 0                     | 0 ± 0                           |
| RA5           | 10                    | 0                     | 0 ± 0                           |
| RA6           | 9                     | 0                     | 0 ± 0                           |
| RA7           | 6                     | 0                     | 0 ± 0                           |
| RA8           | 5                     | 0                     | 0 ± 0                           |
| Mixed taggers | 5                     | 0                     | 0 ± 0                           |
| RA9           | 4                     | 0                     | 0 ± 0                           |
| RA10          | 3                     | 0                     | 0 ± 0                           |
| RA11          | 2                     | 0                     | 0 ± 0                           |
| RA12          | 1                     | 0                     | 0 ± 0                           |
| RA13          | 1                     | 0                     | 0 ± 0                           |
| RA14          | 1                     | 0                     | 0 ± 0                           |
| RA15          | 1                     | 0                     | 0 ± 0                           |
| RA16          | 1                     | 0                     | 0 ± 0                           |
| RA17          | 1                     | 0                     | 0 ± 0                           |
| RA18          | 32                    | 1                     | 0.015 ± 0.031                   |
| RA19          | 12                    | 1                     | 0.04 ± 0.08                     |
| RA20          | 12                    | 1                     | 0.04 ± 0.08                     |
| RA21          | 15                    | 2                     | 0.063 ± 0.088                   |
| RA22          | 7                     | 1                     | 0.067 ± 0.133                   |
| RA23          | 10                    | 2                     | 0.091 ± 0.128                   |
| RA24          | 2                     | 1                     | 0.2 ± 0.391                     |
| <b>Total</b>  | <b>200</b>            | <b>9</b>              | <b>0.022 ± 0.015</b>            |

Key to table

FC = Field Coordinator

RA = Research Assistant

Mixed taggers = Two RAs tagged the same turtle

r<sub>di</sub> = Number of green turtles encountered with two tags

r<sub>si</sub> = Number of green turtles encountered with one tag

1-K<sub>i</sub> = Probability of tag loss

95% CL = 95% confidence limits



### 3.2.2 Hawksbill turtles

Nine individual hawksbill turtles were encountered during the 2006 Green Turtle Program; four were newly tagged, and five were previously tagged in Tortuguero (See Appendix 1). Of these five, one was originally tagged in 1998, one in 2001 and the other three in 2003. None of the newly tagged hawksbill turtles (n = 4) showed evidence of previous tags.

Three of the hawksbill turtles observed on night patrols nested in the open zone (33.3%), four nested in the border zone (44.4%), one nested in the vegetation zone (11.1%) and one did not lay (11.1%).

### 3.2.3 Leatherback turtles

A total of six leatherback encounters were recorded at the beginning of the 2006 Green Turtle Program; the last encounter was on 2 July. All of the females were re-nesters who had been observed during the 2006 Leatherback Program. Four turtles nested during the encounter, all laid in the open zone; the other two females did not lay.

## 3.3 Biometric Data Collection

### 3.3.1 Green turtles

Table 2 shows the mean carapace length and clutch size of green turtle females measured during the 2006 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 CCLmin was 105.1cm (Range = 87.4 – 119.6cm) and the overall mean SCLmax was 99.5cm (Range = 84.8 – 115.4cm).

Newly tagged females (with and without evidence of previous tags) were slightly smaller than the mean length calculated for 2006, whilst previously tagged females were, on average, slightly larger. Mean SCLmax for newly tagged females with no evidence of tagging was slightly larger than that of new females with evidence of tagging (See Table 2).

Clutch size ranged from 22 – 166 for all nests counted ( $\bar{x} = 108$  eggs, n = 145). Newly tagged females laid slightly larger 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 | 890         | 104.1 ± 4.6               | 872         | 99.3 ± 4.3                | 81                 | 108 ± 25                  |
| Newly tagged females – OTH/OTN    | 135         | 104.5 ± 4.3               | 129         | 98.9 ± 3.9                | 15                 | 119 ± 24                  |
| Previously tagged females         | 523         | 105.7 ± 4.8               | 515         | 99.9 ± 4.3                | 49                 | 104 ± 21                  |

OTH = Old tag hole, OTN = Old tag notch

For green turtles, both curved carapace length (CCLmin) and straight carapace length (SCLmax), were measured with an equal degree of precision by research assistants and by participants (Table 3a). CCLmin and SCLmax measurements during one encounter were equally precise (Table 3a). For females encountered and measured on two or more occasions during the season, the SCLmax measurements had a higher level of precision than the CCLmin measurements (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 | 1260        | 0.2 ± 0.1                 | 0.0 – 1.1        | 1273        | 0.2 ± 0.1                 | 0.0 – 1.0        |
| Participants        | 724         | 0.2 ± 0.2                 | 0.0 – 1.0        | 663         | 0.2 ± 0.2                 | 0.0 – 1.3        |
| <b>Total</b>        | <b>1984</b> | <b>0.2 ± 0.1</b>          | <b>0.0 – 1.1</b> | <b>1936</b> | <b>0.2 ± 0.1</b>          | <b>0.0 – 1.3</b> |

**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          | 262         | 1.0 ± 0.7                 | 0.0 – 4.8 | 252         | 0.7 ± 0.4                 | 0.0 – 3.2 |
| 3          | 57          | 1.3 ± 0.8                 | 0.3 – 5.2 | 54          | 0.9 ± 0.6                 | 0.2 – 4.5 |
| 4          | 12          | 1.2 ± 0.6                 | 0.4 – 2.1 | 12          | 1.1 ± 0.8                 | 0.4 – 2.5 |
| 5          | 1           | 1.9                       | N/A       | 1           | 3.0                       | N/A       |

**3.3.2 Hawksbill turtles**

Carapace measurements of nine hawksbill females were taken during the 2006 Green Turtle Program (See Table 4). CCLmin ranged from 81.5 – 97.5cm and SCLmax from 77.9 – 92.7cm. On average, newly tagged females were larger than the previously tagged individuals encountered (See Table 4). Only one hawksbill clutch was counted, and the female only laid 13 yolked and 6 yolckless eggs.

**Table 4. Mean carapace length of hawksbill females**

| Sample                            | CCLmin / cm |                           | SCLmax / cm |                           |
|-----------------------------------|-------------|---------------------------|-------------|---------------------------|
|                                   | n           | $\bar{x} \pm \text{S.D.}$ | n           | $\bar{x} \pm \text{S.D.}$ |
| Newly tagged females – no OTH/OTN | 4           | 91.9 ± 5.7                | 4           | 86.4 ± 4.9                |
| Previously tagged females         | 5           | 87.8 ± 4.0                | 5           | 82.2 ± 2.5                |

For hawksbill turtles, the precision of CCLmin measurements was greater than that of SCLmax measurements; 0.3cm compared to 0.4cm, respectively (See Table 5). A between species comparison shows that the precision of CCLmin and SCLmax measurements is 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     |
| <b>Females</b> | 9           | 0.3       | 0.0 – 0.7 | 9           | 0.4       | 0.0 – 1.2 |

### 3.3.3 Leatherback turtles

During the 2006 Green Turtle Program, five leatherback females were encountered; all had been seen previously during the 2006 Leatherback Program, and were previously tagged when first encountered. The mean carapace length (CCLmin) of these turtles was 148.9cm, with a range of 145.4 – 152.8cm (See Table 6). The only leatherback clutch counted contained 67 eggs and 4 yolkless eggs. See de Haro et al. (2007) for an analysis of the precision of CCLmin measurements for leatherback turtles.

**Table 6. Mean carapace length of leatherbacks**

| Sample  | CCLmin / cm |                           |
|---------|-------------|---------------------------|
|         | n           | $\bar{x} \pm \text{S.D.}$ |
| Females | 5           | 148.9 $\pm$ 3.3           |

### 3.4 Fibropapilloma Assessment

A total of 160 green turtles were subject to a thorough examination for the presence of fibropapilloma tumors; 15 individuals (9.4%) were recorded to be affected. Two females were checked twice, and on both occasions recorded as having no tumors. Nine of the affected turtles were newly tagged (two of these had evidence of prior tagging) and six were previously tagged individuals. Tumors ranged in size from less than 1cm to 4.6cm diameter; most were located on the front flippers, neck and shoulder area.

In addition to these females who were checked specifically for the presence/absence of fibropapilloma, tumors were also recorded for another 73 individuals; these were observed during the routine check for physical abnormalities conducted for each turtle encountered. The largest tumor recorded was 4.9 x 3.0cm. Most were located on the front flippers or the neck area; six females were reported with fibropapilloma tumors on one or both eyes, and one individual had a tumor on the side of her mouth.

### 3.5 Determination of Nest Survivorship and Hatching Success

The mammal predators observed disturbing nests or taking hatchlings during the 2006 Green Turtle Program, include coatis (*Nasua narica*), 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.

#### 3.5.1 Green turtles

A total of 204 green turtle nests were marked between 20 March – 30 September, 2006; five of which were marked during the 2006 Leatherback Program. Of these nests, all three marker tapes were lost for six nests; on 14 occasions another turtle laid a nest very close to the marked nest, so the excavation could not be conducted without disturbing the new nest; six nests were not found, but were presumed poached, and the fate of 15 nests could not be determined with certainty. These 41 nests were excluded from subsequent analysis, leaving a sample of 163 green turtle nests monitored from the date

of oviposition until their fates could be determined. In addition to the *in situ* nests, on three occasions researchers were asked to bury eggs that had been poached and subsequently confiscated by Tortuguero National Park staff. These nests were also monitored to determine their survivorship and hatchling success; giving a total of 166 monitored nests.

Table 7 lists the fate of all of the green turtle nests marked in 2006. It can be seen that the majority of nests (63.3%) remained undisturbed during incubation (n = 131). Of those that were disturbed, nesting turtles partially destroyed 4.3% of nests and depredation accounted for 3.4% of disturbances. In addition, poaching resulted in the loss of a further three nests (1.4%).

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

| Fate                        | Boca<br>n | Park<br>n | Total<br>n | %<br>of total | Hatching<br>success (%) | Emerging<br>success (%) |
|-----------------------------|-----------|-----------|------------|---------------|-------------------------|-------------------------|
| <i>Natural nests</i>        |           |           |            |               |                         |                         |
| 1. Undisturbed              | 64        | 67        | 131        | 78.9          | 88.6                    | 87.4                    |
| 2. Dug up by nesting turtle | 6         | 3         | 9          | 5.4           | 76.3                    | 72.9                    |
| 3. Two nests together       | 2         | 6         | 8          | 4.8           | 84.3                    | 82.8                    |
| 4. Predated                 | 5         | 2         | 7          | 4.2           | 50.5                    | 47.8                    |
| 5. Disturbed                | 1         | 3         | 4          | 2.4           | 48.9                    | 48.9                    |
| 6. Poached                  | 2         | 1         | 3          | 1.8           | 19.7                    | 19.7                    |
| 7. Unhatched                | 0         | 1         | 1          | 0.6           | 0.0                     | 0.0                     |
| <i>Reburied nests</i>       |           |           |            |               |                         |                         |
| 8. Undisturbed              | 2         | 1         | 3          | 1.8           | 41.9                    | 41.5                    |
| <b>Total</b>                | <b>82</b> | <b>84</b> | <b>166</b> | <b>100</b>    | <b>82.7</b>             | <b>81.4</b>             |

|                                 |           |           |           |
|---------------------------------|-----------|-----------|-----------|
| <i>Not included in analysis</i> |           |           |           |
| Unknown                         | 6         | 9         | 15        |
| Another nest laid close         | 9         | 5         | 14        |
| All flagging tape lost          | 3         | 3         | 6         |
| Possibly poached                | 2         | 4         | 6         |
| <b>Total</b>                    | <b>20</b> | <b>21</b> | <b>41</b> |

Data from the nest excavations of the 166 green turtle nests monitored through incubation are summarized in Table 8. Overall hatching success was calculated as 82.7% (15,834 shells from 19,155 eggs) and overall emerging success was estimated as 81.4% (15,584 hatchlings from 19,155 eggs) (See Tables 7 and 8). Average clutch size (determined from egg counts conducted at the time of oviposition) was 109.8 eggs (n = 118) (See Table 8).

Of the 163 marked green turtle nests included in the analysis, the majority (52.8%) were deposited in the border (n = 86), 31.9% in the open zone (n = 52), and few (15.3%) were laid in the vegetation (n = 25). Disturbed nests (n = 30) were more likely to be laid in the border zone than in the vegetation or open zones (47% compared to 30% and 23%, respectively).

**Table 8. Summary of excavation data for green turtle nests marked in 2006**

| Fate*        | n          | Hatchlings |           | Empty shells  | Pipped eggs | Unhatched eggs |            |             | Depredated eggs | Destroyed eggs | $\bar{x}$ clutch |
|--------------|------------|------------|-----------|---------------|-------------|----------------|------------|-------------|-----------------|----------------|------------------|
|              |            | Live       | Dead      |               |             | No embryo      | Embryo     | Full embryo |                 |                |                  |
| 1            | 131        | 154        | 48        | 13,302        | 29          | 936            | 199        | 199         | 461             | 0              | 109.7            |
| 2            | 9          | 4          | 0         | 419           | 2           | 80             | 10         | 12          | 49              | 61             | 105.4            |
| 3            | 8          | 17         | 4         | 1,381         | 23          | 103            | 18         | 27          | 114             | 0              | 99.2             |
| 4            | 7          | 9          | 13        | 444           | 12          | 122            | 11         | 173         | 233             | 0              | 123.2            |
| 5            | 4          | 0          | 0         | 72            | 0           | 20             | 4          | 20          | 32              | 0              | 89.7             |
| 6            | 3          | 0          | 0         | 66            | 0           | 2              | 0          | 0           | 2               | 0              | 132.0            |
| 7            | 1          | 0          | 0         | 0             | 0           | 45             | 62         | 0           | 62              | 0              | 169.0            |
| 8            | 3          | 0          | 1         | 150           | 0           | 134            | 15         | 16          | 33              | 0              | 116.0            |
| <b>Total</b> | <b>166</b> | <b>184</b> | <b>66</b> | <b>15,834</b> | <b>66</b>   | <b>1,442</b>   | <b>319</b> | <b>447</b>  | <b>986</b>      | <b>61</b>      | <b>109.8</b>     |

\* 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 = 93) shows a mean of 5 more eggs counted at the time of excavation than at the time of oviposition (range: -85 to +72 eggs, SD = 27 eggs).

The distance between the sand surface and the top eggshell at the time of excavation for undisturbed nests (n = 131) ranged between 30 and 108cm with a mean of 61.7cm. The distance between the sand surface and the bottom of the egg chamber varied between 45 and 122cm with a mean of 77.4cm.

The incubation period for undisturbed nests for which emerging was observed (n = 23) ranged from 50 to 64 days with a mean of 57 days.

Unhatched eggs that contained albino, twin, triplet and deformed embryos accounted for 0.06% of eggs in undisturbed and reburied undisturbed nests (See Table 9).

**Table 9. Incidence of albinism, twins and deformed embryos in 2006**

| Type of abnormality | n        | % of total  |
|---------------------|----------|-------------|
| Albino              | 2        | 0.01        |
| Twin                | 2        | 0.01        |
| Deformed embryo     | 5        | 0.03        |
| <b>Total</b>        | <b>9</b> | <b>0.06</b> |

### 3.5.2 Hawksbill turtles

Two 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 two nests, one was undisturbed and the other did not hatch. The one nest that failed to hatch only contained 17 yolked and 5 yolkless eggs.

Overall hatching and emerging success for hawksbill nests (n = 2) was 83.5% (167 empty shells and 167 emerged hatchlings from 200 eggs).

The mean distance between the sand surface and the top eggshell at the time of excavation for hawksbill nests (n = 2) was 40.5cm (Range = 37 – 44cm). The mean distance between the sand surface and the bottom of the egg chamber was 55cm (Range = 45 – 65cm).

**Table 10. Summary of hawksbill nest excavations from 2006**

| Fate <sup>1</sup> | n        | Empty shells | Unhatched eggs |          |             | Depredated eggs | Yolkless eggs | Total no eggs   | Hatching success (%) | Emerging success (%) |
|-------------------|----------|--------------|----------------|----------|-------------|-----------------|---------------|-----------------|----------------------|----------------------|
|                   |          |              | No embryo      | Embryo   | Full embryo |                 |               |                 |                      |                      |
| 1                 | 1        | 167          | 4              | 0        | 10          | 2               | 0             | 183             | 91.3                 | 91.3                 |
| 7                 | 1        | 0            | 13             | 0        | 0           | 4               | 5             | 17 <sup>2</sup> | 0.0                  | 0.0                  |
| <b>Total</b>      | <b>2</b> | <b>167</b>   | <b>17</b>      | <b>0</b> | <b>10</b>   | <b>6</b>        | <b>5</b>      | <b>200</b>      | <b>83.5</b>          | <b>83.5</b>          |

<sup>1</sup>For fate code details see Table 7

<sup>2</sup>Plus 5 yolkless

### 3.5.3 Leatherback turtles

Leatherback hatching success at Tortuguero in 2006, is discussed in detail in de Haro et al. (2007).

## 3.6 Physical Data Collection

### 3.6.1 Rainfall

During the 2006 Green Turtle Program, which ran from mid-June to the end of November, the wettest month was August, with 649.4mm of rain recorded (See Table 11). October was the driest month of the Program with 171.9mm of rain recorded for the entire month. For the year, the total rainfall recorded at the station in Tortuguero was 4,954.7mm (although this only included data to 4 December). Average daily rainfall each month ranged from 5.7 – 37.4mm of rain per 24-hour period (October and January, respectively); with an overall mean of 14.6mm per 24-hours from January to November.

**Table 11. Summary of rainfall data – January to December, 2006**

| Month                     | Total rainfall<br>mm/month | $\bar{x}$ rainfall<br>mm/24 hours |
|---------------------------|----------------------------|-----------------------------------|
| January <sup>1,2</sup>    | 1,083.7                    | 37.4                              |
| February <sup>3</sup>     | 487.7                      | 17.4                              |
| March <sup>4</sup>        | 406.2                      | 13.1                              |
| April                     | 385.5                      | 12.9                              |
| May                       | 264.5                      | 8.5                               |
| June                      | 408.7                      | 13.6                              |
| July <sup>5,6</sup>       | 462.9                      | 15.7                              |
| August <sup>7</sup>       | 649.4                      | 21.6                              |
| September                 | 190.1                      | 6.3                               |
| October <sup>8,9</sup>    | 171.9                      | 5.7                               |
| November <sup>10,11</sup> | 258.5                      | 8.3                               |
| December <sup>12,13</sup> | 185.6                      | N/A                               |
| <b>Total</b>              | <b>4,954.7</b>             | <b>14.6<sup>14</sup></b>          |

<sup>1,2</sup> Data for 1-2 January not included; Data for 120 hours 14 -18 January

<sup>3</sup> Data for 120 hours 15-19 February

<sup>4</sup> Data for 48 hours 22-23 March

<sup>5,6</sup> Data for 96 hours 12-15 July; Data for 48 hours 20-21 July

<sup>7</sup> Data for 48 hours 6-7 August

<sup>8,9</sup> Data for 72 hours 23-25 October; Data for 96 hours 27-30 October

<sup>10,11</sup> Data for 48 hours 31 October-1 November; Data for 48 hours 25-26 November

<sup>12,13</sup> Data for 72 hours 2-4 December; Data to 4 December only

N/A Only four days of rainfall collected so daily mean per 24-hour period not calculated

<sup>14</sup> For January – November only

### 3.6.2 Air temperature

Mean monthly minimum and maximum temperatures for January to December 2006 are shown in Table 12. Unfortunately air temperature data were not collected consistently during December; data for only two days are included in the mean values for the month.

Recorded air temperature ranged between 21°C and 31°C during the year. January and November had the lowest mean minimum temperature (23.3°C) and February had the highest mean maximum temperature (29.6°C).

**Table 12. Summary of air temperature data – January to December, 2006**

| Month        | Mean minimum air temp / °C | Mean maximum air temp / °C |
|--------------|----------------------------|----------------------------|
| January      | 23.3                       | 29.3                       |
| February     | 23.6                       | 29.6                       |
| March        | 23.6                       | 27.9                       |
| April        | 23.7                       | 28.0                       |
| May          | 24.4                       | 28.3                       |
| June         | 24.3                       | 27.9                       |
| July         | 24.3                       | 27.6                       |
| August       | 24.2                       | 27.9                       |
| September    | 24.0                       | 27.9                       |
| October      | 24.1                       | 28.3                       |
| November     | 23.3                       | 25.9                       |
| December     | 23.5                       | 26.0                       |
| <b>Total</b> |                            |                            |

No data for 1, 14-18 January; 2 February; 22 March; 30 April; 13-14, 20, 30 July; 6, 19, 28 August; 23, 27-29, 31 October; 25 November; 2-3, 5-31 December

### Sand temperature

Mean sand temperatures recorded during 2006 are shown in Table 13. Mean monthly sand temperatures ranged from 26.1 – 31.1°C between June and November. At all depths, temperatures were greater in the open zone and lower in the vegetation zone (See Table 13). During the 2006 Green Turtle Program, the month with the highest sand temperatures, was June for the open zone and October for the border and vegetation zones. November was the month with the lowest sand temperature (See Table 13).

**Table 13. Mean monthly sand temperatures during the 2006 Green Turtle Program**

| Zone                                 | Open                       |                            |                            | Border                     |                            |                            | Vegetation                 |                            |                            |
|--------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|                                      | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C | $\bar{x}$ temperature / °C |
| <b>Depth / cm</b>                    | <b>30</b>                  | <b>50</b>                  | <b>70</b>                  | <b>30</b>                  | <b>50</b>                  | <b>70</b>                  | <b>30</b>                  | <b>50</b>                  | <b>70</b>                  |
| June                                 | 31.1 <sup>1</sup>          | 30.9 <sup>1</sup>          | 30.0 <sup>1</sup>          | 28.6 <sup>1</sup>          | 28.9                       | 28.4                       | 26.6                       | 26.7                       | 26.9                       |
| Retrieval depth / cm<br>26 June      | 30                         | 50                         | 64                         | 33                         | 48                         | 70                         | 38                         | 62                         | 70                         |
| July                                 | N/A                        | N/A                        | N/A                        | N/A                        | 28.9                       | 28.1                       | 26.6                       | 26.7                       | 27.0                       |
| August                               | N/A                        | N/A                        | N/A                        | N/A                        | 29.1                       | 28.2                       | 26.5                       | 26.6                       | 26.8                       |
| September                            | N/A                        | N/A                        | N/A                        | N/A                        | 30.2                       | 29.0                       | 26.6                       | 26.7                       | 26.9                       |
| Retrieval depth / cm<br>25 September | N/A                        | N/A                        | N/A                        | N/A                        | -                          | -                          | 31                         | 51                         | 70                         |



**Table 13. Continued**

| 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  |
| October                             | N/A                        | N/A | N/A | N/A                        | 30.2              | 29.1              | 27.2                       | 27.2              | N/A |
| Retrieval depth / cm<br>14 October  | N/A                        | N/A | N/A | N/A                        | 52                | 71                | -                          | -                 | N/A |
| November                            | N/A                        | N/A | N/A | N/A                        | 28.4 <sup>2</sup> | 27.5 <sup>2</sup> | 26.1 <sup>2</sup>          | 26.3 <sup>2</sup> | N/A |
| Retrieval depth / cm<br>28 November | N/A                        | N/A | N/A | N/A                        | 40                | 64                | 38                         | 50                | N/A |

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

<sup>1</sup> Data to 26 June

<sup>2</sup> Data to 28 November

Unfortunately, when the Field Coordinator attempted to locate the data loggers in September to download the data, four data loggers (all three in the open zone and one in the border zone) were not encountered. They were presumed stolen as no evidence of beach erosion or natural disturbance was evident. Hence, only five data loggers were in use from July to the end of the Program (See Table 13).

### 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. In 2006, visitation showed an increase of over 4,000 visitors from the number recorded in 2005, and annual visitation in 2006 was also higher than 2004.

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

| Month        | 2004          |                 | 2005          |                 | 2006          |                 |
|--------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|
|              | Total         | $\bar{x}$ / day | Total         | $\bar{x}$ / day | Total         | $\bar{x}$ / day |
| January      | 2,814         | 91              | 2,503         | 81              | 3,061         | 99              |
| February     | 3,648         | 126             | 3,662         | 131             | 3,996         | 143             |
| March        | 3,924         | 127             | 3,841         | 124             | 4,395         | 142             |
| April        | 2,940         | 98              | 2,390         | 80              | 3,020         | 101             |
| May          | 1,497         | 48              | 1,187         | 38              | 1,601         | 52              |
| June         | 2,089         | 70              | 1,605         | 54              | 2,022         | 67              |
| July         | 3,106         | 100             | 2,593         | 84              | 3,610         | 117             |
| August       | 3,415         | 110             | 3,001         | 97              | 3,272         | 106             |
| September    | 1,502         | 50              | 1,509         | 50              | 1,697         | 57              |
| October      | 1,482         | 48              | 1,335         | 43              | 1,338         | 43              |
| November     | 1,995         | 67              | 2,344         | 78              | 2,043         | 68              |
| December     | 2,205         | 71              | 2,352         | 76              | 2,678         | 86              |
| <b>Total</b> | <b>30,617</b> | <b>84</b>       | <b>28,322</b> | <b>78</b>       | <b>32,733</b> | <b>90</b>       |

The mean number of visitors per day in 2006 ranged from 43 (October) to 143 (February), with an average of 90 visitors per day for the year. In every month except June, August and October, daily visitation at the center was higher in 2006 than in either 2004 or 2005.

The number of paying visitors to Tortuguero National Park (TNP), both Costa Rican nationals and foreign tourists, reached 101,344 visitors in 2006, an increase of 14,000 people from 2005 (See Table 15). There was a marked increase in the number of Costa Rican nationals visiting TNP; more than double the number recorded for 2005 (See Table 15). Since 1996 there has been over a 1000% increase in the number of visitors to TNP, from 9,053 in 1996 to 101,344 in 2006.

In 2006, the income generated from the entrance fees to TNP and Barra del Colorado Wildlife Refuge (BCWF) totaled ¢239,924,070 (~ US\$461,392). The decline in paying visitors to BCWR continued in 2006, with only 109 visitors (See Table 15). This could have been due in part to MINAE suspending the sale of fishing permits in BCWF in the first quarter of 2006; the majority of tourists to the refuge are fishermen.

**Table 15. Number of paying visitors to Tortuguero National Park**

| Year | Tortuguero National Park |                  |                | Barra del Colorado Wildlife Refuge<br>Total visitors | TNP and BCWF<br>Total fees raised |
|------|--------------------------|------------------|----------------|--|-----------------------------------|
|      | CR visitors              | Foreign visitors | Total visitors |  |                                   |
| 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                      |
| 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                      |

### 3.7.2 Capacity of hotels and cabinas

The number of hotel rooms available to tourists in Tortuguero continues to increase, rising from 583 rooms in 2005 to 658 rooms in 2006, with several of the hotels/cabinas adding rooms (See Table 16). There was also a corresponding rise in the capacity of the rooms, the number of beds increased from 1,495 in 2005 to 1,760 in 2006 (See Table 16).

The smaller cabinas in the village account for 26% of the overall capacity, an increase in 6% from 2005; this was due primarily to Cabinas Sabina (with 30 rooms and 56 beds) opening to tourists again having been rented exclusively to locals for several years.

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

| <b>Hotel / Lodge</b>                | <b>Rooms</b> | <b>Beds</b>  | <b>Cabina</b>                 | <b>Rooms</b> | <b>Beds</b> |
|-------------------------------------|--------------|--------------|-------------------------------|--------------|-------------|
| Evergreen                           | 36           | 72           | All Rankin Lodge              | 11           | 39          |
| Hotel Vista del Mar                 | 21           | 81           | Aracari                       | 12           | 30          |
| Ilan-Ilan                           | 24           | 57           | Cabinas Ever <sup>4</sup>     |              |             |
| Jungle                              | 44           | 88           | Casa Marbella                 | 5            | 15          |
| Laguna                              | 94           | 240          | La Casona                     | 4            | 14          |
| Manatus <sup>1</sup>                | 12           | 48           | Taylor's Place                | 3            | 10          |
| Mawamba                             | 58           | 270          | Ella y Yo <sup>4</sup>        |              |             |
| Pachira                             | 80           | 166          | La Espiga de Oro <sup>4</sup> |              |             |
| Samoa Lodge <sup>2</sup>            | 20           | 40           | Hostel el Icano               | 9            | 23          |
| Tortuga                             | 27           | 60           | Joruki <sup>4</sup>           |              |             |
| Tortuga Verde <sup>3</sup>          | 32           | 64           | Lapa Verde <sup>4</sup>       |              |             |
| Turtle Beach Lodge                  | 46           | 110          | Meryscar                      | 18           | 45          |
| <b>Total – Hotel/Lodge</b>          | <b>494</b>   | <b>1,296</b> | Miss Miriam                   | 6            | 18          |
|                                     |              |              | Miss Miriam #2                | 8            | 32          |
|                                     |              |              | Miss Junnie Hotel             | 12           | 36          |
|                                     |              |              | Monkeys <sup>5</sup>          | 5            | 16          |
|                                     |              |              | Princesa                      | 8            | 24          |
|                                     |              |              | Sabina                        | 30           | 56          |
|                                     |              |              | Tortuguero                    | 11           | 27          |
|                                     |              |              | Caribbean Dreams              | 6            | 30          |
|                                     |              |              | Pisulin/Tropical Lodge        | 8            | 13          |
|                                     |              |              | (CCC                          | 8            | 36)         |
|                                     |              |              | <b>Total – Cabina</b>         | <b>164</b>   | <b>464</b>  |
| <b>Total - 658 Rooms 1,760 Beds</b> |              |              |                               |              |             |

<sup>1</sup> Manatus, formerly known as El Manati re-opened in 2006 after extensive remodelling

<sup>2</sup> Samoa Lodge formerly known as Caribbean Magic

<sup>3</sup> An extension of Pachira Lodge

<sup>4</sup> Now rented exclusively to locals

<sup>5</sup> Monkeys formerly known as Jumanji

### 3.7.3 Turtle tours

As is 2005, the Turtle Spotter Program was implemented along the entire 5-mile stretch of beach (from Tortuguero river mouth to mile 5) used for night-time turtle tours in 2006. Thirteen local turtle spotters were hired for the duration of the official green turtle nesting season (1 July – 31 October), with funds collected from the Tortuguero hotel and cabina owners.

The number of visitors who participated in night-time turtle tours during 2006 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. The 'Park Beach' is the 1 5/8 miles of beach, from the limit of the National Park to mile 5; visitors who participated in tours within that

section of beach were required to have a valid National Park entrance ticket for that day.

**Table 17. Number of visitors participating in turtle tours in 2006**

| Month                 | Public Beach<br># visitors | Park Beach<br># visitors | Total #<br>visitors | $\bar{x}$ visitors<br>/ night |
|-----------------------|----------------------------|--------------------------|---------------------|-------------------------------|
| January               | N/A                        | N/A                      | N/A                 | N/A                           |
| February              | N/A                        | N/A                      | N/A                 | N/A                           |
| March <sup>1</sup>    | 59                         | 20                       | 79                  | 3                             |
| April                 | 79                         | 225                      | 304                 | 10                            |
| May                   | 209                        | 333                      | 542                 | 18                            |
| June                  | 767                        | 1,330                    | 2,097               | 70                            |
| July                  | 5,394                      | 3,743                    | 9,737               | 314                           |
| August                | 7,657                      | 4,885                    | 12,542              | 405                           |
| September             | 4,093                      | 1,426                    | 5,519               | 184                           |
| October               | 3,089                      | 1,420                    | 4,509               | 146                           |
| November <sup>2</sup> | 29                         | 304                      | 333                 | 48                            |
| December              | N/A                        | N/A                      | N/A                 | N/A                           |
| <b>Total</b>          | <b>21,976</b>              | <b>13,686</b>            | <b>35,662</b>       | <b>133</b>                    |

Data from ACTo

N/A – No tours conducted during those months

<sup>1</sup> First tour on 21 March

<sup>2</sup> Last tour on 7 November

Over 35,000 visitors participated in turtle tours, between March and November 2006 (See Table 17); of those 21,976 went to the Public Beach, and 13,686 went to the Park Beach. Peak visitation occurred in August, when 12,542 visitors went on tours, with an average of 405 visitors per night during that month (See Table 17). During peak months (July – October) more visitors went to the Public Beach than to the Park Beach. An average of 133 visitors per night was recorded for 2006, but this number increased to 224 per night when limited to the official green turtle season (1 July – 31 October).

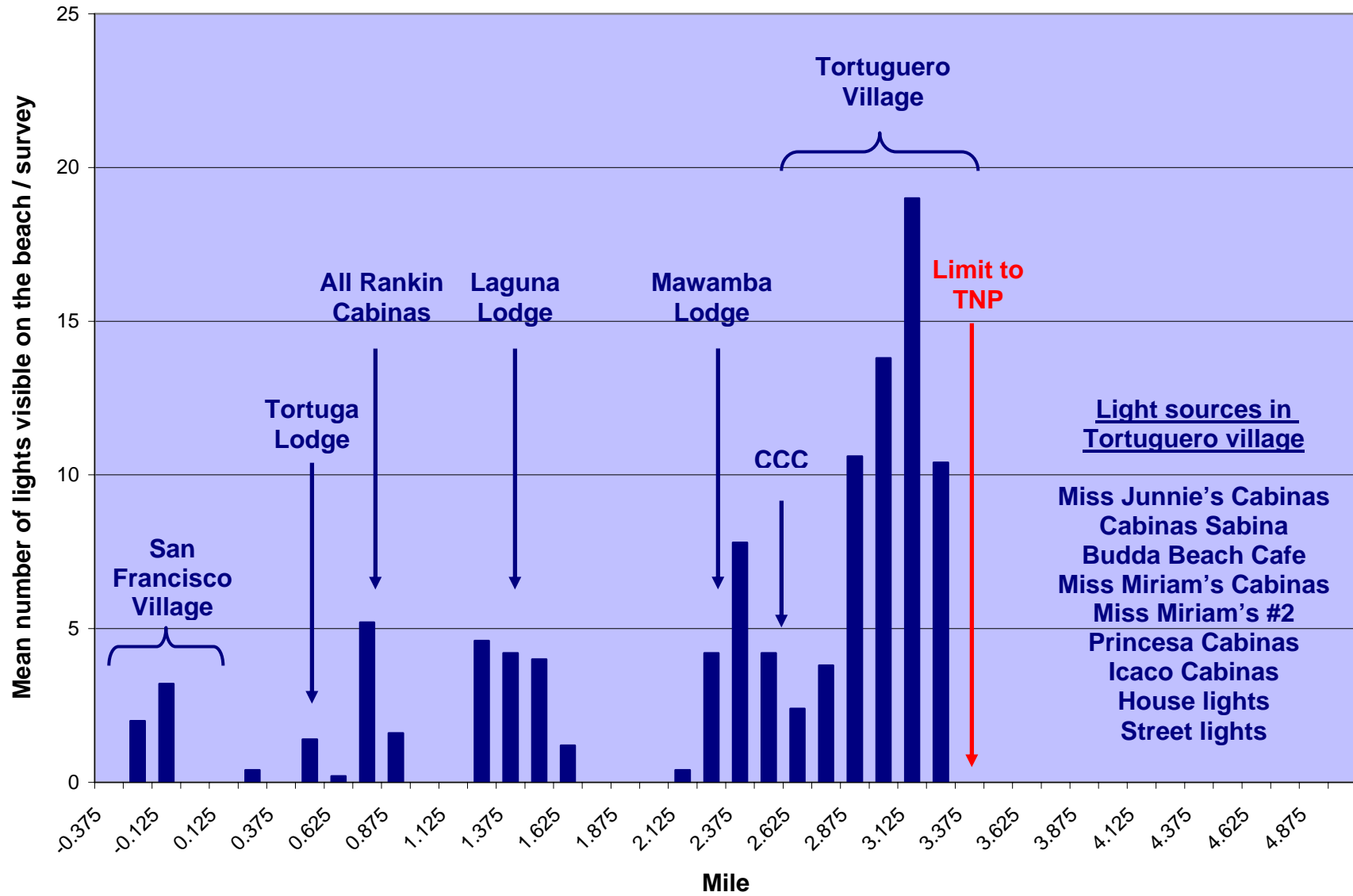
### 3.7.4 Artificial lights

Five light surveys were conducted during the 2006 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 house and street lights in Tortuguero village, between miles 2 6/8 – 3 3/8 (See Figure 7). However, numerous lights from cabinas, lodges, houses and the CCC station that are north of the village were also visible. Unfortunately, the opening of a small café, and the refurbishment of Cabinas Sabina close to the beach in mile 3 increased the number of lights visible in that area.

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 Lodge, 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.

Figure 7. Summary of monthly light surveys conducted during the 2006 Green Turtle Program



### 3.7.5 Hatchling orientation

Turtle hatchling orientation results from the 2006 Green Turtle Program are summarized in Table 18. A total of 55 emergences were observed, 46 green turtle and 9 leatherback nests. On average, more hatchling tracks were recorded for green turtle nests than for leatherbacks (33 compared to 14 per nest, respectively). The mean angular range of green turtle hatchlings when outliers were excluded was 40°, and 33.6° for leatherbacks (See Table 18). Leatherback nests had a higher number of ‘circler’ tracks than green turtle nests.

**Table 18. Turtle hatchling orientation**

| Species      | n  | No. hatchling tracks<br>$\bar{x} \pm \text{std}$ | Angular range (°)<br>$\bar{x} \pm \text{std}$ | Angular range including outliers (°)<br>$\bar{x} \pm \text{std}$ | No. circlers<br>$\bar{x} \pm \text{std}$ |
|--------------|----|--|---|--|--|
| Green turtle | 46 | 33 ± 16  | 40.0 ± 15.5                                   | 53.0 ± 20.5  | 0.5 ± 0.3                                |
| Leatherback  | 9  | 14 ± 12  | 33.6 ± 17.6                                   | 43.4 ± 21.4  | 1.0 ± 1.4                                |

## 3.8 Environmental Education Activities

Several environmental education activities were carried out during the 2006 Green Turtle Program.

- A workshop about the effects of artificial lights on sea turtles, and what could be done to prevent light pollution was given in July by Dr Anne Chaves, for the entire community of Tortuguero.
- In July and August, the Field Coordinator gave a series of lectures to the Turtle Spotters, about sea turtle biology, species identification, nesting behavior and the work of the CCC in Tortuguero.
- In July, the Field Coordinator gave a lecture about the work of the CCC to a group of visiting eco-tourism students from Guácimo and to students of the Tortuguero school.
- Ninth-grade students were given a talk about contamination in Tortuguero National Park by one of the Research Assistants in July.
- A Research Assistant from Mexico gave a presentation about arribadas and fibropapilloma studies in Mexico to the Turtle Spotters and other interested community members in August.
- In September, several researchers from Cano Palma Research Station were given theoretical and practical training sessions in various aspects of the monitoring protocol by the Field Coordinator; to assist with the implementation of their sea turtle project north of the Tortuguero river mouth.
- In September and October students from the school and high school participated in several different activities regarding sea turtles, their conservation and biology. Students were also invited to participate in night-time beach patrols.

## 4. Discussion

### 4.1 Track Surveys

#### 4.1.1 Green Turtles

Green turtle nesting was observed from April to December with the main nesting season extending from 17 June to 28 October. Green turtle nests laid before 17 June and after 28 October only amounted to 0.1% of all counted nests in 2006.

The daily track surveys conducted between the Tortuguero river mouth and the mile 5 marker by the research assistants required considerable efforts on part of the 2006 Green Turtle Program team. The results of the surveys are essential to evaluate the effectiveness of the management actions aimed at reducing the impact of tourism visitation on green turtle nesting. 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 that zone of the beach. For these two important reasons it is strongly suggested that these surveys be continued in future programs.

Green turtle nesting between the Tortuguero river mouth and the mile 5 marker represented 10.2% of all green turtle nesting between the river mouth and Jalova lagoon. The greatest nesting density, however, as has been observed in previous years, was between miles 5 – 15, with mile 12 showing the greatest density of green turtle nests.

The level of illegal take observed during the weekly track surveys of the entire 18 miles of beach was low; one female and 28 nests. However, the results from the daily track surveys of the northernmost five miles revealed that illegal take of green turtles and nests occurred at a disturbing rate in this section of the beach. Unlike the pattern observed in 2005, with most nests being taken during the early part of the season, in 2006 poaching occurred throughout the entire season, increasing in intensity from August – October. Limited park resources were focused within Tortuguero National Park, and so a recommendation for future years would be to try and secure funding for additional park rangers dedicated to this northernmost stretch of beach that is outside the National Park boundaries, and where poaching is continuing uncontrolled. Cooperation with MINAE personnel, to pass information location and intensity of observed illegal take, should continue.

The jaguars continue to kill nesting green turtles within the park, although fortunately the number of individuals killed is a very small percentage of the population, and so this predation does not pose a significant threat to the Tortuguero green turtles. It would be interesting to conduct further investigation into the level of jaguar predation, and to determine temporal and spatial distribution patterns.

#### **4.1.2 Hawksbill turtles**

The continuing low level of hawksbill nesting observed at Tortuguero in 2006 remains discouraging. To ensure increased hawksbill nesting in the future all efforts should be made to ensure that all nests are adequately protected, that tracks are effectively erased and that the female is guarded until she returns to the water if encountered during a night patrol. Also, every effort should be made to mark hawksbill nests to evaluate their survivorship and hatching success, to gain as much information as possible about the species, to assist in future conservation efforts. Every female and nest is vitally important for the future of the nesting population using Tortuguero (Troëng et al. 2005).

#### **4.1.3 Leatherback turtles**

A comprehensive discussion of leatherback nesting at Tortuguero in 2006 can be found in de Haro et al. (2007).

### **4.2 Tagging of Nesting Sea Turtles**

#### **4.2.1 Green turtles**

The goal of 1,000 newly tagged green turtles was successfully achieved in 2006. In future it would be desirable to continue to tag new females that arrive at the end of the season in October; in recent years tagging efforts for new individuals have been concentrated on the beginning and peak of the season, to

ensure that the minimum of 1,000 females is reached.

Large numbers of previously tagged green turtles ( $n = 573$ ) were also recorded during the night patrols. These data are very useful in terms of estimating tag loss and annual survival probabilities. In 2006 it was encouraging to observe 47 females who 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.

The observation of 16 green turtles tagged at nearby nesting beaches in Costa Rica demonstrates that green turtles can use more than one nesting beaches. Although the vast majority of green turtles nest almost exclusively at Tortuguero, these females with non-Tortuguero tags emphasize the need for improved communication and data exchange between the many sea turtle conservation and monitoring projects that are active on the Caribbean coast of Costa Rica. CCC should continue to play an active role in the National Marine Turtle Network in Costa Rica to support all turtle conservation efforts in the country.

The daily track surveys conducted by the research assistants to evaluate tourism visitation impact also increased the sample size for tagging efficiency estimates.

Overall within season tag loss was very low in 2006, at 2.2%. Tag loss varied with tagger and was much higher towards the start of the program (July) than in later months. It is very important that all Research Assistants receive adequate tagging training during the first week of the Program, and are supervised by the Field Coordinator until they are satisfied that each person is efficient. Unfortunately, if nesting density is low at the start of the Program it is often difficult to encounter sufficient turtles during the orientation week. The Field Coordinator should therefore ensure that supervised tagging continues in the second week, to ensure that tags are applied effectively and so minimize tag loss. All tagging equipment must be cleaned on a daily basis and maintained in functioning order; any malfunctioning equipment should be replaced as soon as problems are detected.

#### **4.2.2 Hawksbill turtles**

More hawksbill turtles were encountered during the 2006 program than were observed in 2005 (9 compared to 6, respectively), although the number was still relatively low. Of these it was encouraging to observe five remigrants, all of whom had been originally tagged in Tortuguero; one in 1998. These returning individuals are vitally important to determine the survival probability of reproductive females. 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.

#### **4.2.3 Leatherback turtles**

de Haro et al. (2007) includes a detailed review of the tagging of leatherback turtles at Tortuguero in 2006.

### **4.3 Biometric Data Collection**

#### **4.3.1 Green turtles**

Mean carapace measurements of previously tagged females were greater than those of newly tagged females with evidence of old tag holes or notches and those recorded for newly tagged green turtle females with no such evidence.



Participants had the same precision as the Research Assistants for both CCLmin and SCLmax measurements, suggesting that the training provided by the research team prior to the night patrols was effective, and that Research Assistants were providing supervision during the data collection. It is very important to ensure that everyone responsible for taking carapace measurements is adequately trained; an effective way to assist in the training might be to produce a video showing the exact placement of the measuring tape or the calipers during carapace measurements. Such a video could also incorporate other aspects of the monitoring protocol, such as tagging or nest marking, in addition to the different stages of the nesting process.

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.

#### **4.3.2 Hawksbill turtles**

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

#### **4.3.3 Leatherback turtles**

de Haro et al. (2007) contains information about biometric data collection from leatherback turtles nesting in Tortuguero in 2006.

### **4.4 Fibropapilloma Assessment**

The percentage of green turtles (9.4%) that were recorded as having fibropapillomas was much higher in 2006 than observed in previous years. In addition to the sub-sample of turtles who were specifically examined for the presence of fibropapilloma, a further 73 females were reported as having tumors. This is somewhat worrying as it could imply a sudden increase in the incidence of this disease in the Tortuguero nesting population. However, it is also possible that other types of skin disease and tumors were being incorrectly identified as fibropapilloma. It is, therefore, very important to provide the Research Assistants with as much detailed information about the appearance of fibropapilloma tumors as possible, to minimize the potential for misidentification; a useful aid would be photographs of turtles infected with the disease, at different levels of severity, that could be easily incorporated into the training presentations. It is vital that nesting green turtles continue to be assessed for this disease in future years, to verify whether the dramatic increase in fibropapilloma reported in 2006 was erroneous identification, or a real increase in the level of the disease in the Tortuguero population.

### **4.5 Determination of Nest Survivorship and Hatching Success**

#### **4.5.1 Green turtles**

The sample size of marked green turtle nests was relatively large in 2006 (207) but the fate of a significant proportion of these nests was not categorically determined, and so 41 nests were excluded from analysis of hatching and emerging success. Of those nests where the fate was determined the overall hatching and emerging success was higher than observed in recent years (82.7% and 81.4%, respectively), which was very encouraging. The biggest cause of disturbance to marked nest was due to other nesting females either digging up the original nest, or laying a nest so close that during the excavation the two egg chambers could not be distinguished and so were counted as one nest. This may be due to the fact that the Tortuguero population is increasing sufficiently to impact on its own nesting success, or it might be indicative of a reduced amount of suitable nesting habitat being available, and so females are being forced into the same area. It would be of interest to undertake a

study on the dynamics of the Tortuguero beach during the nesting season, to monitor levels of erosion and accretion, to determine if the beach characteristics might be negatively impacting nesting turtles.

It is also very important that the daily monitoring of marked nests is conducted thoroughly, to record all incidences of disturbance as soon as they occur. Research Assistants must be trained to identify poaching, predation and other forms of disturbance, and made aware of the importance of these data. In addition, attention must be paid to marked nests close to the expected date of emergence, to ensure that the date of eclosion is not missed; this will facilitate the excavation of nests and provide more information on the incubation period in Tortuguero.

The frequency of albinism, twins, triplets and deformed embryos was very low, especially compared to 2005. As with the assessment of individuals for the presence of fibropapilloma tumors, it is important to continue to monitor the frequency with which deformed embryos are encountered, as this may be an indicator of changes in the quality of the nesting beach environment.

#### **4.5.2 Hawksbill turtles**

Of the two hawksbill nest that were marked, one had very few eggs (17 normal and 5 yolkless) and did not hatch. The other had a very high hatching and emerging success (91.3%); this is encouraging as the nesting density for this species is very low in Tortuguero, but at least the nests which are laid appear to be very successful. It is also good to note that the nests were not poached, suggesting that the tracks were effectively erased so that potential poachers could not locate the nest site.

#### **4.5.3 Leatherback turtles**

No leatherback nests were marked during the 2006 Green Turtle Program, however, information on leatherback nest survivorship and hatching success in Tortuguero during 2006 can be found in de Haro *et al.* (2007).

### **4.6 Physical Data Collection**

#### **4.6.1 Rainfall**

Rainfall during the 2006 Green Turtle Program showed a relatively normal pattern, in that the rainy period began in June and continued through August (the wettest month). The months of September and October were exceptionally dry, and the rainfall in November and December was much lower than is normally observed during this second rainy period of the year. To monitor whether such changes in the environmental conditions are simply anomalies, or are indicative of more drastic changes in precipitation patterns in the region, it is vital that the collection of these types of physical data continue. As obviously, they can have a significant impact on the success of nests in Tortuguero; for example, prolonged dry periods with reduced rainfall might lead to increases in sand temperatures which, in turn, may result in changes in the sex ratio of hatchlings being produced in Tortuguero.

#### **4.6.2 Air temperature**

Surprisingly, given that 2006 was a dry year, the air temperatures recorded were not significantly higher than those observed in previous years; indeed, in no month did mean maximum air temperature rise above 30°C as has been seen before.

Greater emphasis should be placed on ensuring that all of the physical data are collected regularly during the entire year, not just during the nesting season. These data are invaluable for providing a baseline of information about environmental conditions in Tortuguero over time.

### **4.6.3 Sand temperature**

As mentioned above, sand temperatures will be influenced by the level of rainfall, and so the lower than normal precipitation experienced in 2006 is likely to have led to effects on the sex ratio of hatchlings. Temperatures above 30°C were witnessed in the open zone in June, despite the start of increased rainfall in that month. It is unfortunate that the data loggers were “lost”, presumed stolen, as it would have been very interesting to observe the sand temperatures in this zone of the beach for the remainder of the 2006 Green Turtle Program, especially during the very dry months of September and October. It is likely that temperatures would have reached levels sufficient to cause embryonic mortality, with a resulting decrease in hatching success. Sand temperatures were lower in the border and vegetation zones, and were less variable than those recorded in the open zone, due to the shading effect of the vegetation. An analysis of these data suggests that the majority of green turtle hatchlings produced in Tortuguero in 2006 were female.

The monitoring of sand temperatures on the nesting beach is an important component of the protocol, and should continue in future programs. It is important that the missing data loggers are replaced to obtain information on all zones of the beach. With attention being drawn towards the impact of global climate change on sea turtles and their nesting beaches, the data that have been collected to date at Tortuguero will form a valuable reference with which to compare future changes. Possible studies to assess the changes in sand temperatures (and hence the potential effect on nest success, and hatchling sex ratios) should be contemplated for Tortuguero, to utilize the data that have been collected over the last eight years.

## **4.7 Collection of Human Impact Data**

### **4.7.1 Visitors to Tortuguero**

Following 2005, when a worrying decline in tourist visitation to the CCC Visitor Center was observed, the trend was reversed in 2006, with an increase of over 4,500 visitors recorded. To ensure that this trend continues in the future, a priority should be the remodeling of the Visitor Center to make it more accessible to multiple groups of tourists that arrive at the same time and the development of new displays, about sea turtle biology, conservation and the results of the research conducted by CCC to date, in addition to information about the flora and fauna of Tortuguero National Park. In its present condition, the Visitor Center is not equipped to handle an increase in daily visitation, and so will continue to function below its potential. As a valuable source of income for CCC, it is important that this deficiency is addressed as swiftly as possible.

### **4.7.2 Capacity of hotels and cabins**

2006 saw a further increase in the capacity of the hotels and cabins in Tortuguero; one of the large lodges that was closed for refurbishment in 2005 reopened, and one of the village cabins that had been renting exclusively to locals changed owner and began renting to tourists, hence increasing both the number of rooms and beds available to visitors. The continuing growth in the tourism industry in Tortuguero should be carefully monitored in future, to ensure that tourist activities do not start to negatively impact on the National Park, particularly with reference to nesting turtles on the beach.

### **4.7.3 Turtle tours**

In 2006, 35,662 visitors to Tortuguero (approximately one third of all those who paid to enter the National Park) participated in turtle tours. The continued implementation of the new Turtle Spotter Program, which began as a pilot project in 2004, has been successful in reducing the impact of this

number of tourists on nesting turtles (de Haro *et al*, 2006). Furthermore, the new tour system allows more tourists to visit the beach each night, thus accommodating the growth in tourism that continues within the region. In addition, the program has created seasonal jobs for 13 members of the local community. While these are obvious benefits of the program, there still exists the need to establish a sustainable funding mechanism to ensure its continued success in future years, and CCC, as part of the commission overseeing the implementation of this project, needs to play an active role in helping to find such funding.

It is recommended that the Turtle Spotter Program be continued, and that CCC continues to be involved in the evaluation and development of the program in coming years.

#### **4.7.4 Artificial lights**

Unfortunately the issue of light pollution in front of the village, and near to several of the lodges continued in 2006. However, the workshop conducted by Dr Anne Chaves was well supported by the community and hopefully the lessons from that activity can be implemented in future years, to reduce the impact on nesting females and eliminate the potential for disorientation of hatchlings. Hopefully it will be possible to incorporate the electricity company (ICE) in any future activities, as one of the major sources of light pollution in the village are the street lights. If some form of shading could be placed around the bulbs it would significantly reduce the amount of lights visible on the beach and it is recommended that this is an area where efforts should be focused. Fortunately in 2006 no incidence of hatchling disorientation was observed during the Green Turtle Program, but there still exists the need to diminish the level of light pollution where possible.

#### **4.7.5 Hatchling orientation**

Data on hatchling orientation were collected in 2006 and represents important baseline information. If artificial lights continue to increase to the point where orientation is compromised, we should be able to detect changes in the overall hatchling orientation. It was interesting to observe the differences in hatchling orientation between the leatherback and green turtle hatchlings, and the collection of these data is something that should be included in future Leatherback Programs.

### **4.8 Environmental Education Activities**

CCC undertook a variety of community environmental education activities during the 2006 Green Turtle Program. All activities conducted by the Field Coordinator and Research Assistants were particularly appreciated by the students of the school and high school. A good relationship has been developed with the directors and teachers of both these establishments, and hopefully a more structured series of activities can be organized for future programs.

CCC also maintains its important role in training researchers, guides and the new turtle spotters, with lectures and practical sessions that help ensure that the new turtle monitoring project north of the Tortuguero river mouth follows a strict protocol, and that the new Turtle Spotter Program runs effectively. It is imperative that CCC continues to disseminate information and results of its research activities to all those involved in tourism, thus building capacity amongst the local community in terms of turtle conservation issues.

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## 6. Appendices

### Appendix 1. Nightly sea turtle encounters for the 2006 Green Turtle Program

| Date   | Green Turtle |     |     |       | Leatherback |     |     |       | Hawksbill |     |     |       |
|--------|--------------|-----|-----|-------|-------------|-----|-----|-------|-----------|-----|-----|-------|
|        | New          | REM | REN | Total | New         | REM | REN | Total | New       | REM | REN | Total |
| 12-Jun |              |     |     | 0     |             |     |     | 0     |           |     |     | 0     |
| 13-Jun |              |     |     | 0     |             |     |     | 0     |           |     |     | 0     |
| 14-Jun |              |     |     | 0     |             |     |     | 0     |           |     |     | 0     |
| 15-Jun |              |     |     | 0     |             |     |     | 0     |           |     |     | 0     |
| 16-Jun |              |     |     | 0     |             |     | 1   | 1     |           |     |     | 0     |
| 17-Jun | 2            |     |     | 2     |             |     |     | 1     | 1         |     |     | 1     |
| 18-Jun |              | 1   |     | 3     |             |     | 1   | 2     | 1         |     |     | 2     |
| 19-Jun | 2            | 1   |     | 6     |             |     | 1   | 3     |           |     |     | 2     |
| 20-Jun | 2            | 1   |     | 9     |             |     | 1   | 4     |           |     |     | 2     |
| 21-Jun | 5            | 2   |     | 16    |             |     |     | 4     |           |     |     | 2     |
| 22-Jun | 2            |     |     | 18    |             |     |     | 4     |           | 1   |     | 3     |
| 23-Jun | 1            |     |     | 19    |             |     |     | 4     |           |     |     | 3     |
| 24-Jun | 1            | 1   | 1   | 22    |             |     | 1   | 5     |           |     |     | 3     |
| 25-Jun | 2            |     |     | 24    |             |     |     | 5     |           |     |     | 3     |
| 26-Jun | 2            |     |     | 26    |             |     |     | 5     |           |     |     | 3     |
| 27-Jun | 2            | 2   |     | 30    |             |     |     | 5     |           |     |     | 3     |
| 28-Jun | 3            | 2   | 1   | 36    |             |     |     | 5     |           |     |     | 3     |
| 29-Jun | 1            | 1   |     | 38    |             |     |     | 5     |           |     |     | 3     |
| 30-Jun | 2            |     |     | 40    |             |     |     | 5     |           |     |     | 3     |
| 1-Jul  | 5            | 2   |     | 47    |             |     |     | 5     |           |     |     | 3     |
| 2-Jul  | 1            | 2   |     | 50    |             |     | 1   | 6     |           |     |     | 3     |
| 3-Jul  | 4            | 1   |     | 55    |             |     |     | 6     |           |     |     | 3     |
| 4-Jul  | 6            | 3   | 1   | 65    |             |     |     | 6     |           |     |     | 3     |
| 5-Jul  | 6            | 4   | 1   | 76    |             |     |     | 6     |           |     |     | 3     |
| 6-Jul  | 2            | 5   | 2   | 85    |             |     |     | 6     |           |     |     | 3     |
| 7-Jul  | 5            | 2   |     | 92    |             |     |     | 6     |           | 1   |     | 4     |
| 8-Jul  | 8            | 7   | 3   | 110   |             |     |     | 6     |           |     |     | 4     |
| 9-Jul  | 4            |     | 2   | 116   |             |     |     | 6     |           |     |     | 4     |
| 10-Jul | 5            | 3   |     | 124   |             |     |     | 6     |           |     |     | 4     |
| 11-Jul | 4            | 4   | 3   | 135   |             |     |     | 6     |           |     |     | 4     |
| 12-Jul | 12           | 5   | 1   | 153   |             |     |     | 6     |           |     |     | 4     |
| 13-Jul | 5            | 4   | 1   | 163   |             |     |     | 6     |           |     |     | 4     |
| 14-Jul | 7            | 4   | 2   | 176   |             |     |     | 6     |           |     |     | 4     |
| 15-Jul | 7            | 6   | 2   | 191   |             |     |     | 6     | 1         |     |     | 5     |
| 16-Jul | 6            | 5   | 2   | 204   |             |     |     | 6     |           |     |     | 5     |

## Appendix 1. Continued

| Date   | Green Turtle |     |     |       | Leatherback |     |     |       | Hawksbill |     |     |       |
|--------|--------------|-----|-----|-------|-------------|-----|-----|-------|-----------|-----|-----|-------|
|        | New          | REM | REN | Total | New         | REM | REN | Total | New       | REM | REN | Total |
| 17-Jul | 6            | 4   | 1   | 215   |             |     |     | 6     |           | 1   |     | 6     |
| 18-Jul | 7            | 5   | 2   | 229   |             |     |     | 6     |           |     |     | 6     |
| 19-Jul | 9            | 4   | 3   | 245   |             |     |     | 6     |           |     |     | 6     |
| 20-Jul | 6            | 6   | 2   | 259   |             |     |     | 6     |           |     |     | 6     |
| 21-Jul | 6            | 9   | 2   | 276   |             |     |     | 6     |           |     |     | 6     |
| 22-Jul | 7            | 9   | 3   | 295   |             |     |     | 6     |           |     |     | 6     |
| 23-Jul | 11           | 3   | 1   | 310   |             |     |     | 6     |           |     |     | 6     |
| 24-Jul | 5            | 6   | 2   | 323   |             |     |     | 6     |           |     |     | 6     |
| 25-Jul | 14           | 6   |     | 343   |             |     |     | 6     |           |     |     | 6     |
| 26-Jul | 18           | 5   | 2   | 368   |             |     |     | 6     |           |     |     | 6     |
| 27-Jul | 15           | 11  | 1   | 395   |             |     |     | 6     |           |     |     | 6     |
| 28-Jul | 9            | 4   | 3   | 411   |             |     |     | 6     |           |     |     | 6     |
| 29-Jul | 8            | 5   | 2   | 426   |             |     |     | 6     |           |     |     | 6     |
| 30-Jul | 8            | 8   | 5   | 447   |             |     |     | 6     |           |     |     | 6     |
| 31-Jul | 12           | 7   | 2   | 468   |             |     |     | 6     |           |     |     | 6     |
| 1-Aug  | 6            | 3   | 2   | 479   |             |     |     | 6     |           |     |     | 6     |
| 2-Aug  | 17           | 3   | 2   | 501   |             |     |     | 6     |           |     |     | 6     |
| 3-Aug  | 9            | 4   | 4   | 518   |             |     |     | 6     |           |     |     | 6     |
| 4-Aug  | 7            | 5   | 5   | 535   |             |     |     | 6     |           |     |     | 6     |
| 5-Aug  | 9            | 4   | 4   | 552   |             |     |     | 6     |           |     |     | 6     |
| 6-Aug  | 8            | 7   | 4   | 571   |             |     |     | 6     |           |     |     | 6     |
| 7-Aug  | 9            | 8   | 1   | 589   |             |     |     | 6     |           |     |     | 6     |
| 8-Aug  | 17           | 10  | 5   | 621   |             |     |     | 6     |           |     |     | 6     |
| 9-Aug  | 15           | 4   | 3   | 643   |             |     |     | 6     |           |     |     | 6     |
| 10-Aug | 7            | 11  | 3   | 664   |             |     |     | 6     |           |     |     | 6     |
| 11-Aug | 20           | 10  | 5   | 699   |             |     |     | 6     |           |     |     | 6     |
| 12-Aug | 17           | 7   | 5   | 728   |             |     |     | 6     |           |     |     | 6     |
| 13-Aug | 10           |     | 5   | 743   |             |     |     | 6     |           |     |     | 6     |
| 14-Aug | 12           | 9   | 4   | 768   |             |     |     | 6     |           |     |     | 6     |
| 15-Aug | 6            | 3   | 3   | 780   |             |     |     | 6     |           |     |     | 6     |
| 16-Aug | 13           | 7   | 11  | 811   |             |     |     | 6     |           |     |     | 6     |
| 17-Aug | 5            | 7   | 3   | 826   |             |     |     | 6     |           |     |     | 6     |
| 18-Aug | 6            | 5   | 3   | 840   |             |     |     | 6     |           |     |     | 6     |
| 19-Aug |              |     |     | 840   |             |     |     | 6     |           |     |     | 6     |
| 20-Aug | 6            | 6   | 3   | 855   |             |     |     | 6     |           |     |     | 6     |
| 21-Aug | 8            | 7   | 3   | 873   |             |     |     | 6     |           |     |     | 6     |
| 22-Aug | 3            | 2   | 7   | 885   |             |     |     | 6     |           |     |     | 6     |
| 23-Aug | 15           | 4   | 1   | 905   |             |     |     | 6     |           |     |     | 6     |

## Appendix 1. Continued

| Date   | Green Turtle |     |     |       | Leatherback |     |     |       | Hawksbill |     |     |       |
|--------|--------------|-----|-----|-------|-------------|-----|-----|-------|-----------|-----|-----|-------|
|        | New          | REM | REN | Total | New         | REM | REN | Total | New       | REM | REN | Total |
| 24-Aug | 9            | 6   | 5   | 925   |             |     |     | 6     |           |     |     | 6     |
| 25-Aug | 9            | 5   | 4   | 943   |             |     |     | 6     |           |     |     | 6     |
| 26-Aug | 11           | 13  | 5   | 972   |             |     |     | 6     |           |     |     | 6     |
| 27-Aug | 12           | 2   | 7   | 993   |             |     |     | 6     |           |     |     | 6     |
| 28-Aug | 11           | 4   | 3   | 1011  |             |     |     | 6     |           |     |     | 6     |
| 29-Aug | 13           | 6   | 6   | 1036  |             |     |     | 6     |           |     |     | 6     |
| 30-Aug | 11           | 5   | 5   | 1057  |             |     |     | 6     |           |     |     | 6     |
| 31-Aug | 7            | 7   | 6   | 1077  |             |     |     | 6     |           |     |     | 6     |
| 1-Sep  | 7            | 5   | 4   | 1093  |             |     |     | 6     |           |     |     | 6     |
| 2-Sep  | 11           | 3   | 4   | 1111  |             |     |     | 6     |           |     |     | 6     |
| 3-Sep  | 11           | 6   | 12  | 1140  |             |     |     | 6     |           |     |     | 6     |
| 4-Sep  | 12           | 8   | 7   | 1167  |             |     |     | 6     |           |     |     | 6     |
| 5-Sep  | 12           | 6   | 6   | 1191  |             |     |     | 6     |           |     |     | 6     |
| 6-Sep  | 15           | 4   | 9   | 1219  |             |     |     | 6     |           |     |     | 6     |
| 7-Sep  | 13           | 5   | 5   | 1242  |             |     |     | 6     |           |     |     | 6     |
| 8-Sep  | 12           | 12  | 8   | 1274  |             |     |     | 6     |           |     |     | 6     |
| 9-Sep  | 20           | 5   | 4   | 1303  |             |     |     | 6     |           |     |     | 6     |
| 10-Sep | 14           | 9   | 8   | 1334  |             |     |     | 6     |           |     |     | 6     |
| 11-Sep | 20           | 3   | 1   | 1358  |             |     |     | 6     |           |     |     | 6     |
| 12-Sep | 15           | 4   | 10  | 1387  |             |     |     | 6     |           |     |     | 6     |
| 13-Sep | 18           | 8   |     | 1413  |             |     |     | 6     |           |     |     | 6     |
| 14-Sep | 13           | 4   | 4   | 1434  |             |     |     | 6     |           | 1   |     | 7     |
| 15-Sep | 15           | 8   | 7   | 1464  |             |     |     | 6     |           |     |     | 7     |
| 16-Sep | 14           | 6   | 7   | 1491  |             |     |     | 6     |           |     |     | 7     |
| 17-Sep | 7            |     | 2   | 1500  |             |     |     | 6     |           |     |     | 7     |
| 18-Sep | 8            | 3   | 4   | 1515  |             |     |     | 6     |           |     |     | 7     |
| 19-Sep | 9            | 4   | 6   | 1534  |             |     |     | 6     |           |     |     | 7     |
| 20-Sep | 14           | 9   | 9   | 1566  |             |     |     | 6     |           |     |     | 7     |
| 21-Sep | 19           | 1   | 11  | 1597  |             |     |     | 6     |           |     |     | 7     |
| 22-Sep | 14           | 6   | 5   | 1622  |             |     |     | 6     |           |     |     | 7     |
| 23-Sep | 15           | 5   | 4   | 1646  |             |     |     | 6     |           |     |     | 7     |
| 24-Sep | 18           | 3   | 5   | 1672  |             |     |     | 6     |           |     |     | 7     |
| 25-Sep | 21           | 8   | 12  | 1713  |             |     |     | 6     |           |     |     | 7     |
| 26-Sep | 22           | 1   | 7   | 1743  |             |     |     | 6     |           |     |     | 7     |
| 27-Sep | 13           | 4   | 5   | 1765  |             |     |     | 6     |           |     |     | 7     |
| 28-Sep | 13           | 7   | 5   | 1790  |             |     |     | 6     |           |     |     | 7     |
| 29-Sep | 15           | 3   | 3   | 1811  |             |     |     | 6     |           |     |     | 7     |
| 30-Sep | 14           | 5   | 7   | 1837  |             |     |     | 6     |           |     |     | 7     |



## Appendix 1. Continued

| Date         | Green Turtle |            |            |             | Leatherback |          |          |          | Hawksbill |          |          |          |
|--------------|--------------|------------|------------|-------------|-------------|----------|----------|----------|-----------|----------|----------|----------|
|              | New          | REM        | REN        | Total       | New         | REM      | REN      | Total    | New       | REM      | REN      | Total    |
| 1-Oct        | 15           | 7          | 4          | 1863        |             |          |          | 6        |           |          |          | 7        |
| 2-Oct        | 3            | 2          | 3          | 1871        |             |          |          | 6        |           |          |          | 7        |
| 3-Oct        | 2            | 5          | 7          | 1885        |             |          |          | 6        |           |          |          | 7        |
| 4-Oct        | 2            | 6          | 10         | 1903        |             |          |          | 6        |           |          |          | 7        |
| 5-Oct        | 2            | 6          | 6          | 1917        |             |          |          | 6        |           | 1        |          | 8        |
| 6-Oct        |              | 4          | 5          | 1926        |             |          |          | 6        |           |          |          | 8        |
| 7-Oct        |              | 5          | 6          | 1937        |             |          |          | 6        |           |          |          | 8        |
| 8-Oct        |              | 6          | 9          | 1952        |             |          |          | 6        |           |          |          | 8        |
| 9-Oct        |              | 2          | 11         | 1965        |             |          |          | 6        |           |          |          | 8        |
| 10-Oct       |              | 2          | 12         | 1979        |             |          |          | 6        |           |          |          | 8        |
| 11-Oct       |              | 9          | 3          | 1991        |             |          |          | 6        |           |          |          | 8        |
| 12-Oct       |              | 4          | 7          | 2002        |             |          |          | 6        | 1         |          |          | 9        |
| 13-Oct       |              |            |            | 2002        |             |          |          | 6        |           |          |          | 9        |
| 14-Oct       |              |            |            | 2002        |             |          |          | 6        |           |          |          | 9        |
| 15-Oct       | 3            | 4          | 7          | 2016        |             |          |          | 6        |           |          |          | 9        |
| 16-Oct       | 3            |            | 3          | 2022        |             |          |          | 6        |           |          |          | 9        |
| 17-Oct       | 3            | 2          | 1          | 2028        |             |          |          | 6        |           |          |          | 9        |
| 18-Oct       | 4            |            | 1          | 2033        |             |          |          | 6        |           |          |          | 9        |
| 19-Oct       | 3            | 3          | 1          | 2040        |             |          |          | 6        |           |          |          | 9        |
| 20-Oct       | 8            | 4          | 4          | 2056        |             |          |          | 6        |           |          |          | 9        |
| 21-Oct       | 2            | 3          | 4          | 2065        |             |          |          | 6        |           |          |          | 9        |
| 22-Oct       | 9            | 1          | 2          | 2077        |             |          |          | 6        |           |          |          | 9        |
| 23-Oct       | 3            | 1          |            | 2081        |             |          |          | 6        |           |          |          | 9        |
| 24-Oct       | 4            | 4          | 4          | 2093        |             |          |          | 6        |           |          |          | 9        |
| 25-Oct       | 4            | 1          | 4          | 2102        |             |          |          | 6        |           |          |          | 9        |
| 26-Oct       |              |            |            | 2102        |             |          |          | 6        |           |          |          | 9        |
| 27-Oct       | 2            | 3          | 1          | 2108        |             |          |          | 6        |           |          |          | 9        |
| 28-Oct       |              |            |            | 2108        |             |          |          | 6        |           |          |          | 9        |
| 29-Oct       |              |            | 1          | 2109        |             |          |          | 6        |           |          |          | 9        |
| 30-Oct       |              |            |            | 2109        |             |          |          | 6        |           |          |          | 9        |
| 31-Oct       |              |            |            | 2109        |             |          |          | 6        |           |          |          | 9        |
| <b>Total</b> | <b>1059</b>  | <b>573</b> | <b>477</b> | <b>2109</b> | <b>0</b>    | <b>0</b> | <b>6</b> | <b>6</b> | <b>4</b>  | <b>5</b> | <b>0</b> | <b>9</b> |

### Key to table

New – Turtles that had no tags on first encounter in 2006

REM – Remigrant turtles that had tags from previous years/other projects on first encounter in 2006

REN – Renester turtles that were encountered on more than one occasion during 2006