



REPORT ON THE 2007 LEATHERBACK PROGRAM AT TORTUGUERO, COSTA RICA

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**By
Dagnia Nolasco Del Aguila, Field Coordinator
Xavier Debade, Field Coordinator
and
Dr Emma Harrison, Scientific Director**

**With the assistance of
Siviany Briceño Arias, Research Assistant
Carlos Bustos Segura, Research Assistant
Jennifer Carr, Research Assistant
Alejandra Galvez Gutierrez, Research Assistant
Katie Howard, Research Assistant
David Melero Duro, Research Assistant
Noga Neeman Horowitz, Research Assistant
Soledad Trujillo Barbadillo, Research Assistant
Leonel Gutierrez, Research Assistant
Jesús Valverde, Research Assistant
Enrique Vargas, Track Surveyor**

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Foundation**



CARIBBEAN CONSERVATION CORPORATION

Address:	Apartado Postal 246-2050 San Pedro COSTA RICA	4424 NW 13th St. Suite B-11 Gainesville, FL 32609 USA
Tel:	Int + 506 2297 5510	001 352 373 6441
Fax:	Int + 506 2297 6576	001 235 375 2449
E-mail:	emma@cccturtle.org	ccc@cccturtle.org
Webpage:	http://www.cccturtle.org	http://www.cccturtle.org

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Executive Summary

Monitoring and Research Activities Conducted

- 1 A total of 22 track surveys were conducted between the Tortuguero river mouth and Jalova lagoon between January and July 2007
- 2 Leatherback nesting was observed from late February to late June.
- 3 Peak nesting was recorded on 14 April when 12 fresh leatherback nests were recorded from one night.
- 4 The Field Coordinators (FCs) and the Research Assistants (RAs) conducted a total of 22 additional track surveys between the Tortuguero and Parismina river mouths between 12 March and 4 June 2007. Poaching was estimated at a minimum of 9.3% of leatherback nests, 4.0% of green turtle nests and 15.8% of hawksbill nests.
- 5 Comparison of the leatherback nesting estimates obtained from track surveys conducted either by the track surveyor (489 nests) or by the FCs and RAs (555 nests) between Tortuguero river mouth and Jalova lagoon between 12 March – 4 June revealed that the two methods showed quite similar results.
- 6 A total of 127 leatherback turtle encounters were recorded during 977 hours of night patrols between 5 March and 6 June, 2007; 34 were newly tagged females, 59 had tags from previous years and/or other nesting beaches, and 34 were renesters. In addition, 25 green turtles and seven hawksbill turtles were encountered.
- 7 A total of 63.4% (n = 59) of female leatherback turtles bore tags from previous years or other nesting beaches. Of the previously tagged leatherback turtles, 28.8% were originally tagged in Tortuguero (n = 17); the others were tagged in Caño Palma (n = 1), Parismina (n = 2), Pacuare (n = 19), Mondonguillo (n = 12), Gandoca/Manzanillo (n = 4) and in Panama (n = 4). One of those originally tagged in Tortuguero was first observed in 1989, 18 years previously, which is a record for the longest nesting history of a leatherback turtle in Tortuguero. One green turtle was first tagged in Pacuare in 2006, and a hawksbill was encountered with tags from Tortuguero in 2003.
- 8 A total of 11.8% (n = 4) of the newly tagged leatherback turtles (n = 34) showed evidence of old tag holes or notches when they were encountered for the first time.
- 9 A total of 88.2% of the encountered leatherback turtles nested in the open beach zone (n = 112), 2.4% nested in the border zone (n = 3) and 9.4 % did not lay eggs (n = 12).
- 10 No significant difference in carapace length (CCLmin) was found for leatherback turtles with complete or incomplete caudal projections.
- 11 Mean curved carapace length of leatherbacks was 152.1 cm (n = 90).
- 12 Mean clutch size for leatherback females was 69 yolked and 20 yolkless eggs (n = 21).
- 13 Mean carapace length (CCLmin) was 103.7 cm for green turtles (n = 20), and 89.5 cm for hawksbill turtles (n = 6). Mean clutch size for green turtles was 101 eggs (n = 1) and 147 for

hawksbills (n = 1); the hawksbill female also laid five yolkless eggs.

- 14 Precision of the CCLmin measurement during the same encounter was high in 2007, and was similar for all species; 0.3 cm for leatherback (n = 118), 0.3 cm for green (n = 23) and 0.2 cm for hawksbill turtles (n = 7).
- 15 Precision of the CCLmin measurement for leatherback turtles measured during more than one encounter was 0.8 cm for two encounters (n = 19), 1.1 cm for three encounters (n = 2) and 2.2 cm for four encounters (n = 2).
- 16 A total of 31 leatherback nests were marked for monitoring. In addition, a further four nests were monitored; they were relocated due to their location below/close to the high tide line. The relocated nests were treated independently during analysis of survivorship and hatching success. Of the *in situ* nests four could not be located for excavation and were eliminated from the analysis.
- 17 One green turtle and one hawksbill nest were also marked for monitoring; they will be included in the analysis of hatching success in the 2007 Green Turtle Program Report.
- 18 Overall hatching success for monitored *in situ* leatherback nests (n = 27) was 32.9% and overall emerging success was 30.3%.
- 19 Mean distance between the sand surface and the top egg at the time of excavation for undisturbed nests (n = 14) varied between 41-77 cm with a mean of 61.6 cm. The mean distance from the sand surface to the bottom of the egg chamber varied between 73-96 cm, with a mean of 82.3 cm.
- 20 The incubation period for undisturbed leatherback nests for which emergence was observed (n = 10) ranged from 60-66 days with a mean of 63 days.
- 21 Five deformed embryos, corresponding to 0.26% of eggs, were encountered during nest excavations. In addition, one deformed live hatchling was also observed.
- 22 Hatching success of relocated nests was 30.2% (n = 4) and emerging success was 29.0%.
- 23 Rainfall was heaviest in April (436.0 mm), and March was the driest month (313.0 mm).
- 24 Monthly mean sand temperatures ranged between 25.8 – 33.5°C. Sand temperatures were higher in the open zone than in the border and vegetation zones.
- 25 A total of 116,751 visitors paid to enter Tortuguero National Park (TNP) in 2007, continuing the increasing trend observed in previous years. A significant rise in the number of Costa Rican nationals visiting the park has occurred in the last three years.
- 26 The visitation at the CCC Natural History and Visitor Center decreased in 2007, reversing the increase observed in 2006. A total of 30,019 visitors were registered for the year, an average of 82 visitors per day.
- 27 The pattern of artificial lights visible on the beach remains the same as that recorded in other years; most lights are in Tortuguero village and several lodges and cabinas north of the village.
- 28 13 dead turtles were encountered during the 2007 Leatherback Program, all of which had

been killed by jaguars (12 green turtles and 1 hawkbill).

- 29 On 16 April a leatherback turtle was encountered on the beach during a night patrol; she was trapped in a buried tree close to the river mouth. Despite the efforts of the research team to remove the tree she died on the beach.
- 30 Environmental education activities were organized by the FC and RAs for students at the Tortuguero school and high school in May.

Conclusions

- 1 Replacing and painting mile markers along the entire beach is absolutely indispensable to facilitate night patrols and track surveys.
- 2 Leatherback nesting was much higher in 2007 than in 2006, although the overall decline in nesting continues; 67% fewer nests are now being laid in Tortuguero than at the start of the Leatherback Program in 1995.
- 3 The two methods, track surveyor and FC/RAs track surveys, used to estimate the number of leatherback nests gave quite similar results for the 2007 leatherback nesting season.
- 4 Levels of poaching declined for all species of turtle in 2007.
- 5 Poaching levels within Tortuguero National Park decreased, and were significantly lower than those recorded south of the park limit at Jalova.
- 6 The number of leatherback turtles encountered during nightly patrols (n = 127) was higher than that recorded during the 2006 Leatherback Program; the patrol effort by the FC and RAs was similar in both years.
- 7 Hatching success of leatherback nests was considerably lower in 2007 than in 2006.
- 8 Hatching and emerging success of relocated leatherback nests was slightly lower than that observed for *in situ* nests.

Recommendations

- 1 Continuing high levels of poaching just south of the limit of the National Park at Jalova highlight the need for extra patrols by park rangers in this area. While poaching within the park decreased during 2007, this positive result was offset by the fact that the area from Jalova – Parsimina remained subject to unacceptable levels of poaching throughout the season.
- 2 There needs to be continuing communication between turtle research projects along the Caribbean coast of Costa Rica and Panama, to facilitate data exchange about leatherback turtles that are frequently utilizing different nesting beaches in the region.
- 3 Data should be collected on the ground water level during the nesting season, to monitor changes in the water table that might have an impact on nesting and emerging success, particularly for leatherback turtles.
- 4 The small sample number of relocated nests for the investigation into the impacts of

relocation on leatherback survivorship and hatching success during the 2007 Leatherback Program was insufficient to provide any conclusive results. The study should be continued in 2008, with the possibility of extending the protocol to the Jalova section of the beach to increase the chance of encountering a nest laid within the range permitted for relocation. No decision should be taken regarding the implementation of this practice as a conservation management strategy for leatherbacks at Tortuguero until the completion of this study.

- 5 The CCC Visitor Center needs to be modernized and updated to fulfill its role in raising awareness and improving education about sea turtle conservation issues, the history of the CCC in Tortuguero, and the flora and fauna of TNP.
- 6 CCC should remain active in monitoring the impacts of the increasing levels of tourism within the Tortuguero region, to ensure that the impacts on nesting turtles are minimal.
- 7 A more structured approach to the environmental educational activities needs to be taken; each RA group should be given a specific theme and asked to develop a series of activities for a range of age groups related to that theme.
- 8 The RA orientation and training program should be extended to a two-week period. In addition to the talks and practical sessions relating to sea turtle biology and the monitoring protocol, RAs should be provided with information about the history of Tortuguero village (from a member of the community), and the development of Tortuguero National Park (from National Park staff), with specific reference to laws concerning sea turtles.

1. Introduction

Research and conservation of the sea turtle populations of Tortuguero, Costa Rica was initiated by Dr Archie Carr in 1955 (Carr *et al.* 1978) and continues to this day. Caribbean Conservation Corporation (CCC) began an annual leatherback (*Dermochelys coriacea*) program in Tortuguero in 1995 (Campbell *et al.* 1996); this program is implemented in partial fulfillment of 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'

CCC staff and the Scientific Advisory Committee made a major revision of the Leatherback Program monitoring protocol in 1997, and they conduct regular reviews and modifications as necessary. The 2007 Leatherback Program represents the thirteenth consecutive leatherback program and the tenth year of implementing the new monitoring protocol.

The objectives of this report are to summarize the results of the 2007 Leatherback Program, assess the accomplishments and shortcomings of the program and provide appropriate recommendations for future research activities and conservation efforts in Tortuguero.

2. Methods

2.1 Preparations

The Field Coordinators (FCs) arrived in Tortuguero on 3 March to prepare for the 2007 Leatherback Program. The Research Assistants (RAs) arrived at the field station on 5 March, 2007. During the first two weeks of the 2007 Leatherback Program the RAs received an intensive program of training and orientation; they had lectures about sea turtle biology and conservation, and the Leatherback Program monitoring protocol was explained in detail. In addition to theoretical instruction they also received practical training in flipper tagging, nest marking and other data collection procedures from the FCs. Training patrols were conducted on several nights along sections of beach close to the field station (between the Tortuguero river mouth and mile 5); the FCs demonstrated field techniques and supervised RAs collecting data and tagging turtles. Additional training patrols were also conducted at the southern end of the beach, close to the Jalova lagoon, on 9 and 10 March, 2007.

The positions of mile markers along the 22 miles (36km) of beach between the Tortuguero and Parismina river mouths were verified using a 300ft fiberglass measuring tape. Mile markers were located every 1/8 of a mile between the Tortuguero river mouth (mile -3/8) and mile 5, and every 4/8 mile between mile 5 and the Parismina river mouth (mile 21 4/8). Three markers were put up in every location from mile -3/8 to mile 5, and two markers for the rest of the beach. All markers were painted white, with the marker number painted in black.

2.2 Track Surveys

2.2.1 Weekly track surveys

Track surveys between the Tortuguero river mouth and Jalova lagoon (18 miles) were conducted approximately weekly by CCC track surveyor Enrique Vargas. Track surveys started near Tortuguero river mouth at 5:00am and were completed at Jalova lagoon at approximately

10:30am. Only fresh sea turtle tracks from the previous night were counted. Notes were also kept on the number of turtles depredated by jaguars (*Panthera onca*) or taken by poachers, and the number of poached fresh nests.

Dead turtles were considered depredated by jaguars when they were surrounded by jaguar tracks or showed characteristic jaguar injuries, such as large bite wounds to the neck.

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.

The total number of leatherback nests for the season was extrapolated from the track survey data by applying a GAM model and integrating resulting values using Berkeley Madonna software (For methodology see Troëng *et al.* 2004).

2.2.2 Three-day track surveys

Track surveys were conducted by the FCs and RAs between the Tortuguero and Parismina river mouths, every three days during the 2007 Leatherback Program, following the completion of the RA orientation and training week. The beach was divided into four sections: Tortuguero river mouth - CCC station (mile 2 5/8); CCC station - Juana López trail (mile 15); Juana López trail - Jalova lagoon (mile 18) and Jalova lagoon - Parismina river mouth (mile 21 4/8). All tracks since the previous survey were recorded, to get a total count of all nesting activity during the season. Once a track had been recorded two lines were drawn through it, and sticks were placed in a cross formation over the nest, to ensure that it was not counted on future surveys. Notes were also kept on jaguar predation, and levels of illegal take of turtles and nests.

2.3 Tagging of Nesting Sea Turtles

Nightly tagging patrols were conducted, with varying frequency, on three different beach sections; Tortuguero river mouth - CCC station (mile 2 5/8), CCC station - mile 5, and Jalova lagoon (mile 18) - mile 14. On three nights in May, when personnel permitted, patrols were also conducted on the beach between Jalova lagoon and Parismina river mouth (mile 18 4/8 - 21 4/8).

Following the findings of an independent research project conducted at Tortuguero in 2006, in which it was found that the amplitude of the high tide had a significant influence on the arrival time of leatherback turtles at the nesting beach, it was decided to vary the time and duration of research patrols, in an effort to maximize the encounter rate with females. At the start of the 2007 nesting season information about the timing and amplitude of high tides in Tortuguero was obtained from the Central American Sea Level Observation Network, and a patrol schedule was devised to ensure that research groups were present on the beach during the optimum hours around the high tide. Patrols commenced between 8.00pm and midnight, and varied in duration from three to five hours (seven in Jalova), depending on the number of Research Assistants and volunteer participants available.

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

For each encounter the following information was recorded:

- Date
- Time
- Mile marker (to the north of the turtle)
- Activity when first encountered
- Species
- Tag numbers and/or evidence of old tag holes or notches

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

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

Tags used during the 2007 Leatherback Program were National Band & Tag Company (NBTC) Monel #49 tags VA4101-4200 (except VA4150), VA4901-4905, VA4916, VA4926-VA4931, and Inconel #681 tags 107001-107004, 107024-107032, 107051-107132, 107140-107142.

2.4 Biometric Data Collection

If the turtle was encountered before the start of oviposition, the eggs were counted as they were laid into the egg chamber. They were counted by a person wearing a plastic glove to avoid contamination of the nest. Normal sized and yolkless eggs were counted separately.

Curved Carapace Length minimum (CCLmin) was recorded for each leatherback; this was measured using a flexible fiberglass tape measure from the nuchal notch to the end of the caudal projection, next to the central ridge. The caudal projection was classified as ‘complete’ if no irregularities occurred and ‘incomplete’ if it was irregular or part of it was missing that would effect the carapace measurement. CCLmin was measured for green and hawksbill turtles from where the skin meets the carapace at the nuchal notch, along the midline, to the posterior notch between the supracaudals. All measurements were recorded to the closest millimeter. To determine precision, all measurements were repeated three times by the same person. Precision for one encounter is defined as the difference between the shortest and the longest of the three measurements. Precision for females encountered more than once during the Program is defined as the difference between the shortest and the longest of all measurements collected from the same turtle.

2.5 Determination of Nest Survivorship and Hatching Success

If a leatherback turtle was encountered along the beach section between the Tortuguero river mouth (mile – 3/8) and the mile 5 marker, and the egg chamber was still open (prior to covering) the nest was marked for inclusion in the study of nest survivorship and hatching success. Green and hawksbill nests were also marked in this section of beach if the female had not covered the egg chamber.

Three pieces of flagging tape were attached to vegetation behind the nest, and the distance from the centre of the egg chamber to each tape was measured so that the location of the nest could be determined at a later date using triangulation. The third flagging tape ensured that nests could be located even if one piece of flagging tape went missing. Each morning the marked nests were

inspected so that the fate of the nest could be determined. Evidence of depredation, poaching or beach erosion were noted and resulted in termination of monitoring for that nest; if the evidence was inconclusive, monitoring continued as normal, but the date of the observed disturbance was recorded, so that any resulting anomalous excavation data could be accounted for.

Marked nests were excavated two days after evidence of hatching, or 75 days after oviposition (65 days for green or hawksbill nests) if no signs of hatching were observed. For each nest the following information was recorded to determine hatching and emerging success:

- 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 – a fully developed embryo was present
- Number of pipped eggs – embryo had broken the shell but did not 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.

2.5.1 Independent Research Project – Effect of relocation on hatching success

An investigation conducted during the 2006 Leatherback Program into possible factors affecting leatherback hatching success concluded that those nests laid below the high tide line had a significantly lower hatching success than those laid higher up the beach (Runemark, 2006). Following this finding a study was initiated in 2007 to look at the effect of relocation on the survivorship and hatching success of leatherback nests. The objective of the study was to determine if the relocation process significantly improved the success of these nests, and could be a potential conservation management strategy for the Tortuguero leatherback population.

Prior to the start of the 2007 Leatherback Program, the Masters student conducting the research (Noga Neeman Horowitz) participated in a training course at the leatherback monitoring project in Gandoca (on the southern Caribbean coast of Costa Rica). She received practical training in the correct technique for relocating leatherback nests.

Only those nests laid below or within 1m of the high tide line (to account for variability in the location of the high tide line along the beach) were included in the study. If a patrol encountered a female nesting within this zone of the beach they immediately radioed for Noga Neeman to come and conduct the relocation. Ideally, a plastic bag was placed inside the egg chamber just prior to oviposition, to collect all the eggs deposited; this was removed just before the female started covering. However, if the turtle had already started laying, the precise location of the nest was marked and the eggs were removed once the turtle had returned to the sea. Nests were relocated within the same 1/8 mile section, as close as possible to the original nest site, but well above the high tide line, and not close to the vegetation. They were marked using the same method described above, and were checked on a daily basis during the incubation period.

2.6 Physical Data Collection

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

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

2.7 Collection of Human Impact Data

2.7.1 Visitors to Tortuguero

The number of tourists that paid to enter the CCC Visitors Center was recorded each day by the administrator. Staff at the Tortuguero National Park offices at Cuatro Esquinas provided information on tourist visitation to the park in 2007.

2.7.2 Artificial lights

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

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

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

2.8 Dead Turtles

Any dead turtles encountered during track surveys or other monitoring activities were recorded and an attempt was made to determine the cause of death.

2.9 Environmental Education Activities

Presentations about sea turtle biology, conservation and environmental economics were given opportunistically to groups staying at or visiting the John H. Phipps Biological Station. In addition, researchers conducted environmental education activities at the Tortuguero village school, involving students from 1st – 5th grade.

3. Results

3.1 Preparations

Many of the beach mile markers had to be replaced at the start of the 2007 Leatherback Program because they had either been washed away or destroyed by termites since the end of the 2006 Green Turtle Program. The preparation of the mile markers was a significant task for the RAs during the first week of the Program.

3.2 Track Surveys

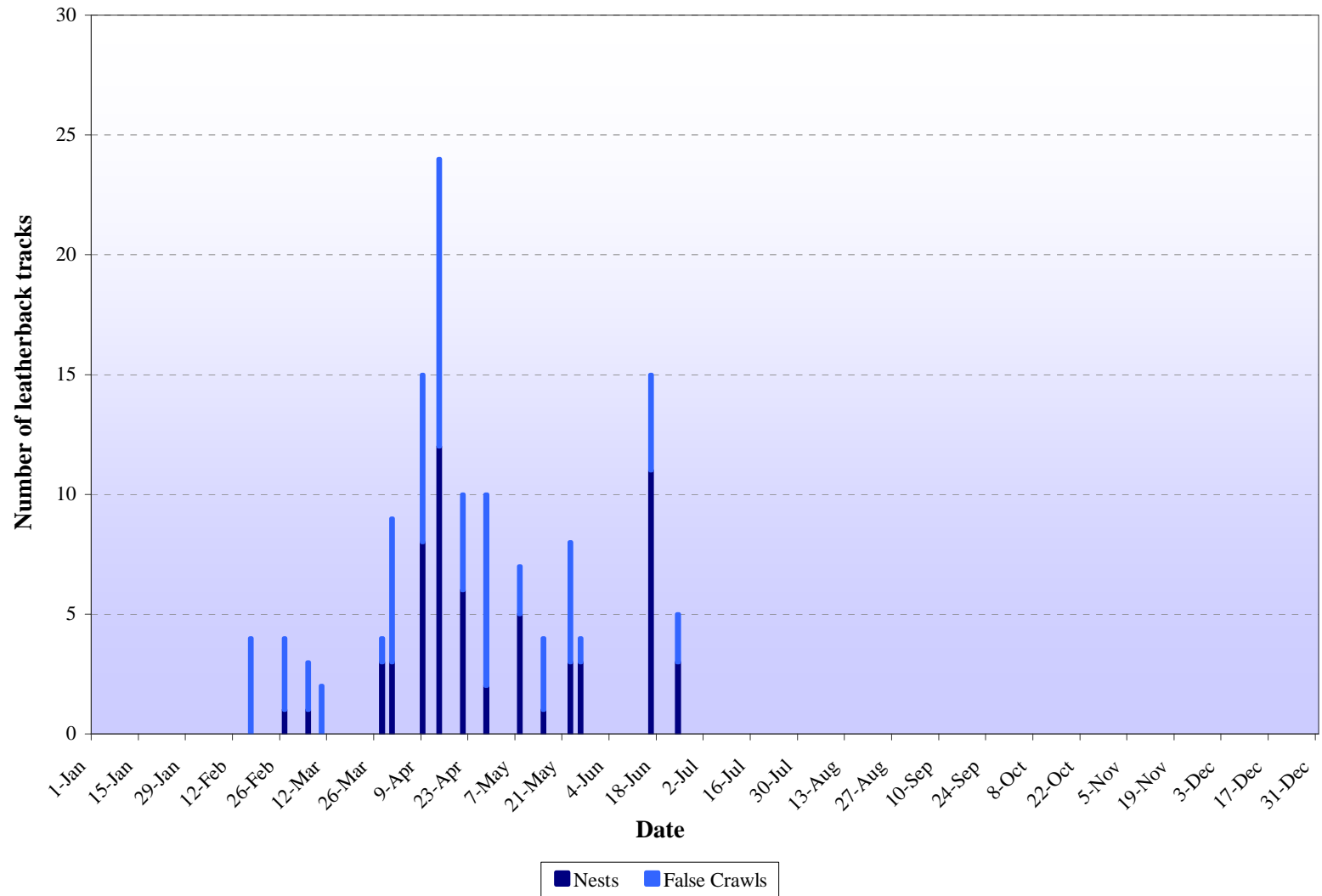
3.2.1 Weekly track surveys

A total of 22 weekly track surveys were conducted between January and July 2007, during which 62 leatherback nests and 66 false crawls were recorded by the track surveyor. Figure 1 displays the results of the weekly track surveys; each bar represents the number of leatherback nests and false crawls recorded during a single survey. It can be seen that leatherback nesting activity occurred from late-February to late-June. However, several females were encountered after this date during night patrols conducted during the 2007 Green Turtle Program, thus it is known that leatherback nesting continued until at least 7 July. Peak nesting, as determined from the weekly track surveys, was recorded on 14 April, with 12 leatherback nests counted in one night (See Figure 1). There was also a second peak in nesting activity late in the season; on 16 June, 11 nests were recorded for a single night (See Figure 1).

Using the methodology described in Troëng *et al.* (2004) extrapolations from the weekly survey data suggest that 489 leatherback nests were laid between Tortuguero river mouth and Jalova lagoon. The FC and RA track surveys, conducted every three days from March – June, recorded 555 leatherback nests along the same beach section.

The annual leatherback nesting trend at Tortuguero for the last 13 seasons is shown in Figure 2. It can be seen that while the overall decline in nesting continues, with 67% fewer nests laid in 2007 than in 1995, the number of nests estimated for 2007 was more than double the number in 2006. Using the nesting estimates calculated from the weekly track surveys, in the last five years an average of 578 leatherback nests have been laid per season.

Figure 1. Temporal distribution of leatherback nesting activity during 2007, as determined during weekly track surveys



3.2.2 Three-day track surveys

The FCs and RAs conducted 29 track surveys between 12 March and 4 June, 2007. They recorded a total of 776 leatherback, 150 green turtle and 19 hawksbill nests during those surveys; in addition 206 leatherback, 136 green turtle and 21 hawksbill false crawls were also counted.

Peak leatherback nesting, as determined from the from the 3-day surveys, was recorded on 14 April; 50 leatherback nests had been laid during the previous three nights. This coincides exactly with the peak nesting date recorded by the weekly track surveyor (See Figure 1).

The spatial distribution of leatherback nesting during the 2007 Leatherback Program is shown in Figure 3. It can be seen that, as observed in previous years, the majority of nests were laid towards the southern end of the National Park, beyond mile 13; 506 nests were recorded between mile 13-22, accounting for 65.2% of the total. Mile 19 had the highest nesting density; 102 (13.1% of the total) leatherback nests were recorded in that section of beach (See Figure 3).

Illegal poaching of nests was observed throughout the 2007 Leatherback Program (See Table 1). A total of 81 nests were reported as poached during track surveys conducted by the FCs and RAs; 72 leatherback, six green turtle and three hawksbill nests. The minimum poaching levels observed were significantly lower than those recorded in 2006, when almost 200 nests were poached. In 2007, poached nests represented at least 9.3% of all leatherback nests recorded, 4.0% of green turtles nests and 15.8% of hawksbill nests (See Table 1).

The spatial distribution of illegal take of nests is shown in Figure 4. Only one nest was poached from the beach north of the Tortuguero National Park boundary at mile 3 3/8; a hawksbill nest from mile 2 5/8 (close to the CCC field station). It is interesting to note that very few nests were poached close to the village of Tortuguero. With regards to the poaching of leatherback nests, it is strikingly obvious from Figure 4 that most of the poaching occurred from mile 19 – 22; this section of the nesting beach lies outside the limits of Tortuguero National Park. Of the 102 leatherback nests laid along this stretch of beach 48% (49) were poached; these poached nests accounted for 68.1% of all those poached during the season. This pattern of increased poaching outside the National Park boundaries has been frequently observed in previous years, though it indicates a decrease in poaching within the park from levels recorded in 2006.

Observations and anecdotal information regarding illegal take of turtles and nests during the 2007 Leatherback Program are summarized in Appendix 2.

Figure 2. Annual leatherback nesting trend at Tortuguero from 1995 - 2007, as determined from weekly track surveys

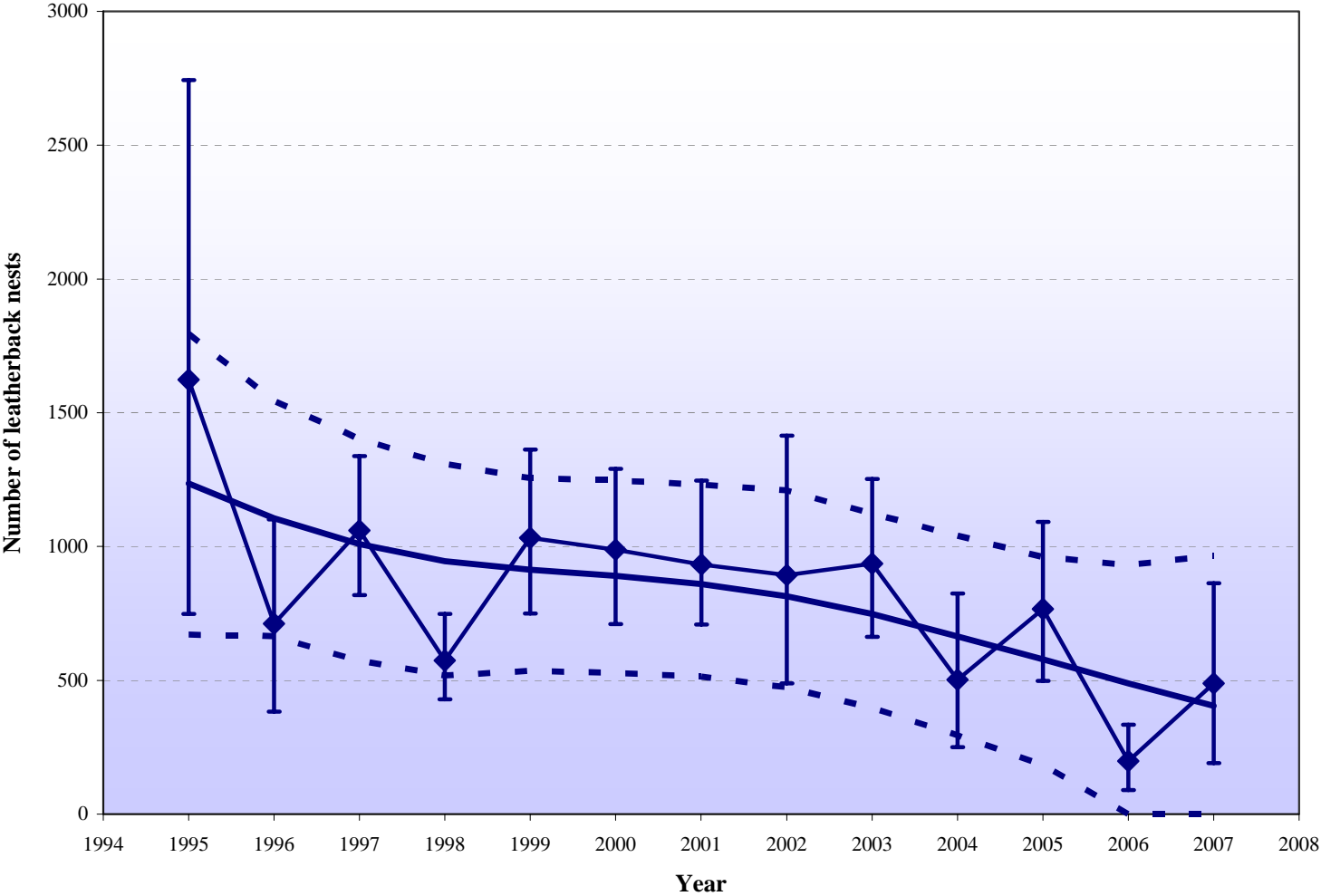


Table 1. Number of turtle nests and level of illegal poaching, as determined from track surveys conducted by FC and RAs every three days during the 2007 Leatherback Program

Date	Leatherback			Green turtle			Hawksbill		
	Nests	Min no. poached	Min % poached	Nests	Min no. poached	Min % poached	Nests	Min no. poached	Min % poached
12-Mar-07	22	3	13.6	4	0	0.0	0	0	N/A
15-Mar-07	6	1	16.7	2	0	0.0	0	0	N/A
18-Mar-07	9	1	11.1	1	0	0.0	0	0	N/A
21-Mar-07	2	1	50.0	1	1	100.0	0	0	N/A
24-Mar-07	21	2	9.5	4	1	25.0	0	0	N/A
27-Mar-07	24	3	12.5	5	0	0.0	0	0	N/A
30-Mar-07	28	1	3.6	4	0	0.0	0	0	N/A
2-Apr-07	13	0	0.0	0	0	N/A	0	0	N/A
5-Apr-07	31	3	9.7	1	0	0.0	0	0	N/A
8-Apr-07	25	2	8.0	3	0	0.0	1	0	0
11-Apr-07	31	1	3.2	11	0	0.0	0	0	N/A
14-Apr-07	50	0	0.0	6	1	16.7	0	0	N/A
17-Apr-07	43	0	0.0	9	0	0.0	0	0	N/A
20-Apr-07	41	0	0.0	9	1	11.1	0	0	N/A
23-Apr-07	35	0	0.0	8	0	0.0	0	0	N/A
26-Apr-07 ¹	24	0	0.0	8	0	0.0	0	0	N/A
29-Apr-07	34	9	26.5	3	0	0.0	0	0	N/A
2-May-07	37	2	5.4	4	0	0.0	0	0	N/A
5-May-07	34	2	5.9	9	0	0.0	2	0	0
8-May-07	25	1	4.0	8	0	0.0	0	0	N/A
11-May-07	29	8	27.6	7	1	14.3	1	1	100.0
14-May-07	19	4	21.1	8	0	0.0	2	0	0
17-May-07	19	4	21.1	5	0	0.0	2	0	0
20-May-07	37	4	10.8	5	0	0.0	0	0	N/A
23-May-07	21	4	19.0	6	0	0.0	3	1	33.3
26-May-07	33	3	9.1	1	0	0.0	4	1	25.0
29-May-07	27	11	40.7	3	1	33.3	0	0	N/A
1-Jun-07	24	0	0.0	10	0	0.0	1	0	0
4-Jun-07	32	2	6.3	5	0	0.0	3	0	0
Total	776	72	9.3%	150	6	4.0%	19	3	15.8%

¹ Spring tides may have affected track count

Figure 3. Spatial distribution of leatherback nests during the 2007 Leatherback Program, as determined by track surveys conducted by FCs and RAs every three days

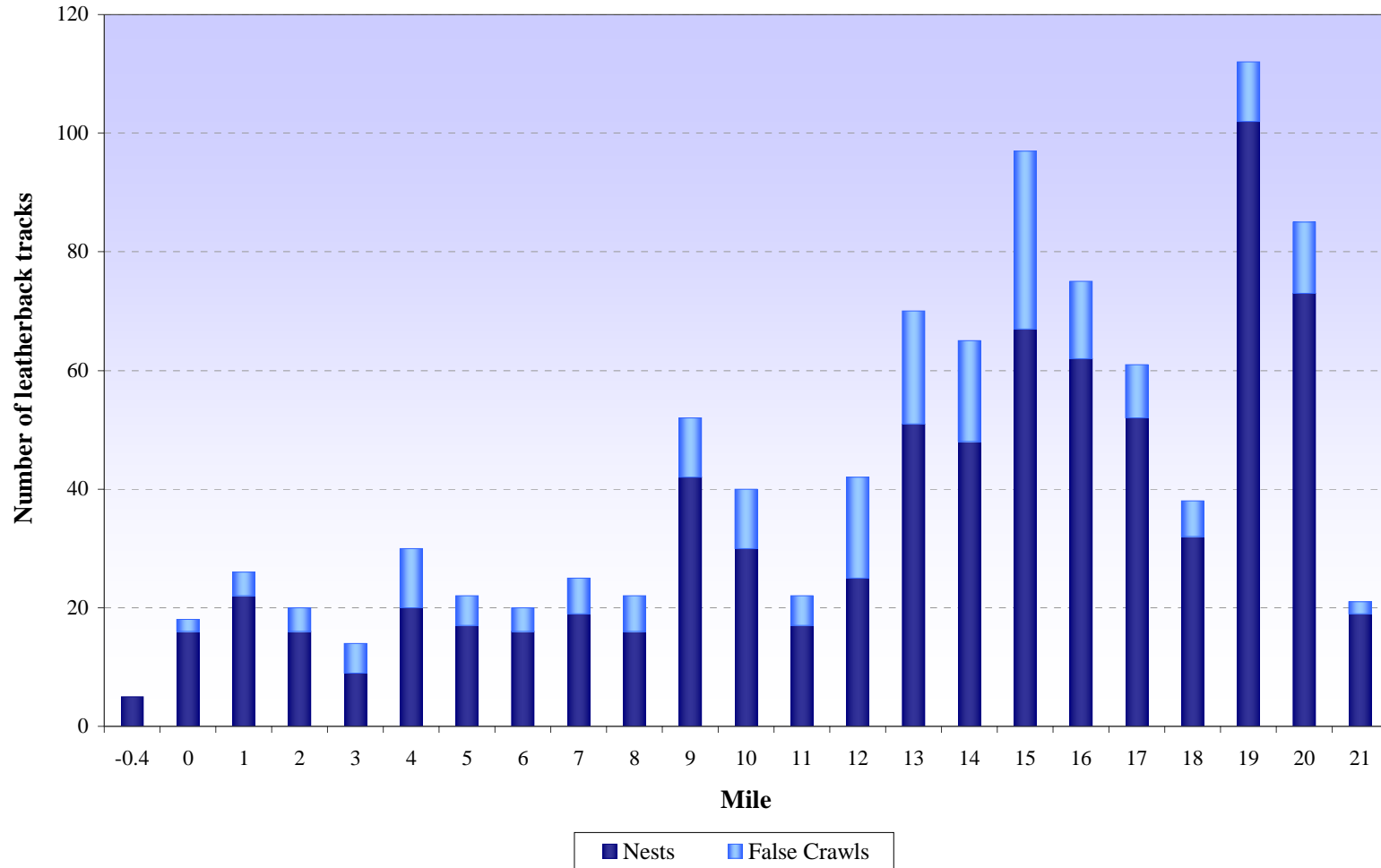
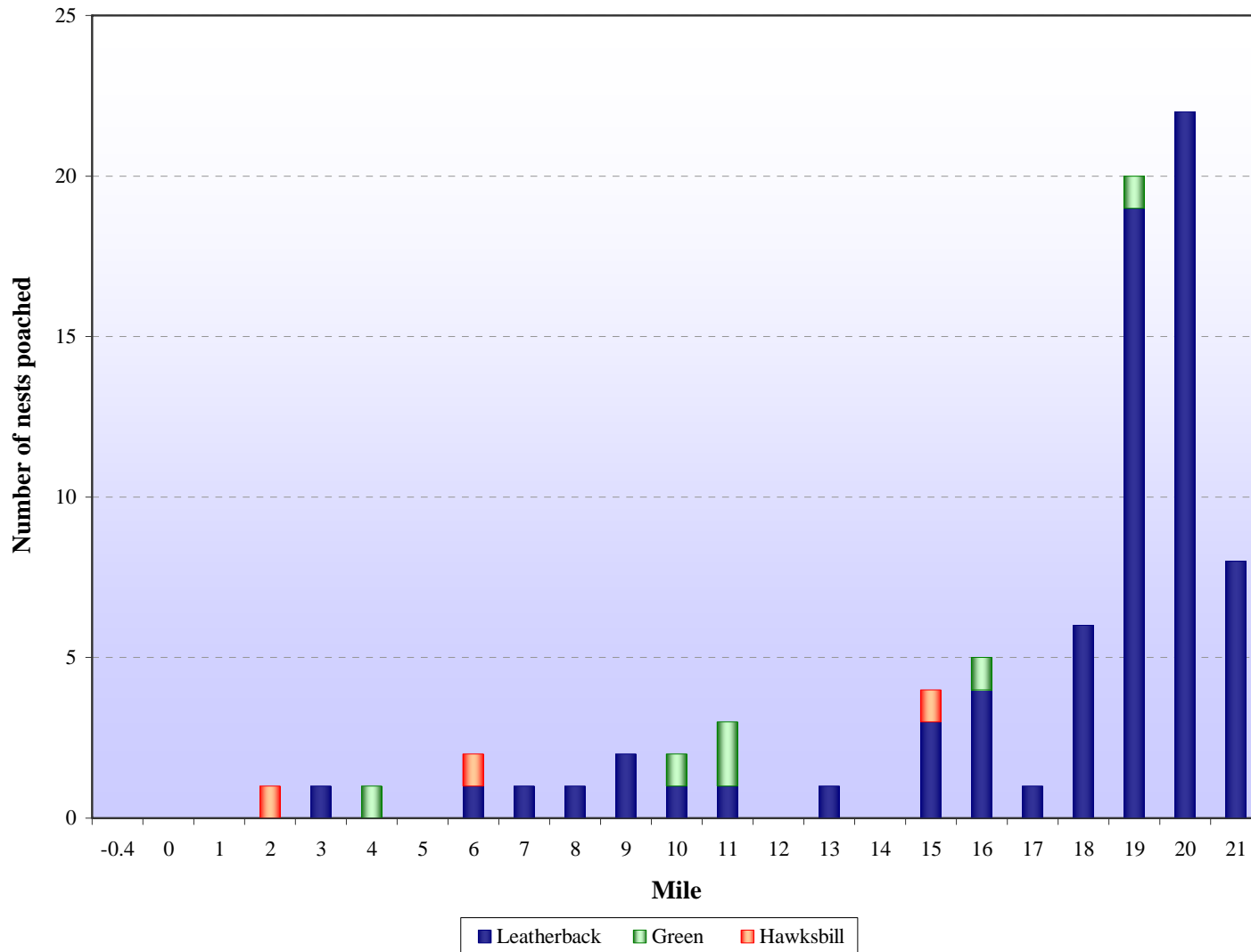


Figure 4. Spatial distribution of illegal poached nests during the 2007 Leatherback Program, as determined by track surveys conducted by FCs and RAs every three days



3.3 Tagging of Nesting Sea Turtles

Nightly patrols were conducted between 5 March – 6 June 2007 (with the exception of 7, 8, 11, 14, 17 March and 1, 5 June); in total, 977 team patrol hours were logged.

During these patrols a total of 127 leatherbacks, 25 green turtles, and seven hawksbills were encountered (See Appendix 1). This is equal to a mean of 0.130 leatherback, 0.026 green and 0.007 hawksbill turtles encountered per patrol hour.

The turtles encountered correspond to 93 individual female leatherbacks, 21 green turtles and six hawksbills. The majority of the leatherbacks (59) observed were already tagged when first encountered during the 2007 nesting season, accounting for 63.4% of all the individuals (See Appendix 1).

Of the previously tagged leatherback turtles encountered in 2007, 28.8% had originally been tagged in Tortuguero ($n = 17$). The remainder were tagged by researchers at Caño Palma (north of the river mouth in Tortuguero; $n = 1$) and other nesting beaches on the southern Caribbean coast of Costa Rica, including Parismina ($n = 2$), Pacuare ($n = 19$), Mondonguillo ($n = 12$) and Gandoca/Manzanillo ($n = 4$). Four females were also encountered that had originally been tagged at the CCC project in Chiriquí Beach Panama. Of the turtles tagged in Tortuguero, five were originally seen more than 10 years ago; one was first tagged in 1989 (before the official Leatherback Program had been initiated; she would have been observed opportunistically by the research team searching for green turtles). Another was first seen in 1995, and three others were observed in 1997. One green turtle was encountered with tags that were attached at Pacuare in 2006, and one hawksbill female had been previously seen at Tortuguero in 2003.

Evidence of holes or notches were found on only 11.8% ($n = 4$) of the newly tagged leatherback turtles checked for previous tagging ($n = 34$) when they were encountered for the first time during the 2007 Leatherback Program.

Most leatherbacks nested in the open beach zone (88.2%, $n = 112$); 2.4% nested in the border zone ($n = 3$) and 9.4% did not lay eggs ($n = 12$). Four leatherbacks laid their nests within 1m of, or below, the high tide line; these nests were relocated for inclusion in the independent research project looking at the effect of relocation on leatherback nest survivorship and hatching success.

3.4 Biometric Data Collection

CCLmin measurements were taken for 90 of the 93 individual leatherback turtles encountered.

Of 26 females observed more than once during the 2007 season, 18 (69.2%) had their caudal projection consistently identified on each occasion; ten were classified as complete and eight as incomplete. The other eight females had caudal projections that were inconsistently categorized on successive sightings. Data from these eight individuals were, therefore, excluded from an initial comparison of CCLmin between females with complete or incomplete caudal projections.

The results of this test showed no significant difference in carapace length between individuals with complete or incomplete caudal projection (Mann-Whitney test: $z = 0.36$ $p = 0.72$, $n = 82$), and so for further analyses the two categories were pooled and data from all females were included.

The mean carapace length for leatherback females was 152.1 cm ($n = 90$); with a range from

134.5 - 175.5 cm. Only 21 leatherback clutches were counted; they contained a mean of 69 yolked eggs (range = 7 - 101) and 20 yolkless eggs (range = 0 - 55) (See Table 2).

Table 2. Mean carapace length and clutch size of leatherback turtles encountered in 2007

Carapace length / cm			Clutch size / no. eggs		
n	\bar{x} CCLmin ± S.D.	Range	n	\bar{x} yolked ± S.D.	\bar{x} yolkless ± S.D.
90	152.1 ± 7.8	134.5 - 175.5	21	69 ± 24	20 ± 14

Mean carapace length (CCLmin) for green turtles encountered during the 2007 Leatherback Program was 103.7 cm (n = 20). Only one clutch was counted and the female laid 101 eggs (See Table 3). The six hawksbill turtles that were encountered had a mean carapace length (CCLmin) of 89.5 cm, and the one clutch of eggs that was counted contained 147 yolked eggs plus five yolkless (See Table 3).

Table 3. Mean carapace length and clutch size of green and hawksbill turtles

Species	Carapace length / cm			Clutch size / no. eggs	
	n	\bar{x} CCLmin ± S.D.	Range	n	\bar{x}
Green	20	103.7 ± 4.8	94.5 – 116.0	1	101
Hawksbill	6	89.5 ± 1.8	87.1 – 91.6	1	147 ¹

¹ The hawksbill female also laid five yolkless eggs

The precision of the CCLmin measurements was high in 2007, and was almost identical for all three species encountered during the Leatherback Program (See Table 4).

Table 4. Precision of carapace measurements for the different species of turtle

Species	n	\bar{x} precision for CCLmin (cm) ± S.D.	Range / cm
Leatherback	118	0.3 ± 0.2	0 – 1.0
Green	23	0.3 ± 0.2	0.1 – 1.0
Hawksbill	7	0.2 ± 0.1	0.1 – 0.4

The precision of the CCLmin carapace measurements for leatherback turtles measured during more than one encounter was 0.8 cm for two encounters, 1.1 cm for three encounters and 2.2 cm for four encounters (See Table 5). It can be seen that the more times a turtle was encountered and measured the greater the difference between the measurements.

Table 5. Precision of carapace measurements for individual leatherbacks encountered more than once during the 2007 Leatherback Program

No. of encounters	n	\bar{x} precision for CCLmin (cm) \pm SD	Range / cm
2	19	0.8 \pm 0.4	0.1 – 1.9
3	2	1.1 \pm 0.2	1.0 – 1.3
4	2	2.2 \pm 0.9	1.6 – 2.9

3.5 Determination of Nest Survivorship and Hatching Success

A total of 31 leatherback nests were marked between 6 March and 4 July 2007; six of these were marked during the 2007 Green Turtle Program. There were also four nests that were relocated as part of the on-going study into the effect of relocation on hatching success; they were initially laid below or within 1m of the high tide line; these were marked and monitored as for the *in situ* nests. The *in situ* and relocated nests were treated separately during the analysis of survivorship and hatching success. In addition, four *in situ* nests were eliminated from the analysis as they could not be located for excavation.

One green turtle and one hawksbill nest were also marked; these will be included in the analysis of nest survivorship and hatching success in the 2007 Green Turtle Report.

The fate, hatching and emerging successes of 31 marked and monitored leatherback nests are summarized in Table 6. The data from the nest excavations are summarized in Table 7.

Table 6. Fate, hatching and emerging success of marked leatherback nests

Fate	n	% of total	% Hatching success	% Emerging success
<i>In situ nests</i>				
Undisturbed	14	51.9	55.1	50.9
Unhatched	9	33.3	0.0	0.0
Partially predated by dogs	1	3.7	53.4	52.1
Predated by dogs	1	3.7	0.0	0.0
Washed out	1	3.7	0.0	0.0
Poached	1	3.7	0.0	0.0
Total	27	100	32.9	30.3
<i>Relocated nests</i>				
Undisturbed	2	50.0	53.9	52.1
Unhatched	2	50.0	0.0	0.0
Total	4	100	30.2	29.0
<i>Unknown</i>	4			

Table 7. Summary of data from nest excavations of marked leatherback nests during the 2007 Leatherback Program

Fate	n	Hatchlings		Empty shells	Pipped	Unhatched eggs			Predated	Deformed	Yolkless eggs	Total number of eggs	\bar{x} clutch size
		Live	Dead			No Embryo	Embryo	Full Embryo					
<i>In situ nests</i>													
Undisturbed	14	13	33	518	9	118	37	212	79	3	471	973	69.5
Unhatched	9	0	0	0	1	123	69	466	15	0	280	674	74.9
Partial dog predation	1	0	1	39	0	1	10	3	20	2	21	73	73.0
Dog predation	1	?	?	?	?	?	?	?	?	?	?	?	?
Washed out	1	?	?	?	?	?	?	?	?	?	?	?	?
Poached	1	?	?	?	?	?	?	?	?	?	?	?	?
<i>Relocated nests</i>													
Undisturbed	2	1	2	77	2	15	2	28	18	0	45	142	71.0
Unhatched	2	0	0	0	0	57	0	56	0	0	114	113	56.5
Total	31	14	36	634	12	314	118	765	132	5	931	1,975	N/A

The incubation period for undisturbed leatherback nests for which emerging was observed (n = 10) varied between 60 – 66 days, with a mean of 63 days.

Using the data for the mean clutch size for the different fate categories of excavated nests (See Table 7) the total number of eggs for all marked nests was estimated at 1,929 eggs ((69.5 x 17) + (74.9 x 9) + (73.0 x 1)); this figure also takes into account the three nests (predated, washed out and poached) that were not excavated.

Overall hatching success was estimated as 32.9% for monitored *in situ* leatherback nests (634 empty shells from 1,929 eggs in 27 nests). Emerging success for monitored *in situ* leatherback nests was estimated at 30.3% (584 emerged hatchlings from 1,929 eggs).

The distance from the sand surface to the top egg at the time of excavation for undisturbed nests (n = 14) varied between 41 - 77 cm with a mean of 61.6 cm. The distance from the sand surface to the bottom of the egg chamber for the same nests varied between 73 - 96 cm, with a mean of 82.3 cm.

Five deformed embryos were recorded, corresponding to 0.26% of eggs encountered during nest excavations. In addition, one live hatchling was observed that had deformities.

Hatching success for the four relocated nests was calculated as 30.2% (77 empty shells from 255 eggs) and emerging success was calculated as 29.0% (74 hatchlings from 255 eggs).

3.6 Physical Data Collection

Table 8 summarizes the rainfall and air temperature data collected during the 2007 Leatherback Program. Rainfall between March and June varied considerably (313.0 mm – 436.0 mm per month); with March being the driest month, and April the wettest (See Table 8). Average daily rainfall, over a 24-hour period, ranged from 12.5 mm in March to 14.5 mm, in April.

Daily air temperature at the CCC field station in Tortuguero from March to June 2007 ranged between 22.0 – 32.0°C (See Table 8). Average daily temperatures did not vary greatly during the season; March was the coolest month (25.7°C) and April was the warmest month (27.0°C).

Table 8. Rainfall and air temperature recorded during the 2007 Leatherback Program

Month	Total rainfall mm/month	\bar{x} rainfall mm/24hrs	\bar{x} temperature/°C	Temperature range / °C
March ¹	313.0	12.5 ²	25.7 ²	22.0 – 32.0
April	436.0	14.5	27.0	22.0 – 30.0
May	360.2	12.9 ²	25.9 ²	22.0 – 29.0
June	414.9	14.3 ²	26.2 ²	23.0 – 29.0

¹From 6 March

²Data for 48 hours 26-27 March; 13-14, 17-18, 22-23 May and 13-14 June

The mean monthly sand temperatures recorded from March – September are shown in Table 9; data from June – September are included as the last marked leatherback nest was excavated on 17 September.

Table 9. Mean monthly sand temperatures recorded during 2007 Leatherback Program

Zone	Open			Border			Vegetation		
	\bar{x} temperature / °C			\bar{x} temperature / °C			\bar{x} temperature / °C		
Depth	30	50	70	30	50	70	30	50	70
March	N/A	N/A	30.6	N/A	28.2	26.5	N/A	26.1	26.2
April – to 16/4	N/A	N/A	29.9	N/A	27.7	26.0	N/A	26.0	26.1
Retrieval depth / cm 16 April	N/A	N/A	65	N/A	65	85	N/A	50	65
April – from 16/4	33.5	33.0	32.5	N/A	30.3	28.1	27.1	27.0	27.0
May	31.5	31.4	31.3	N/A	29.2	27.3	26.6	26.6	26.7
June	31.8	31.8	31.7	N/A	29.8	27.8	27.1	27.1	27.2
July	29.1	29.1	29.1	N/A	27.7	25.8	26.0	26.0	26.2
August – to 10/8	31.0	30.7	30.4	N/A	28.6	26.5	26.4	26.4	26.5
Retrieved 10 August*	?	?	?	N/A	?	?	?	?	?
August – from 10/8	32.6	32.3	31.8	29.4	29.6	27.4	26.7	26.7	26.9
September	32.4	32.3	32.0	29.8	29.8	27.6	26.8	26.8	27.1
Overall mean	31.7	31.5	31.0	29.6	29.0	27.0	26.7	26.5	26.7

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

* No retrieval depths recorded on 10 August

Mean monthly sand temperatures ranged from 25.8°C (border zone in July) to 33.5°C (open zone in late April). From March to September, sand temperatures were consistently higher in the open zone than the border or vegetation zones, at all depths. Except for July (and the beginning of April), mean sand temperature in the open zone did not fall below 30°C; for the vegetation and border zones, the temperature did not exceed 30°C (except for in the border zone in late April). Temperatures in all zones, and at all depths, showed quite an obvious decline in July. Most leatherback nests were laid in the open zone and so would have been subject to temperatures greater than 30°C during incubation.

3.7 Collection of Human Impact Data

3.7.1 Visitors to Tortuguero

The number of people visiting Tortuguero National Park rose in 2007, continuing the trend that has been observed over the last few years (See Table 10). In 2007, data from the Tortuguero Conservation Area (ACTo) show that 116,751 tourists were registered as paying the entrance fee to the park; this is over 15,000 more visitors than in 2006. There has also been a dramatic increase in the number of Costa Rican national visiting Tortuguero in the last three years; in 2007 almost 24,000 were recorded throughout the year (See Table 10).

Table 10. Number of paying visitors to Tortuguero National Park, 2005 – 2007

Year	Costa Rican visitors	Foreign visitors	Total no. of visitors
2005	9,292	77,291	87,083
2006	21,257	80,087	101,344
2007	23,898	92,853	116,751

Data from Tortuguero Conservation Area (ACTo)

The number of visitors registered at the CCC Natural History and Visitors Center decreased by over 2,000 in 2007, to 30,019 visitors (See Table 11). The overall daily visitation rate to the center was 82 visitors, 8 less than the number recorded in 2006; only in January and November was daily visitation higher in 2007 than the previous year. The pattern of visitation was similar to that observed previously; most visitors came in January – April, with a significant decline in May and June. The increase in visitation observed during July and August coincides with an increase in green turtle nesting; one of the major tourists attractions to the area.

Table 11. Visitors to the CCC Visitors Center, January 2005 – December 2007

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

3.7.2 Artificial lights

Light surveys were conducted in March, April and May of the 2007 Leatherback Program. The spatial distribution of the artificial lights visible on the beach is shown in Figure 5; the bars represent the average number of lights counted in each 1/8 mile section during the three surveys.

It is very obvious that the majority of lights visible on the beach are found between miles 2 5/8

and 3 2/8; which is the section in front of the village of Tortuguero. The limit of Tortuguero National Park is at mile 3 3/8; no light sources exist within the national park (See Figure 5).

Lights visible to the north of the village (between miles -3/8 and 2 5/8) are coming from San Francisco village (close to the river mouth) and several of the lodges and cabinas that are located either on the beach or on the opposite side of the river. This pattern of lights visible on the beach remains the same as that observed in previous years.

3.8 Dead Turtles

In addition to the turtles that were taken by poachers, 13 dead turtles (12 green turtles and one hawksbill) were encountered during the 2007 Leatherback Program, all of which had been killed by jaguars (See Table 12).

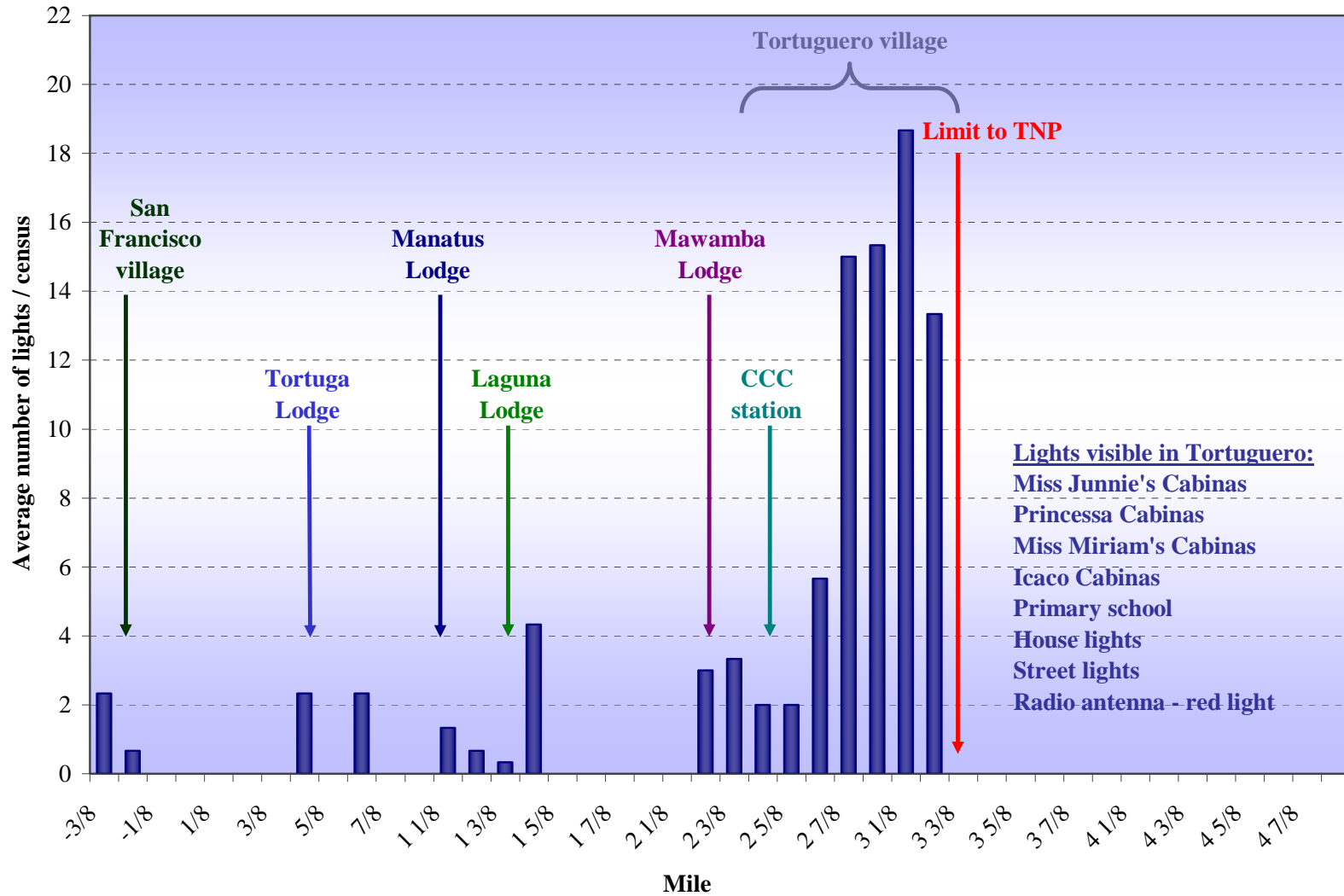
During the night patrol of 16 April the research team in the Boca section of the beach encountered a leatherback turtle at mile -1/8 (almost at the river mouth) that had become entangled in a small tree that was partially buried in the sand. They tried for approximately 30 minutes to free her, but were unable to dig the tree out sufficiently for her to pass. They radioed the CCC station and the park ranger station in Tortuguero to request assistance, but unfortunately the animal suffocated and died. Shortly afterwards the park rangers arrived and managed to cut the branches that were preventing her from returning to the sea. The body was buried by National Park staff the following day.

Table 12. Turtles killed by jaguars during the 2007 Leatherback Program

Date	Species	Sex	Mile	Comments
27-Mar-07	Cm	F	9 4/8	Killed by jaguar
5-Apr-07	Cm	F	9	Killed by jaguar
8-Apr-07	Cm	F	12 4/8	Killed by jaguar
17-Apr-07	Cm	F	6 4/8	Killed by jaguar – very fresh
26-Apr-07	Cm	F	7 4/8	Killed by jaguar
2-May-07	Cm	F	9 4/8	Killed by jaguar – very fresh
2-May-07	Cm	F	10 4/8	Killed by jaguar
5-May-07	Cm	F	9 4/8	Killed by jaguar – very fresh
5-May-07	Cm	F	12 4/8	Killed by jaguar – very fresh
11-May-07	Cm	F	7 4/8	Killed by jaguar
11-May-07	Cm	F	13 4/8	Killed by jaguar
20-May-07	Cm	F	11	Killed by jaguar
26-May-07	Ei	F	5 4/8	Killed by jaguar – with tags from Tortuguero 2002

Cm = Green turtle, Ei = Hawksbill

Figure 5. Spatial distribution of artificial lights visible on the beach at Tortuguero, as determined by the monthly light surveys



3.9 Environmental Education Activities

The FCs and RAs worked with students from the Tortuguero school and high school during the 2007 Leatherback Program. Unfortunately difficulties were encountered in trying to organize activities on a regular basis; on several occasions planned sessions were cancelled or postponed due to miscommunication in the school, which led to the students not being available at the arranged time.

Despite this problem, several activities were conducted in May, including a talk for 3rd - 5th grade students about the different materials that are recycled in Tortuguero; an interactive story following the life of a turtle informing the students about the different threats she faced during her life (for 1st and 2nd grade students); a bingo game with local species of animals found in Tortuguero National Park, aimed at increasing the awareness of the students to the flora and fauna in the park and an adventure game about turtles and their predators.

In addition, the high school students were given a questionnaire to complete regarding their opinions on turtles and the different uses of them as a resource; they were asked to give the questionnaire to their parents and grand-parents to complete, to try and assess the differences of opinion between the generations regarding turtles.

Researchers from Caño Palma biological station, involved in sea turtle research on the beach north of the Tortuguero river mouth, attended training sessions organized by the FCs in several different aspects of the monitoring protocol. They received talks and also practical experience in tagging, nest marking and taking carapace measurements.

4. Discussion

4.1 Preparations

While replacing and painting the mile markers along the entire 22 miles of beach is incredibly hard work for the newly arrived RAs at the start of each Leatherback Program these mile markers are, however, absolutely indispensable during night-time patrols and track surveys. In addition to the patrols of CCC personnel, the markers are often utilized by park rangers to locate themselves on the beach. It was suggested that in future years it might be possible to hire one of several ATVs which are in the village; this would be of considerable benefit for the 10-mile stretch between mile 5 and mile 15, which takes all day to complete.

The RAs all receive an intensive training and orientation program during their first week at the field station in Tortuguero. This includes the rules and regulations for all personnel, and important information about daily life at the station. In addition there are talks about sea turtle biology and a thorough review of the monitoring protocol, with practical sessions on data collection, flipper tagging and nest marking. From comments received from the RAs in their evaluation of the program, a recommendation for future years is to extend this training period to two weeks, to avoid having to rush through this each talk/session, while trying to also find time to prepare the mile markers for the entire beach.

4.2 Track Surveys

Leatherback nesting was observed during weekly track surveys from February to June, with peak nesting occurring in April, although there was a second peak of activity in mid-June (See Figure 1). Track surveys conducted by the FCs and RAs (March – June) cover the period of heaviest leatherback nesting (See Figure 1 and Table 1).

Estimated leatherback nesting was much higher in 2007 than in 2006 (See Figure 2); this is encouraging as 2006 was the lowest leatherback nesting season since the program began in 1995. It will be interesting to see if this trend continues in future years, or whether 2007 was just an exception. Personal communication with other research projects monitoring leatherback nesting beaches along the Caribbean coast of Costa Rica and Panama suggest that 2007 was an incredibly high year for this species throughout the region; they all reported high levels of nesting during the season.

Unlike in 2006, the two methods used for estimating the number of leatherback nests laid in 2007 showed relatively similar values for the season; weekly track surveys = 489 nests compared to 555 nests from the 3-day surveys for the same 18 miles of beach. The temporal distribution for the season was very well correlated between the two different methods, with peak nesting observed in mid-April. It is valuable to continue with the 3-days surveys during future Leatherback Programs to act as a comparison for the weekly survey data.

The spatial distribution of leatherback nests in 2007 remained very similar to that observed in previous years; with higher levels of nesting occurring in the southern five miles of beach within the National Park, close to the Jalova lagoon.

Illegal poaching of turtle nests occurred sporadically throughout the 2007 Leatherback Program. Fortunately, the high levels of poaching observed in 2006 were not repeated in 2007; all three species of turtle recorded nesting showed a reduction in poaching from the previous years. Poaching was between 4.0% and 15.8% of nests, depending on the species (See Table 1). However, poaching on the section of beach from Jalova to Parismina (outside the southern limit to Tortuguero National Park) remained at unacceptably high levels; 25% of all leatherback nests laid in those four miles were poached (See Figure 4). As if to highlight the need for increased vigilance in that area; in May additional research personnel were available for several nights which permitted night patrols to be conducted on the four miles between Jalova and Parismina. The RAs encountered a man with a hawksbill turtle flipped over on the beach; fortunately they were able to talk with him and he released the turtle unharmed to sea. Obviously if they hadn't been there, that turtle would have been killed. If the presence of a research team was enough of a deterrent to prevent poaching, patrols by Tortuguero National Park staff would definitely provide additional protection to turtles and nests laid along that stretch of beach.

4.3 Tagging of Nesting Sea Turtles

The period of tagging patrols from March to early June coincides with the period of heaviest leatherback nesting (See Figure 1) and it is suggested that night patrols be conducted during the same period in future years.

The number of leatherback turtle encounters during nightly patrols in 2007 (n = 127) was higher than the number of encounters recorded in 2006, despite fewer patrol hours being conducted by

the FCs and RAs research teams due to limited personnel on occasions. The results of the track surveys suggest that there was a much higher density of nesting during the 2007 season and so patrols were more likely to encounter females coming ashore to nest. With leatherback nesting concentrated in the southern part of the beach close to Jalova, it is valuable to continue the night patrols in this area in future years. The presence of CCC personnel on the beach at night in this part of the beach might also act as a deterrent for poachers, and so there will also be the additional benefit to nests and females. Fewer green turtle encounters were recorded in 2007 than in 2006 (25 compared to 66) but this species typically nests later in the year, and so this value is within the normal range for encounters during the Leatherback Program. Seven hawksbills were observed from March – June; providing very valuable data about this critically endangered species. All efforts should be made to collect data on nesting hawksbills, as they are present in much smaller numbers than the other species, and so each individual encountered can provide vital information.

The proportion of new leatherback turtles (individuals that did not have tags when first encountered) observed during the 2007 season was similar to that in previous years (26.8%). This figure is important as it potentially relates to the number of females reaching sexual maturity and recruiting to the adult nesting population; thus it is reassuring to see that this is not in decline, which could indicate that there are fewer individuals surviving to sexual maturity.

As in previous years, the majority of leatherbacks encountered during 2007 had already been tagged when first observed (46.4%), either at Tortuguero in previous years or at other nesting beaches in the region. This frequent movement between the different nesting sites in Costa Rica and Panama is well documented, and there is an effort being undertaken to update the regional leatherback data base, which will allow these movements to be more easily tracked by the various projects involved. The object of the data base is to provide minimal data about where and when an individual was tagged, and subsequently recorded, so that participating researchers can instantly access the nesting history of a given female. Of the leatherbacks seen in 2007 that had been originally tagged in Tortuguero five were first seen over 10 years previously; one female was tagged in 1989, 18 years previously. This is the longest nesting record for a leatherback tagged in Tortuguero, and she was encountered before the official Leatherback Program had been initiated, presumably opportunistically by researchers searching for green turtles.

One hawksbill was encountered with tags that had been applied in Tortuguero in 2003, and one green turtle had tags that suggest she had originally been observed on the nesting beach at Pacuare, in southern Costa Rica. This is quite unusual for a green turtle to utilize more than one nesting beach, as they typically have a strong site fidelity to their natal beach; however, Pacuare is not such a great distance from the end of the Tortuguero nesting beach, and so it is not completely unexpected for there to be some movement between these two locations.

4.4 Biometric Data Collection

No significant difference was detected in the mean carapace length (CCL_{min}) of female leatherback turtles with complete or incomplete caudal projections; the overall mean was 152.1 cm (See Table 2), which is comparable to that observed in previous years. There was also a similar size diversity in the size of leatherback females encountered in 2007 to that seen during other nesting seasons; ranging from very small (134.5 cm) to very large individuals (175.5 cm). This would suggest therefore, that there is a mixture of young and old females within the

Tortuguero nesting population; also supported by the fact that there was a significant proportion of 'new' individuals (those without tags, and therefore possibly recruits to the nesting population) encountered during 2007.

The majority of leatherback females that were encountered on more than one occasion (69.2%) had their caudal projection consistently identified by the different researchers. In previous years there has been a much higher level of inconsistency in this aspect of the protocol, and so care was taken to improve the training given to the RAs for the 2007 Leatherback Program with regard to the definition of a 'complete' or 'incomplete' caudal projection. Obviously this is one area that is open to individual interpretation and is quite a subjective measure. RA training could be greatly improved if photographs could be taken of caudal projections in each of these two classification groups, to provide a visual aid to the descriptions given by the FCs; whilst photography is not permitted on the nesting beach at Tortuguero, it might be possible to search for viable photographs in on-line image libraries for such pictures.

The precision of leatherback, green turtle and hawksbill carapace measurements was high in 2007 (0.2 - 0.3cm); reflecting good training of the RAs at the start of the season, and care being taken when collecting biometric data from the individuals. However, attention should be paid when volunteer participants are assisting with measurements, to ensure that they are following the protocol. As has been seen in other years, precision decreased substantially with an increase in the number of encounters with individual females during the nesting season (See Table 5), reflecting observer variation in measuring the same turtle.

4.5 Determination of Nest Survivorship and Hatching Success

Unfortunately, overall hatching and emerging success of leatherback nests were considerably lower in 2007 than in 2006, 32.9% and 30.3%, respectively compared to 43.5% and 42.1%. Of the 31 nests marked one was poached, one was depredated by dogs and one was lost due to erosion; all of these nests obviously had 0% hatching or emerging success. In addition, one nest was partially depredated by dogs. Of those nests that were undisturbed one third did not hatch; it was believed that these were all fertilized eggs, because during the excavations they were found to contain embryos. The majority of these embryos were in the late stages of development, suggesting that the catastrophic event which caused the nest to not hatch occurred during the latter part of the incubation period, close to when they were due to emerge. One possible cause might have been inundation of the nest, either from the high tides or from rising ground water. It would be very interesting to re-initiate the collection of ground water level data during the nesting season, to monitor any changes in the water table that could have an impact on nesting success, particularly of leatherback nests which are typically much deeper than the other species and so are more susceptible to flooding if the ground water level rises.

With the low nesting density of leatherbacks at Tortuguero, it is important to try and obtain as much information as possible about the survivorship and success of their nests, so each nest that can be marked and monitored is incredibly valuable. RAs should be encouraged to try and mark every nest that they observe, even if the female has already started laying when she is encountered and so they are unable to count the eggs.

During the 2007 Leatherback Program a Master's student from Costa Rica initiated a study into the effect of relocation on nest survivorship and hatching success of leatherback nests. This research was a continuation of the work conducted in 2006 that investigated the various factors

affecting hatching and emerging success; the findings from which showed that nests laid below the high tide line were less successful than those laid elsewhere on the beach. This new study is of importance for if it is shown that relocation has only positive impacts on hatching success, then it may be a potential conservation management technique that could be employed in Tortuguero. However, relocation should not necessarily be incorporated into the protocol for all leatherback nests; there should be strict guidelines to ensure that only those nests at risk from erosion or inundation by high tides are relocated. Obviously, CCC keenly awaits the finding of this project and will review the results with interest. Due to the very small number of nests that were relocated during the 2007 Leatherback Program (n = 4) the study will need to be continued in 2008 for any statistically viable data to be gathered. It was, however, interesting to note that the hatching and emerging success of the relocated nests was similar to that estimated for *in situ* nests (30.2% and 29.0% compared to 32.9% and 30.3%, respectively).

4.6 Physical Data Collection

The precipitation pattern during the 2007 Leatherback Program was different to that observed in 2006, in that April was the wettest month and March was the driest. The difference in the average monthly rainfall during the program, 313.0 – 436.0mm, was less than that observed in other years. It was surprising to note that despite the high rainfall, April was also the warmest month, with an average daily temperature of 27.0°C, and some of the highest sand temperatures were also recorded (See Table 9).

The mean monthly sand temperatures recorded in the open zone, where the majority of leatherback nests were laid during 2007, remained constantly above 29.1°C (See Table 9), reaching up to 33.5°C. Thus during much of the incubation period the temperatures were above those that could result in embryo mortality, and thus could have contributed to the low overall hatching success observed in 2007.

With the growing interest in climate change and its impact on the environment, it is of significant importance to continue to monitor air temperature, sand temperature and precipitation levels in Tortuguero. Such data will provide a historical baseline for possible future research into the impact of climate change on the nesting beach, and its subsequent impacts on nest survivorship and hatching success.

4.7 Collection of Human Impact Data

The number of visitors to Tortuguero continues to increase each year; in 2007, 116,751 tourists paid the entrance fee to Tortuguero National Park (See Table 10); more than 15,000 more than in 2006. This increase was reflected in both national and international visitation. It is vital that CCC continues to monitor the impact of tourism on the beach to ensure that any negative impacts are avoided. Future research projects could focus on the potential effects of tourism on turtles in the area; either on the nesting females or their nest survivorship or hatching success. The rapid rate of development in the village is quite worrying, as it appears to be happening with little control or thought for the surrounding environment; it could result in increasing pressure not only on the nesting turtle populations but also on all the ecosystems within Tortuguero National Park.

Despite the continuing growth in tourism to Tortuguero National Park, the CCC Visitor Center saw a decline in visitation during 2007 (See Table 11); over 2,000 fewer tourists came to the

centre, compared to numbers recorded in 2006. The pattern of visitation, however, followed that observed in previous years, with January – April having the highest number of tourists, followed by a sharp decline in May and June. Although there was a subsequent increase in July and August, which are typically months with high numbers of tourists due to the corresponding peak in sea turtle nesting, which is one of the main tourist attractions to Tortuguero, it was disappointing that the daily visitation rate stayed below levels recorded in the last two years.

One reason for this apparent decline in interest in the CCC Visitor Center is the pressure on the tour guides to complete their assigned ‘village tour’ (which includes a stop at the CCC) within a specific time frame; if the guides arrive at the center and there is already a group inside, they are sometimes not inclined to wait for that group to leave, and so pass straight on to the village. For many guests at the lodges in the area, this is often the only opportunity that they have to visit the village or the CCC Visitor Center (as the majority of the lodges are located across the river). Also, some of the lodges show the CCC video to their guests in the hotel, thus negating the need to visit the Center. This decline in visitation once again highlights the need for CCC to re-evaluate the entire Visitor Center; funds are urgently required to improve the infrastructure of the Visitor Center as well as the content and format of the displays. The video shown to tourists needs to be updated, to include recent investigations being conducted by CCC in Tortuguero and at other sites in the Caribbean, and all of the information displays need to be reorganized to ensure that they are readily accessible to all visitors, and contain pertinent and interesting information. The role of the Visitor Center administrator also needs to be reviewed, so that they act not only as a sales person for merchandise and turtle adoptions, but also as a source of information about the work currently being conducted by CCC in the region. The active participation of the volunteer research assistants in the Visitor Center should be encouraged as they have first-hand experience of the research and monitoring program that can be shared with tourist groups.

At present the Visitor Center is not being used to its full capacity, it should be a priority of CCC to improve this facility as quickly as possible as it is the ideal location in which to expand the organization’s public outreach and environmental education capabilities, and increase public awareness of sea turtle conservation issues not only within the region, but on a national and international level. It could also serve as an important educational center for the local community; not just about turtles but to provide information about the flora and fauna found in the National Park.

The problems associated with increasing construction in the communities of Tortuguero and San Francisco persist; more artificial lights are visible on the nesting beach close to the river mouth (from San Francisco) and in front of the village of Tortuguero. Notable is the increase in the number of cabins close to the beach which are illuminated at night. A focus for future years should be to raise awareness within the community about the problems that artificial lighting creates for nesting turtles and hatchlings. While there have been previous campaigns aimed at reducing the number of lights visible on the beach during the nesting/hatching season, it is something that needs to be repeated occasionally to remind people about the issue. It would also be extremely useful to provide lodge and cabina owners with practical information about how they can reduce the impact of their lights, while retaining the security of their guests at night, for example, a design for a shade that could deflect light away from the beach.

4.8 Dead Turtles

The number of green turtles that were recorded as killed by jaguars during the 2007 Leatherback Program was much lower than that observed in 2006; it was also unfortunate that a hawksbill turtle was among those killed by jaguars (See Table 13).

The case of the leatherback turtle that was encountered trapped on the beach during a night patrol was incredibly distressing for all those involved. This incident highlighted some communication issues that were encountered throughout the season, with no response from the CCC station when the patrol first called to report the problem. This was confounded by the fact that there was no access to a saw at the station, which could have been used to cut the branches that were causing the problem. To avoid a repetition of such a situation in the future one solution might be to have a small folding saw kept in a readily available location at the station so that anyone could have access to it if needed in an emergency situation on the beach.

4.9 Environmental Education Activities

All of the environmental education events held at the Tortuguero school and high school were appreciated by all those who took part, both from the community and the CCC. It was informative for the students and a great experience for them to be able to interact on a personal level with people from around the world who come to Tortuguero especially to work with sea turtles. It was also a valuable opportunity for the RAs to be able to integrate themselves into the community and learn from the students about the feeling in the village towards turtles, the natural environment, conservation and the work of the CCC.

While the events were well received by the teachers and students, the coordination between the school directors and the teachers was sometimes frustrating; on several occasions CCC personnel arrived to conduct an event only to learn that the teachers had not received notification, and so the students were unavailable. In future years, the FCs should liaise with the school and high school directors at the start of the season to set a schedule to ensure that there is a regular program of activities. It would also be beneficial to try to coordinate with the community of San Francisco to conduct activities for students in that village also.

5. References

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6. Appendices

Appendix 1. Nightly sea turtle encounters for the 2007 Leatherback Program

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
5-Mar				0				0				0
6-Mar				0				0				0
7-Mar				0				0				0
8-Mar				0				0				0
9-Mar	1			1				0				0
10-Mar				1				0				0
11-Mar				1				0				0
12-Mar				1				0				0
13-Mar				1				0				0
14-Mar				1				0				0
15-Mar				1				0				0
16-Mar				1				0				0
17-Mar				1				0				0
18-Mar	1			2				0				0
19-Mar				2				0				0
20-Mar				2				0				0
21-Mar	2	2		6				0				0
22-Mar	1	1		8	1			1				0
23-Mar	1	1		10	1			2				0
24-Mar	1	1		12				2				0
25-Mar				12				2				0
26-Mar	1			13				2				0
27-Mar				13				2				0
28-Mar				13				2				0
29-Mar	2			15				2				0
30-Mar	1			16				2				0
31-Mar	2			18				2				0
1-Apr				18				2				0
2-Apr	1			19				2				0
3-Apr	2			21				2				0
4-Apr				21				2				0
5-Apr	2			23				2				0
6-Apr				23	1			3				0
7-Apr	2			25				3				0
8-Apr			2	27				3				0
9-Apr				27	1			4				0
10-Apr		1		28				4				0
11-Apr	2			30				4				0
12-Apr		4	1	35	1			5				0

Appendix 1. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
13-Apr	1	3		39	1			6				0
14-Apr		2		41			1	7				0
15-Apr	3	2		46				7				0
16-Apr		1	1	48	1			8				0
17-Apr	1	2	2	53				8				0
18-Apr	1	1	1	56		1		9				0
19-Apr		1		57	1			10				0
20-Apr		2		59				10				0
21-Apr		1		60				10				0
22-Apr		2		62	1			11				0
23-Apr		1		63	1			12				0
24-Apr			2	65	2		1	15				0
25-Apr		2		67	1		1	17				0
26-Apr				67				17				0
27-Apr			1	68				17				0
28-Apr	1			69				17				0
29-Apr				69				17				0
30-Apr		2	1	72	1			18				0
1-May		2	1	75				18				0
2-May	2		1	78				18				0
3-May		4		82			1	19				0
4-May	1		1	84	1			20	1			1
5-May		2		86				20				1
6-May		3		89				20				1
7-May				89				20				1
8-May				89				20				1
9-May				89				20				1
10-May				89				20				1
11-May			1	90				20				1
12-May			1	91				20	1			2
13-May				91				20				2
14-May			2	93				20				2
15-May				93				20				2
16-May		1		94				20				2
17-May		2	2	98				20				2
18-May		1	1	100	1			21				2
19-May		2	2	104	1			22				2
20-May				104				22				2
21-May				104				22				2
22-May				104				22				2
23-May	1		1	106	1			23	1			3
24-May		2	3	111				23				3

Appendix 1. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
25-May				111				23				3
26-May				111				23		1		4
27-May				111				23				4
28-May	1	1	2	115				23				4
29-May		2	3	120				23	1			5
30-May			1	121	1			24				5
31-May		3	1	125	1			25			1	6
1-Jun				125				25				6
2-Jun		1		126				25				6
3-Jun		1		127				25				6
4-Jun				127				25	1			7
5-Jun				127				25				7
6-Jun				127				25				7
Total	34	59	34	127	20	1	4	25	5	1	1	7
%	26.8	46.4	26.8	100	80	4	16	100	71.4	14.3	14.3	100

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

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

REN = Renester; turtles that were encountered more than once during 2007

Appendix 2. Observations and Anecdotal Information on Illegal take of turtles during the 2007 Leatherback Program.

There was an overall decline in the level of illegal take of nests and turtles recording during the 2007 Leatherback Program, in relation to the numbers observed in 2006.

During the track survey on 30 May a dead female leatherback turtle was encountered at mile 4 5/8 (within Tortuguero National Park); one of her front flippers had been removed and her plastron had been cut open to remove the eggs inside. It was believed that she had been tagged, as someone had cut a notch in the rear flippers, where the metal tags would have been located. This incident was reported in writing to the National Park staff, and flyers denouncing this illegal activity were posted throughout the village; to raise awareness within the local community that turtles were still being killed.

On the night of 29 May the research team working on the section of beach from Jalova to Parismina encountered a hawksbill turtle flipped over on her back during the night patrol. They tagged and measured her, and then released her back to the ocean.