



REPORT ON THE 2006 LEATHERBACK PROGRAM AT TORTUGUERO, COSTA RICA

**Submitted to
Caribbean Conservation Corporation
and
The Ministry of Environment and Energy, Costa Rica
9 May, 2007**

**By
Andrea de Haro, Field Coordinator
and
Dr Emma Harrison, Scientific Director**

**With the assistance of
Ernesto Acevedo, Research Assistant
Mònica Arso, Research Assistant
Mark Barrett, Research Assistant
Amy Burden, Research Assistant
Paolo Roberto Fleury, Research Assistant
Fiona Maxwell, Research Assistant
Florent Michaut, Research Assistant
Rodolfo Sarmiento, Research Assistant
Xavier Debade, Student
Dagnia De Nasco, Student
Anna Runemark, Student
Enrique Vargas, Track Surveyor**

With the Financial Support of:

**Lemmon
Foundation**



	CARIBBEAN CONSERVATION CORPORATION	
Address:	Apartado Postal 246-2050 San Pedro COSTA RICA	4424 NW 13th St. Suite A-1 Gainesville, FL 32609 USA
Tel:	Int + 506 297 5510	001 352 373 6441
Fax:	Int + 506 297 6576	001 235 375 2449
E-mail:	roxana@cccturtle.org	ccc@cccturtle.org
Webpage:	http://www.cccturtle.org	http://www.cccturtle.org

Table of Contents

TABLE OF CONTENTS	2
LIST OF FIGURES	3
LIST OF TABLES	3
ACKNOWLEDGEMENTS	4
EXECUTIVE SUMMARY	5
Monitoring and Research Activities Conducted	5
Conclusions	7
Recommendations	7
1. INTRODUCTION	8
2. METHODS	8
2.1 Preparations.....	8
2.2 Track Surveys	8
2.3 Tagging of Nesting Sea Turtles.....	9
2.4 Biometric Data Collection	9
2.5 Determination of Nest Survivorship and Hatching Success	10
2.6 Physical Data Collection	10
2.7 Collection of Human Impact Data	11
2.8 Dead Turtles.....	11
2.9 Environmental Education Activities	11
3. RESULTS	11
3.1 Preparations.....	11
3.2 Track Surveys	11
3.3 Tagging of Nesting Sea Turtles.....	18
3.4 Biometric Data Collection	18
3.5 Determination of Nest Survivorship and Hatching Success	20
3.6 Physical Data Collection	22
3.7 Collection of Human Impact Data	23
3.8 Dead Turtles.....	25
3.9 Environmental Education Activities	26
4. DISCUSSION	26
4.1 Preparations.....	26
4.2 Track Surveys	27
4.3 Tagging of Nesting Sea Turtles.....	27
4.4 Biometric Data Collection	28
4.5 Determination of Nest Survivorship and Hatching Success	28
4.6 Physical Data Collection	28
4.7 Collection of Human Impact Data	29
4.8 Dead Turtles.....	29
4.9 Environmental Education Activities	30
5. REFERENCES	30
6. APPENDICES	31
Appendix 1. Daily sea turtle encounters for the 2006 Leatherback Program.	31
Appendix 2. Observations and Anecdotal Information on Illegal take of turtles and nests....	33

List of Figures

Figure 1. Temporal distribution of leatherback nests during 2006, as determined by weekly track surveys.....	12
Figure 2. Annual leatherback nesting trend at Tortuguero from 1995 - 1996, as determined from weekly track surveys.	14
Figure 3. Spatial distribution of leatherback nests during the 2006 Leatherback Program, as determined by track surveys conducted by FC and RAs every three days.	15
Figure 4. Spatial distribution of illegal poached nests during the 2006 Leatherback Program, as determined by track surveys conducted by FC and RAs every three days.	17

List of Tables

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 2006 Leatherback Program....	16
Table 2. Mean carapace length and clutch size of leatherback turtles encountered in 2006.	19
Table 3. Mean carapace length and clutch size of green and hawksbill turtles.	19
Table 4. Precision of carapace measurements for the different species of turtle.....	19
Table 5. Precision of carapace measurements for individual leatherbacks encountered more than once during the 2006 Leatherback Program.	20
Table 6. Fate, hatching and emerging success of marked leatherback nests.	20
Table 7. Summary of data from nest excavations of marked leatherback nests.....	21
Table 8. Rainfall recorded during the 2006 Leatherback Program.....	22
Table 9. Mean monthly sand temperatures recorded during 2006 Leatherback Program.	22
Table 10. Number of paying visitors to Tortuguero National Park, 2003 – 2005.	23
Table 11. Visitors to the CCC Visitors Center, January 2004 – August 2006.	23
Table 12. Summary of results of monthly light surveys conducted during the 2006 Leatherback Program.	24
Table 13. Dead turtles encountered during the 2006 Leatherback Program.....	25

Acknowledgements

The 2006 Leatherback Program was conducted under a research permit from the Tortuguero Conservation Area of the Ministry of Environment and Energy of Costa Rica, detailed in resolution N° ACTo-GASP-PIN-003-05.

All data presented in this report were collected by Field Coordinator Andrea de Haro and her hardworking team of research assistants: Ernesto Acevedo (Mexico), Mònica Arso (Spain), Mark Barrett (UK), Amy Burden (UK), Paolo Roberto Fleury (Brazil), Fiona Maxwell (Australia), Florent Michaut (France) and Rodolfo Sarmiento (Argentina). They were aided by several post-graduate students who provided invaluable help during the program: Xavier Debade, Dagnia De Nasco and Anne Runemark. In addition, numerous program participants assisted in data collection and their help is gratefully recognized.

Enrique Vargas conducted the weekly track surveys of the entire nesting beach; his considerable efforts are very much appreciated.

The dedicated staff of the John H. Phipps Biological Field Station were an integral part of the 2006 Leatherback Program. Station Manager Sergio Campos provided logistical support; Jimmy Estrada was administrator of the visitor center and assisted with research activities; boat captains Luis Mungrido and Francisco Herrera safely transported researchers on the canals; Katia Vargas and Analive Guardamuz ensured that everyone was provided with good food and clean clothes; and the station was kept secure, day and night by security personnel Pablo Pereira and Francisco Bartolo Pereira.

Sr Eduardo Chamorro and the dedicated park rangers of the Tortuguero Conservation Area (ACTo) are acknowledged for their on-going efforts to protect sea turtles in Tortuguero National Park; and thanks also to the rangers at the Jalova field station for sharing their living quarters with the research assistants.

The continued support of tour guides and the community of Tortuguero during the 2006 Leatherback Program is much appreciated. Hotel managers and cabina owners provided information of the capacity of their respective facilities on request.

Gratitude is also extended to National Director Roxana Silman and her administrative assistant Ileana Vargas at the CCC office in San José for the provision of logistical support throughout the Program. The help of the CCC staff in Gainesville, Florida in purveying necessary equipment and providing any support requested is also acknowledged.

For financial assistance during the 2006 Leatherback Program we would like to thank the Firedoll Foundation, the Lemmon Foundation, the Marisla Foundation and all of the Program participants.

Executive Summary

Monitoring and Research Activities Conducted

- 1 A total of 25 track surveys were conducted between the Tortuguero river mouth and Jalova lagoon between January and July 2006
- 2 Peak nesting was recorded on 27 May when 8 fresh leatherback nests were recorded.
- 3 The Field Coordinator (FC) and the Research Assistants (RAs) conducted a total of 29 additional track surveys between the Tortuguero and Parismina river mouths between 13 March and 5 June 2006. Poaching was estimated to a minimum of 18.9 % of leatherback nests, 20.7 % of green turtle nests and 26.3% of hawksbill nests.
- 4 Comparison of the leatherback nesting estimates obtained from track surveys conducted either by the track surveyor (199 nests) or by the FC and RAs (332 nests) between Tortuguero river mouth and Jalova lagoon between 13 March – 5 June revealed that the two methods showed quite different results.
- 5 A total of 101 leatherback turtle encounters were recorded during 1,007 hours of night patrols between 6 March and 6 June, 2005; 26 were newly tagged females, 42 had tags from previous years and/or other nesting beaches, and 33 were renesters. In addition, 66 green turtles and six hawksbill turtles were encountered.
- 6 A total of 61.8% (n = 42) of female leatherback turtles bore tags from previous years or other nesting beaches. Of the previously tagged leatherback turtles, 50% were originally tagged in Tortuguero (n = 21); the others were tagged in Caño Palma (n = 3), Parismina (n = 4), Pacuare/Mondonguillo (n = 11), Gandoca/Manzanillo (n = 1) and in Panama (n = 2). One of those originally tagged in Tortuguero was fitted with a satellite transmitter in 2004, to track her migration movements. One hawksbill was encountered with tags from Mondonguillo.
- 7 A total of 26.9% (n = 7) of newly tagged leatherback turtles (n = 26) showed evidence of old tag holes or notches when they were encountered for the first time.
- 8 A total of 82% of the encountered leatherback turtles nested in the open beach zone (n = 82), 1% nested in the border zone (n = 1) and 17 % did not lay eggs (n = 17).
- 9 No significant difference in carapace length (CCLmin) was found for leatherback turtles with complete or incomplete caudal projections.
- 10 Mean curved carapace length of leatherbacks was 149.7 cm (n = 67).
- 11 Mean clutch size for leatherback females was 78 yolked and 31 yolkless eggs (n = 48).
- 12 Mean carapace length (CCLmin) was 102.5 cm for green turtles (n = 51), and 89.8 cm for hawksbill turtles (n = 5). Mean clutch size for green turtles was 108 eggs (n = 22) and 185 for hawksbills (n = 3).
- 13 Precision of the CCLmin measurement during the same encounter was high in 2006, and was similar for all species; 0.2 cm for leatherback (n = 100), 0.3 cm for green (n = 66) and 0.2 cm

for hawksbill turtles (n = 6).

- 14 Precision of the CCLmin measurement for leatherback turtles measured during more than one encounter was 0.8 cm for two encounters (n = 15), 1.9 cm for three encounters (n = 6), 3.2 cm for four encounters (n = 2) and 1.5 cm for six encounters (n = 1).
- 15 A total of 23 leatherback nests were marked for monitoring. Four nests could not be located for excavation and so were eliminated from further analysis.
- 16 Overall hatching success for monitored leatherback nests (n = 19) was 43.5% and overall emerging success was 42.1%.
- 17 Mean distance between the sand surface and the top egg at the time of excavation for undisturbed nests (n = 13) varied between 43 – 75 cm with a mean of 63.6 cm. The mean distance from the sand surface to the bottom of the egg chamber varied between 62 – 88 cm, with a mean of 78.8 cm.
- 18 The incubation period for leatherback nests for which emergence was observed (n = 8) ranged from 59 – 72 days with a mean of 66 days.
- 19 Two deformed embryos, corresponding to 0.19% of eggs were encountered during nest excavations.
- 20 Rainfall was heaviest in June (408.7 mm), and May was the driest month (264.5 mm).
- 21 Monthly mean sand temperatures ranged between 24.5 – 31.1°C. Sand temperatures were higher in the open zone than in the border and vegetation zones.
- 22 A total of 87,083 visitors paid to enter Tortuguero National Park (TNP) in 2005, continuing the increasing trend observed in the last ten years.
- 23 The visitation at the CCC Natural History and Visitors' Center increased in 2006, reversing the decline observed in 2005. A total of 32,733 visitors were registered for the year, an average of 90 visitors per day.
- 24 The number of artificial lights in Tortuguero village continues to increase, particularly in the village (mile 2 6/8 – mile 3 2/8).
- 25 32 dead turtles were encountered during the 2006 Leatherback Program; 30 of these were killed by jaguars (28 green turtles and 2 hawksbills).
- 26 A very small juvenile hawksbill and an adult female green turtle were encountered dead on the beach with no obvious signs of the cause of death.
- 27 Environmental education activities were organized by the FC and RAs for students at the Tortuguero and San Francisco schools. In addition talks were given to interested members of the community and TNP staff about the evaluation of the new turtle tour system.
- 28 A visiting researcher spoke to students and community members about sea turtle conservation activities in Baja California, Mexico.

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 lower in 2006 than in 2005, continuing the declining nesting trend that has been observed since 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 dissimilar results. The weekly track surveys probably underestimated the number of nests laid in 2006.
- 4 Levels of poaching increased for all species of turtle in 2006.
- 5 Poaching levels within TNP increased, and were similar to those recorded south of the park limit at Jalova, indicating a rise in poaching within the park from 2005.
- 6 The number of leatherback turtles encountered during nightly patrols (n = 101) was much lower than the number recorded in 2005, despite a similar patrol effort by the FC and RAs, indicating that 2006 was a low nesting year for leatherbacks in Tortuguero.
- 7 Hatching success of leatherback nests was much higher in 2006 than in 2005.
- 8 The distance of leatherback nests to the high tide line at time of laying was found to have an effect on hatching and emerging success of nests.

Recommendations

- 1 Increasing levels of poaching highlight the need for increased patrols by TNP guards to ensure effective enforcement of laws within the protected area, especially at the southern limit of the park close to the Jalova lagoon.
- 2 There needs to be improved 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 The results of the study focused on factors effecting leatherback hatching success suggest that nest relocation may be a strategy to improve success in future years; an investigation should be implemented to look at the effects of relocation on nesting success of leatherbacks, before it is implemented as a management strategy in Tortuguero.
- 4 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.
- 5 Impacts of the increasing levels of tourism within the Tortuguero region should continue to be closely monitored to ensure that there are minimal negative impacts on nesting sea turtles.
- 6 Educational activities should be conducted with all members of the community and not only focused on students within the school system. RAs should be invited to talk about their previous experiences in different sea turtle conservation projects in other countries.

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 the 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 2006 Leatherback Program represents the twelfth consecutive leatherback program and the ninth year of implementing the new monitoring protocol.

The objectives of this report are to summarize the results of the 2006 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 Coordinator (FC) arrived in Tortuguero the first week of March to prepare for the 2006 Leatherback Program. The Research Assistants (RAs) arrived at the field station on 6 March 2006. The first two weeks of the 2006 Leatherback Program were dedicated to training and orientation for the RAs; they were given information 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 FC. 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 FC demonstrated field techniques and supervised RAs collecting data and tagging turtles. An additional training patrol was also conducted at the southern end of the beach, close to the Jalova lagoon on 11 March 2006.

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 and the two markers nearest to the vegetation were painted white with the marker number in black.

2.2 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 or taken by poachers, and the number of poached fresh nests. The total number of leatherback nests for all nights was extrapolated from these data by applying a GAM model and integrating resulting values using Berkeley Madonna software (Troëng *et al.* 2004).

Track surveys were also conducted between the Tortuguero and Parismina river mouths, every 3 days from 13 March to 5 June by the FC and the RAs. The beach was divided into four sections: Tortuguero river mouth - CCC station (mile 2 5/8); CCC station - Juana López trail (close to 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 nests during the season. 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. Notes were also kept on jaguar predation, turtles taken by poachers and the number of poached nests.

2.3 Tagging of Nesting Sea Turtles

Nightly tagging patrols were conducted 6 March – 5 June 2006 (with the exception of 8 – 10 March, 12 March and 4 June). Three beach sections were patrolled with varying frequency; Tortuguero river mouth – CCC station, CCC station – mile 5, and Jalova lagoon (mile 18) – mile 14.

Turtles were 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. 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, 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 Leatherback Program were National Band & Tag Company (NBTC) Monel #49 tags VA4001-4010, VA4026-4061, VA404069-VA4070, VA4076-VA4095, and Inconel #681 tags 104001-104143.

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). For leatherbacks, 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. CCCLmin 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 turtles 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 individual.

2.5 Determination of Nest Survivorship and Hatching Success

For leatherback turtles encountered while the egg chamber was still open (prior to covering) the nest was marked for inclusion in the study of nest survivorship and hatching success.

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 piece of 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. Depredation, poaching or beach erosion were noted and resulted in termination of monitoring for that nest. Nests were only marked along the beach section between the Tortuguero river mouth and the mile 5 marker.

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

- 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.

2.6 Physical Data Collection

Throughout the 2006 Leatherback Program several environmental variables were monitored on a daily basis at the John H. Phipps Biological station in Tortuguero, to assess their impact on turtle nesting and hatching success. 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 maximum and minimum 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.

2.7 Collection of Human Impact Data

Staff at the Tortuguero National Park Cuatro Esquinas ranger station provided information on visitation to the park in 2005/06. Jimmy Estrada and Sergio Campos recorded the number of visitors to the CCC Natural History and Visitors Center each day. To assess the impact of artificial light on the nesting beach, light surveys were conducted on 29 March, 27 April and 26 May; dates as close as possible to the new moon when natural light levels on the beach are lowest. The beach was surveyed from the Tortuguero river mouth to the mile 5 marker; each artificial light visible from the beach was noted and the source was identified when possible. For each light the location was classed as either 'beach', if it was directly behind the beach, or 'river', if it was situated across the river.

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

Talks and slide shows 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 implemented environmental education activities at the Tortuguero village school and high school, involving students from 4th – 9th grade. Students were also invited to accompany RAs on night-time beach patrols to learn more about leatherback turtles and the research methods of the CCC.

3. Results

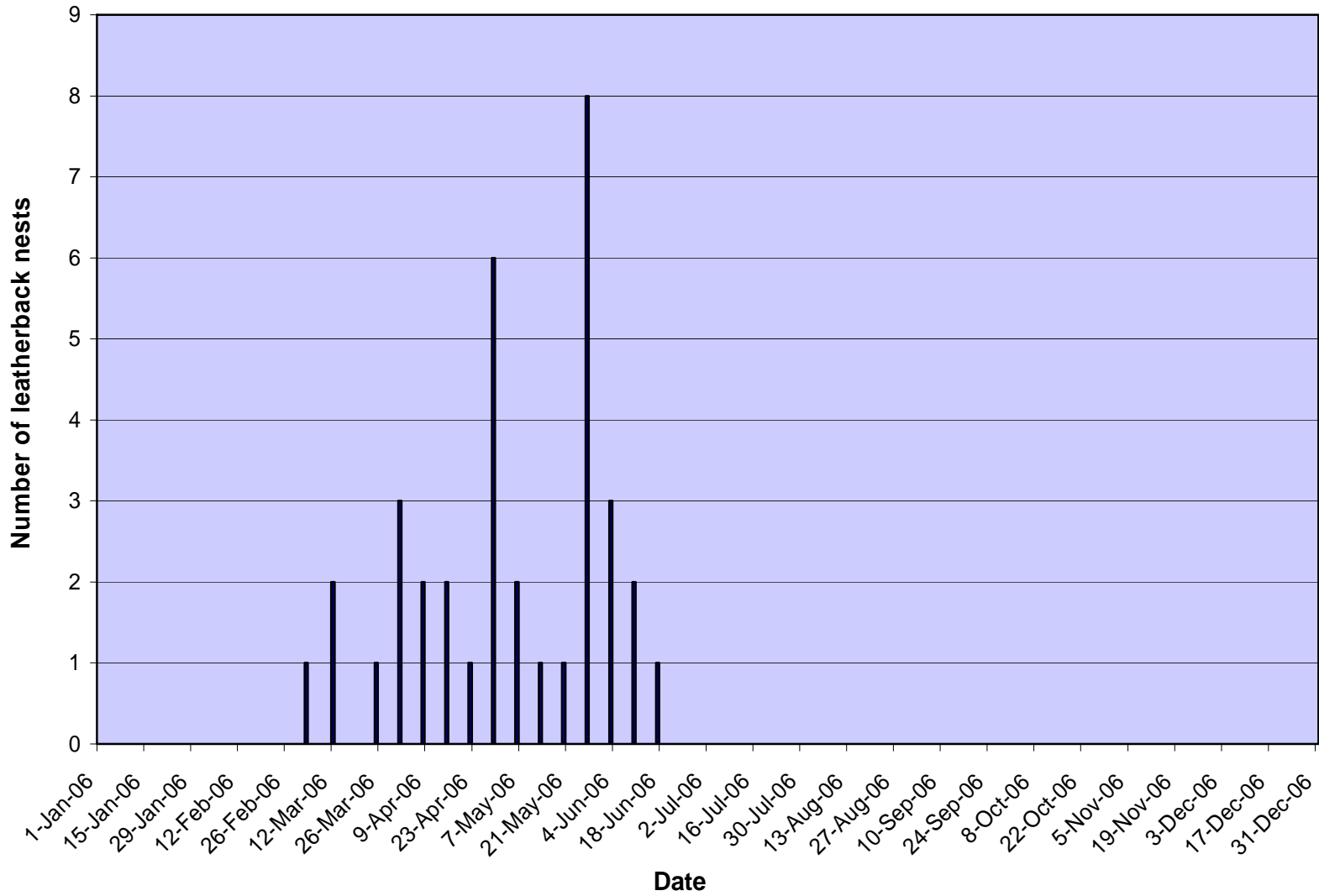
3.1 Preparations

Only a few of the mile markers on the beach had been washed away since the end of the 2005 Green Turtle Program and so it was only necessary to replace some of the mile markers at the start of the 2006 Leatherback Program.

3.2 Track Surveys

Leatherback nesting, as recorded by weekly track surveys, occurred from early March to mid-June (See Figure 1). However, several females were encountered after this date during night patrols conducted during the 2006 Green Turtle Program, thus it is known that leatherback nesting continued until at least until 2 July. Peak nesting, with 8 leatherback nests counted in one night, was recorded during the 27 May track survey (Figure 1).

Figure 1. Temporal distribution of leatherback nests during 2006, as determined by weekly track surveys.



For the period 4 March – 17 June, extrapolations from the weekly surveys using the methodology described in Troëng *et al.* (2004) suggest that only 199 leatherback nests were laid between Tortuguero river mouth and Jalova lagoon (range of 90 – 334 within 95% confidence limits). The FC and RA track surveys, conducted every three days during the same time period, recorded 332 leatherback nests along the same beach section.

The annual leatherback nesting trend at Tortuguero for the last twelve seasons is shown in Figure 2; it can be seen that 2006 had the lowest number of leatherback nests since the start of the Leatherback Program in 1995.

The spatial distribution of leatherback nesting during the 2006 Leatherback Program is shown in Figure 3. It can be seen that the majority of nests are laid south of mile 12; 329 nests were recorded between mile 12-22, accounting for 68.4% of the total. Almost one third of all nests were laid on the stretch of beach between Jalova lagoon and the Parismina river mouth (149 nests, 31% of the total).

Illegal poaching of nests was regularly observed throughout the 2006 Leatherback Program (See Table 1). A total of 91 leatherback, 95 green turtle and ten hawksbill nests were reported as poached during track surveys conducted by the Field Co-ordinator and Research Assistants. Minimum poaching levels were higher than those observed in 2005 for all species of turtle nesting in Tortuguero. Poached nests represented at least 18.9% of all leatherback nests recorded, 20.7% of green turtles nests and 26.3% of hawksbill nests.

The spatial distribution of illegal take of nests is shown in Figure 4. With regard to poaching of leatherback nests; only one nest was poached from the beach north of the TNP boundary at mile 3 3/8. However, it is interesting to note that for nests south of this point the percentage of poaching was almost equal, irrespective of whether they were laid within TNP (mile 3 3/8 – mile 18) or south of the park (mile 18 – 22); 20.4% and 20.8% respectively. Compared to 2005 figures, this demonstrates a decline in poaching outside the National Park, but indicates a dramatic increase in poaching levels on the beach within the protected area.

Observations and anecdotal information regarding illegal take of turtles and nests during the 2006 Leatherback Program are summarized in Appendix 1.

Figure 2. Annual leatherback nesting trend at Tortuguero from 1995 - 2006, as determined from weekly track surveys.

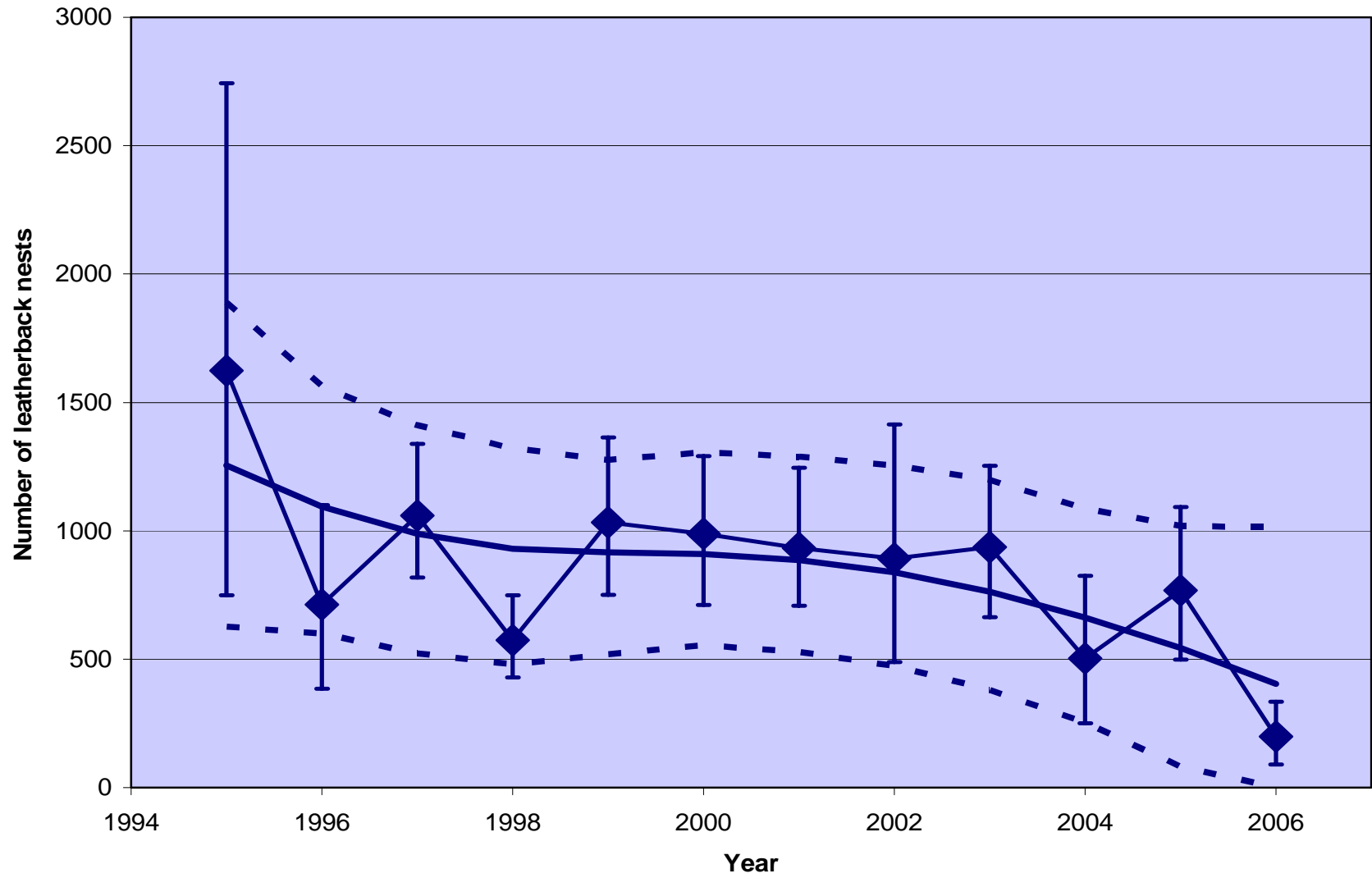


Figure 3. Spatial distribution of leatherback nests during the 2006 Leatherback Program, as determined by track surveys conducted by FC and RAs every three days.

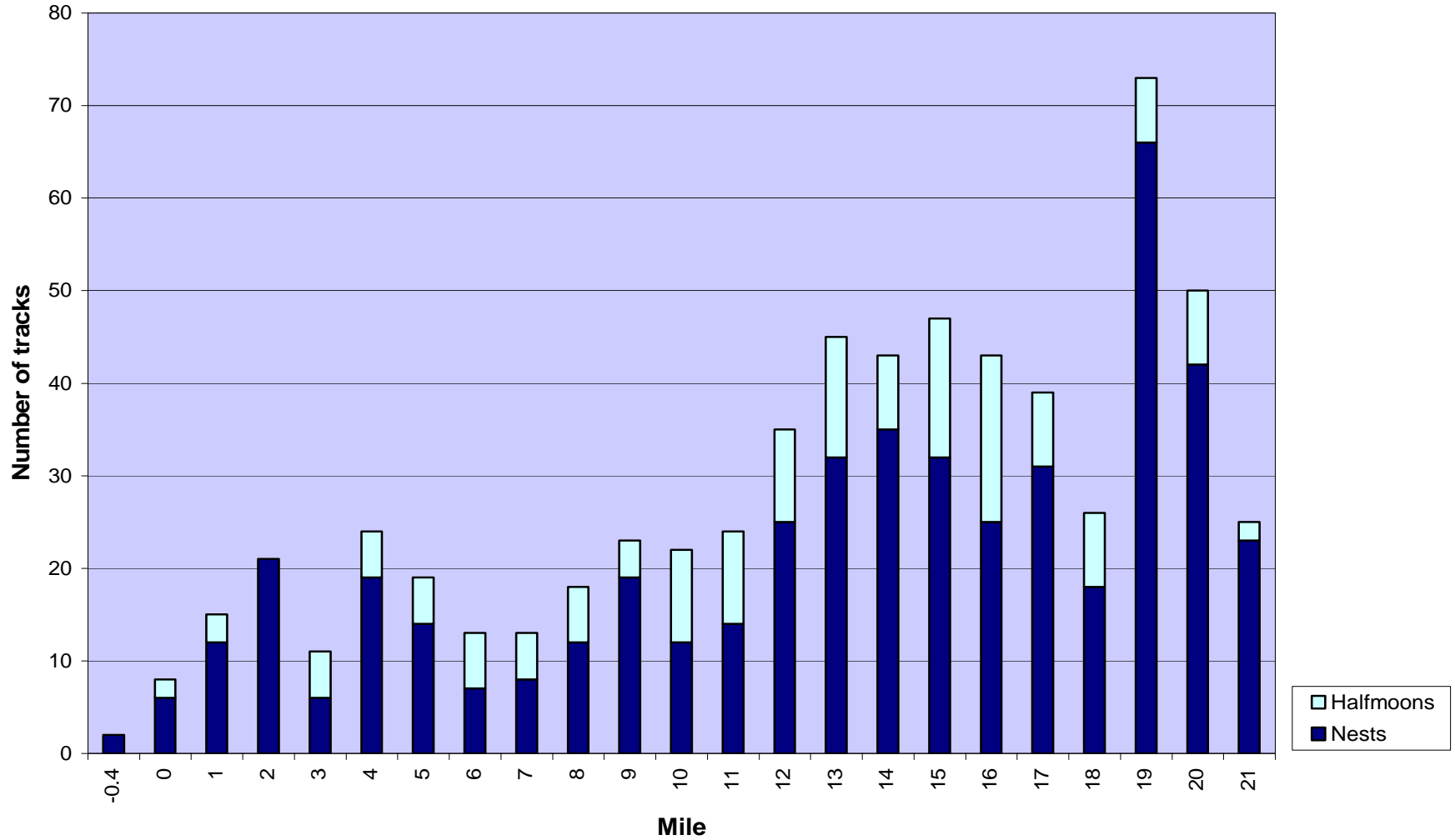


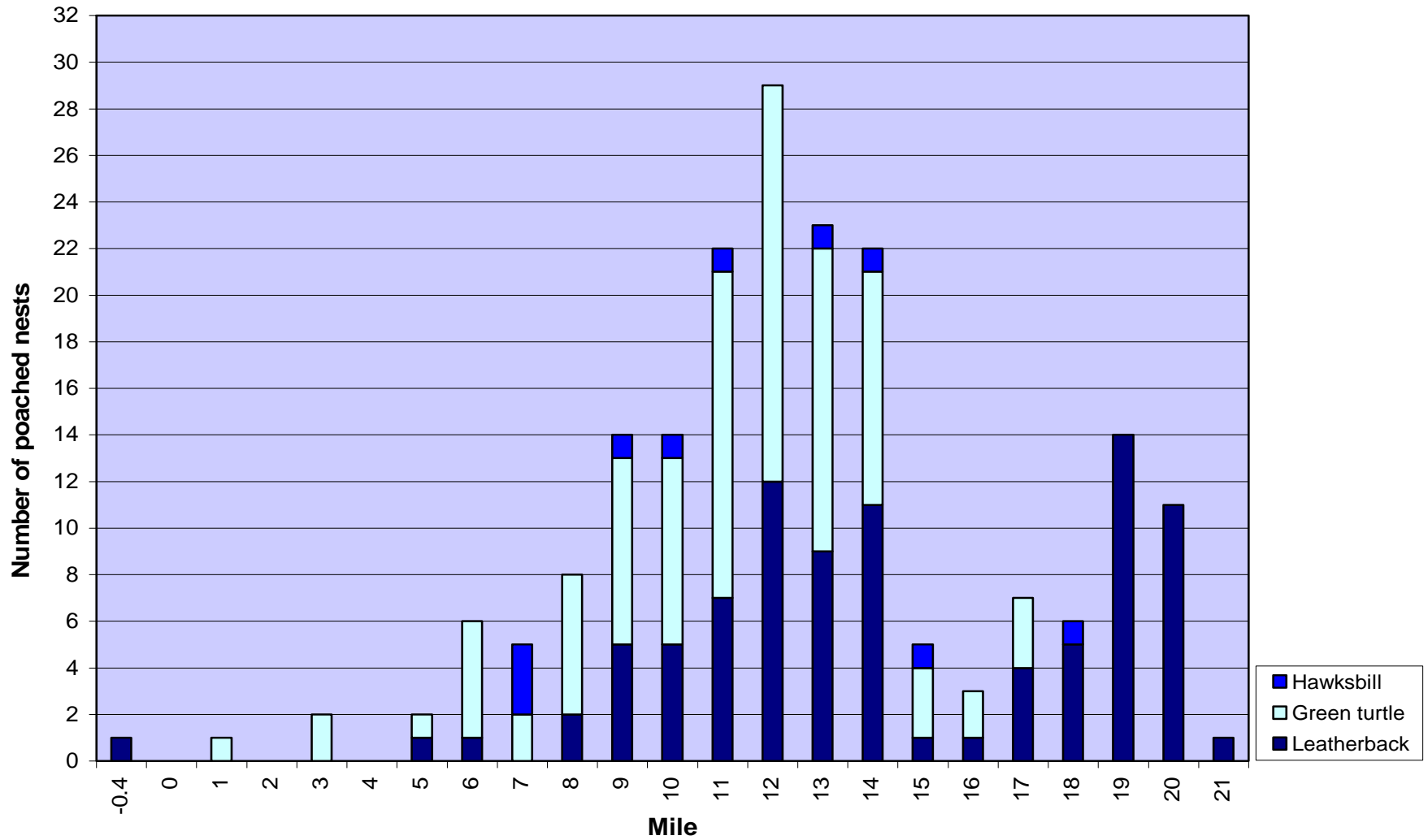
Table 1. Number of turtle nests and level of illegal poaching as determined from track surveys conducted by FC and RAs every three days during the 2006 Leatherback Program.

Date	Leatherback			Green turtle			Hawksbill		
	Nests	Min no. poached	Min % poached	Nests	Min no. poached	Min % poached	Nests	Min no. poached	Min % poached
13-Mar-06	19	2	10.5	14	2	14.3	1	0	0.0
16-Mar-06	6	0	0.0	9	5	55.6	0	0	N/A
19-Mar-06	15	1	6.7	12	4	33.3	0	0	N/A
22-Mar-06	12	2	16.7	16	2	12.5	0	0	N/A
25-Mar-06	13	3	23.1	24	7	29.2	1	1	100.0
28-Mar-06	16	4	25.0	13	10	76.9	0	0	N/A
31-Mar-06 ¹	4	0	0.0	14	1	7.1	1	0	0.0
3-Apr-06	15	0	0.0	18	1	5.6	0	0	N/A
6-Apr-06	14	0	0.0	42	3	7.1	0	0	N/A
9-Apr-06	15	0	0.0	15	2	13.3	1	0	0.0
12-Apr-06	25	11	44.0	28	4	14.3	0	0	N/A
15-Apr-06	7	2	28.6	17	10	58.8	0	0	N/A
18-Apr-06	15	6	40.0	22	6	27.3	0	0	N/A
21-Apr-06	39	12	30.8	18	1	5.6	0	0	N/A
24-Apr-06	24	0	0.00	17	1	5.9	0	0	N/A
27-Apr-06	11	4	36.4	28	8	28.6	3	0	0.0
30-Apr-06	21	3	14.3	18	4	22.2	0	0	N/A
3-May-06	21	0	0.0	8	0	0.0	2	0	0.0
6-May-06	16	1	6.3	27	5	18.5	1	0	0.0
9-May-06	24	6	25.0	15	1	6.7	2	0	0.0
12-May-06	10	0	0.0	12	2	16.7	0	0	N/A
15-May-06	13	0	0.0	9	2	22.2	5	1	20.0
18-May-06	18	2	11.1	14	0	0.0	3	0	0.0
21-May-06	19	7	36.8	4	1	25.0	2	1	50.0
24-May-06 ²	13	3	23.1	6	1	16.7	1	0	0.0
27-May-06 ²	25	8	32.0	4	1	25.0	4	3	75.0
30-May-06	17	8	47.1	16	3	18.8	4	2	50.0
2-Jun-06	18	1	5.6	11	3	27.3	3	0	0.0
5-Jun-06	16	5	31.3	8	5	62.5	4	2	50.0
Total	481	91	18.9	459	95	20.7	38	10	26.3

¹ Heavy rain may have affected track count

² Very high tides may have affected track count

Figure 4. Spatial distribution of illegal poached nests during the 2006 Leatherback Program, as determined by track surveys conducted by FC and RAs every three days.



3.3 Tagging of Nesting Sea Turtles

In total, 1,007 team hours of night patrols were conducted between 6 March and 5 June 2006.

During these patrols a total of 101 leatherbacks, 66 green turtles, and six hawksbills were encountered (Appendix 1). This is equal to a mean of 0.100 leatherback, 0.066 green and 0.001 hawksbill turtles encountered per patrol hour.

The turtles encountered correspond to 68 individual female leatherbacks, 51 female green turtles and five female hawksbills. A total of 61.8% (n = 42) of the leatherbacks observed were tagged previous to the first encounter with RAs during the 2006 nesting season (See Appendix 1).

Of the previously tagged leatherback turtles encountered in 2006, 50% had originally been tagged in Tortuguero (n = 21). The remainder were tagged on nesting beaches at Caño Palma (north of the river mouth in Tortuguero; n = 3), Parismina (n = 4), Pacuare/Mondonguillo (n = 11), Gandoca/Manzanillo (n = 1) and in Panama (n = 2). Of the turtles tagged in Tortuguero, four were originally seen more than 10 years ago; one was first tagged in 1995, and she returned to nest in 2001. Another was first encountered in 1996, and returned in 1998, 2002 and 2004, when she was fitted with a satellite transmitter to monitor her migration movements. Two other leatherbacks were originally observed in 1997, one of which returned in 2002. The two previously tagged green turtles were both seen in Tortuguero in 2001. One hawksbill turtle was encountered with tags which suggest she was originally tagged in Mondonguillo.

Evidence of holes or notches were found on 26.9% (n = 7) of newly tagged leatherback turtles checked for previous tagging (n = 26) when they were encountered for the first time during the 2006 Leatherback Program.

A total of 82% of the encountered leatherback turtles nested in the open beach zone (n = 82), 1% nested in the border zone (n = 1) and 17% did not lay eggs (n = 17).

3.4 Biometric Data Collection

CCLmin measurements were taken for 67 of the 68 individual leatherback turtles encountered.

Of 19 females observed more than once during the 2006 season, only eight had their caudal projection consistently identified on each occasion; five were identified as complete and three as incomplete. The other 11 individuals had caudal projections that were inconsistently categorized on successive sightings. The caudal projection of one female was not categorized. Data from these 11 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: $z = -0.52$ $p = 0.60$, $n = 55$), 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 149.7 cm (n = 67) and the 48 clutches that were counted contained a mean of 78 yolked eggs (range = 26 – 111) and 31 yolckless eggs (range = 7 – 55) (See Table 2).

Table 2. Mean carapace length and clutch size of leatherback turtles encountered in 2006.

Carapace length / cm			Clutch size / no. eggs		
n	\bar{x} CCLmin ± S.D.	Range	n	\bar{x} yolked ± S.D.	\bar{x} yolless ± S.D.
67	149.7 ± 6.9	133.4 – 162.4	48	78 ± 17	31 ± 11

Mean carapace length (CCLmin) for green turtles encountered during the 2006 Leatherback Program was 102.5 cm (n = 51), and the 22 clutches for which eggs were counts contained a mean of 108 eggs, with a range of 71 – 153 eggs (See Table 3). The five hawksbill turtles that were encountered had a mean carapace length (CCLmin) of 89.8 cm, and the three clutches that were counted had a mean of 185 eggs, with a range of 161 – 200 eggs (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} ± S.D.
Green	51	102.5 ± 6.4	87.3 – 116.0	22	104 ± 23.0 ¹
Hawksbill	5	89.8 ± 1.9	87.5 – 92.3	3	185 ± 21.2

¹ Includes yolked eggs only; only four green turtles laid yolless eggs (range = 1 – 3 eggs)

The precision of the CCLmin measurements was high in 2006, 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	100	0.2 ± 0.2	0.0 – 1.0
Green	66	0.3 ± 0.2	0.0 – 1.3
Hawksbill	6	0.2 ± 0.0	0.2

The precision of the CCLmin carapace measurements for leatherback turtles measured during more than one encounter was 0.8 cm for two encounters, 1.9 cm for three encounters, 3.2 cm for four encounters and 1.5 cm for six encounters (See Table 5).

Table 5. Precision of carapace measurements for individual leatherbacks encountered more than once during the 2006 Leatherback Program.

No. of encounters	n	\bar{x} precision for CCLmin (cm) \pm SD	Range / cm
2	10	0.8 \pm 0.5	0.1 – 1.6
3	6	1.9 \pm 0.8	1.3 – 3.4
4	2	3.2 \pm 1.1	2.4 – 4
5	0	N/A	N/A
6	1	1.5	N/A

3.5 Determination of Nest Survivorship and Hatching Success

A total of 23 leatherback nests were marked between 6 March and 2 July 2006; three of these were during the 2006 Green Turtle Program. Four nests could not be located for excavation and so were eliminated from further analysis.

The incubation period for monitored leatherback nests for which emerging was observed (n = 8) varied between 59 – 72 days, with a mean of 66 days.

The fate, hatching and emerging successes of 19 marked and monitored leatherback nests are summarized in Table 6.

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

Fate	n	% of total	% Hatching success	% Emerging success
Undisturbed	13	68.4	62.5	60.5
Inundated	1	5.3	3.9	3.9
Unhatched	2	10.5	0.0	0.0
Washed out	3	15.8	0.0	0.0
Total	19	100	43.5	42.1
<i>Unknown</i>	4			

Data from the nest excavations are summarized in Table 7. From these data the total number of eggs for all marked nests was estimated at 1,265 eggs (64.8 x 16 + 76.0 x 3). This figure takes into account the three nests that were washed out during incubation.

Overall hatching success was estimated as 43.5% for monitored leatherback nests (550 empty shells from 1,265 eggs). Emerging success for monitored leatherback nests was estimated at 42.1% (533 emerged hatchlings from 1,265 eggs in 19 nests).

Table 7. Summary of data from nest excavations of marked leatherback nests.

Fate	n	Hatchlings		Empty shells	Pipped eggs	Unhatched eggs			Depredated	Destroyed	Total no. eggs	\bar{x} clutch size
		Live	Dead			No embryo	Embryo	Full embryo				
Undisturbed	13	6	11	547	5	191	34	11	54	0	842	64.8
Inundated	1	0	0	3	0	70	2	1	0	0	76	76.0
Unhatched	2	0	0	0	0	56	16	80	0	0	152	76.0
Washed out	3	?	?	?	?	?	?	?	?	?	?	?
Total	19	6	11	550	5	317	52	92	54	0	1,070	N/A

The distance from the sand surface to the top egg at the time of excavation for undisturbed nests (n = 13) varied between 43 -75 cm with a mean of 63.6 cm. The distance from the sand surface to the bottom of the egg chamber for the same nests varied between 62 - 88 cm with a mean of 78.8 cm; n = 12 because the depth to the bottom of the egg chamber was not be measured for one nest.

Only two deformed embryos were recorded, corresponding to 0.19% of eggs encountered during nest excavations. In addition, two live hatchlings were observed that had deformities.

3.6 Physical Data Collection

Rainfall during the months of the 2006 Leatherback Program (March – June) varied considerably (264.5 mm – 408.7 mm per month); with May being the driest month, and June the wettest (See Table 8). Average daily rainfall, over a 24-hour period, ranged from 8.5 mm (in May) to 13.6 mm (in June). Visit

Table 8. Rainfall recorded during the 2006 Leatherback Program.

Month	Total rainfall mm/month	\bar{x} rainfall mm/24hrs
March	406.2	13.1*
April	385.5	12.9
May	264.5	8.5
June	408.7	13.6

* Data for 48 hours 22-23 March

Mean monthly sand temperatures ranged between 24.5 – 31.1°C (See Table 9) during the 2006 Leatherback Program. Sand temperatures were higher and more variable in the open zone than in the border and vegetation zones (See Table 9).

Table 9. Mean monthly sand temperatures recorded during 2006 Leatherback 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
Depth	30	50	70	30	50	70	30	50	70
January	N/A	28.0	27.4	N/A	26.2	26.0	N/A	24.5	24.7
February	N/A	28.9	28.3	N/A	27.7	27.4	N/A	25.1	25.4
March ¹	30.4 ²	28.3	29.2	28.0 ²	28.2	27.8	25.6 ²	25.6	25.8
April	31.1	30.6	29.6	28.4	28.5	27.9	25.9	25.9	26.1
May	31.9	31.7	30.8	29.6	29.8	29.2	26.8	26.8	27.0

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

¹ No retrieval depths recorded on 4 March

² Data from 4 March

Table 9. Continued.

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
June	31.1 ³	30.9 ³	30.0 ³	28.6 ³	28.9	28.4	26.6	26.7	26.9
Retrieval depth / cm 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	26.6	26.6	26.8

³ Data to 26 June

3.7 Collection of Human Impact Data

The number of visitors to Tortuguero National Park has continuously increased since 2003; in 2005, 87,083 visitors were registered as paying the entrance fee to the park (See Table 10). It is interesting to note, however, that visitation by Costa Rican nationals decreased slightly in 2005.

Table 10. Number of paying visitors to Tortuguero National Park, 2003 – 2005.

Year	Costa Rican visitors	Foreign visitors	Total no. of visitors
2003	8,643	59,026	67,669
2004	9,545	71,912	81,457
2005	9,292	77,791	87,083

The number of visitors registered at the CCC Natural History and Visitors Center increased substantially during 2006 (See Table 11), reversing the trend observed in 2005. Daily visitation in 2006 was higher than the previous two years in every month except June, August and October, and the total number of visitors for the year was over 2,000 higher than either 2004 or 2005.

Table 11. Visitors to the CCC Visitors Center, January 2004 – December 2006.

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

Table 11. Continued.

Month	2004		2005		2006	
	Total	\bar{x} / day	Total	\bar{x} / day	Total	\bar{x} / day
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
Total	30,617	84	28,322	78	32,733	90

A summary of the results of the monthly light surveys is shown in Table 12. It can be seen that the majority of the lights visible on the beach are coming from lodges, or from street lights, houses and cabinas in Tortuguero village. Although the beach sections with artificial lights remain the same, there has been a large increase in the number of lights visible from the villages of San Francisco (mile -2/8 – 1/8) and Tortuguero (mile 2 6/8 – 3 2/8) from previous years.

Table 12. Summary of results of monthly light surveys conducted during the 2006 Leatherback Program.

Mile	Light Source	Beach side	River side	March	April	May
- 2/8	San Francisco lights and houses		✓	✓	✓	
- 1/8	San Francisco houses		✓			✓
0	San Francisco houses		✓			✓
1/8	San Francisco houses		✓			✓
6/8	Tortuga Lodge		✓	✓	✓	✓
1 1/8	House light		✓	✓		
1 2/8	All Rankin Lodge	✓		✓	✓	✓
1 3/8	Laguna Lodge	✓		✓	✓	✓
1 4/8	Laguna Lodge	✓		✓		✓
1 5/8	Laguna Lodge	✓			✓	
2 2/8	Mawamba Lodge	✓		✓		✓
2 3/8	Mawamba Lodge	✓		✓	✓	✓
2 4/8	CCC station	✓		✓		✓
2 5/8	CCC station	✓		✓	✓	✓
2 6/8	Cabinas, street lights and houses	✓		✓ ¹	✓ ¹	✓
2 7/8	Cabinas, street lights and houses	✓		✓	✓	✓
3	Cabinas, street lights and houses	✓		✓	✓	✓
3 1/8	Cabinas, street lights and houses	✓		✓	✓	✓
3 2/8	Cabinas, street lights and houses	✓		✓	✓	✓

¹In addition, the red light from the communication tower was visible

3.8 Dead Turtles

In addition to the turtles that were taken by poachers, 32 dead turtles (29 green turtles and three hawksbills) were encountered during the 2006 Leatherback Program; of these, 30 were killed by jaguars (See Table 13). The bodies of three of the turtles that were killed by jaguars were not encountered, and it was presumed that they were poached shortly after they were killed.

A very small juvenile hawksbill (CCL ~10cm) was found on the beach during the track survey of 27 April; there were no obvious signs as to the cause of death. An adult female green turtle was found dead between the vegetation and the beach on 30 May; the only injuries recorded were two cuts on her neck which did not appear to have caused her death (See Table 13).

Table 13. Dead turtles encountered during the 2006 Leatherback Program.

Date	Species	Sex	Mile	Comments
13-Mar-06	CM	F	13	Killed by jaguar
19-Mar-06	CM	F	11	Killed by jaguar – very fresh
28-Mar-06	CM	F	12 4/8	Possibly killed by jaguar ¹
3-Apr-06	CM	F	11 4/8	Killed by jaguar
3-Apr-06	CM	F	13	Killed by jaguar
6-Apr-06	CM	F	12	Killed by jaguar
9-Apr-06	CM	F	9 4/8	Killed by jaguar
9-Apr-06	CM	F	15	Killed by jaguar
12-Apr-06	CM	F	11 4/8	Killed by jaguar – very fresh
18-Apr-06	CM	F	6	Killed by jaguar
24-Apr-06	CM	F	7 4/8	Killed by jaguar
24-Apr-06	CM	F	12 4/8	Killed by jaguar
26-Apr-06	CM	F	13	Killed by jaguar – reported by Caño Palma staff
27-Apr-06	CM	F	9	2 turtles killed by jaguar
27-Apr-06	EI	?	10	Juvenile turtle ~10cm carapace length found on beach; no obvious signs of cause of death
27-Apr-06	EI	F	10 4/8	Possibly killed by jaguar ¹
27-Apr-06	CM	F	11	Killed by jaguar
27-Apr-06	CM	F	12 4/8	Killed by jaguar
27-Apr-06	CM	F	13	Killed by jaguar
29-Apr-06	CM	F	10 3/8	Killed by jaguar – reported by track surveyor
30-Apr-06	CM	F	6	Killed by jaguar – very fresh
30-Apr-06	CM	F	13	Killed by jaguar
30-Apr-06	CM	F	13 4/8	Killed by jaguar

Cm = Green turtle, Ei = Hawksbill

¹Presumed poached as body of turtle not encountered

Table 13. Continued.

Date	Species	Sex	Mile	Comments
9-May-06	CM	F	9	Possibly killed by jaguar ¹
9-May-06	CM	F	9 4/8	Killed by jaguar – very fresh
12-May-06	CM	F	10	Killed by jaguar
15-May-06	CM	F	9 4/8	Killed by jaguar
21-May-06	CM	F	10 4/8	Killed by jaguar
27-May-06	EI	F	13 4/8	Killed by jaguar
30-May-06	CM	F	7	Killed by jaguar
30-May-06	CM	F	10 4/8	Dead turtle found between vegetation and the beach. No obvious signs of cause of death – possibly from two cuts on her neck.

Cm = Green turtle, Ei = Hawksbill

¹ Presumed poached as body of turtle not encountered

3.9 Environmental Education Activities

The FC and RAs worked with students from the Tortuguero and San Francisco schools during the 2006 Leatherback Program; giving talks about the work of CCC with sea turtles in the local area. Members of the public were also invited to a talk given by the FC that included the evaluation of the new turtle tour system that was presented at the International Sea Turtle Symposium in Greece in 2006.

In addition a visiting researcher from Mexico spoke to students, interested members of the Tortuguero community and TNP staff about turtle conservation efforts in Baja California, Mexico, comparing them to the work being done by CCC in Tortuguero.

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 FC 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 very 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, and possibly by poachers, to locate themselves on the beach.

4.2 Track Surveys

Leatherback nesting was only observed during weekly track surveys from March to June, with peak nesting occurring in late May (See Figure 1). Track surveys conducted by the FC and RAs cover the period of heaviest leatherback nesting (See Figure 1 and Table 1).

Estimated leatherback nesting was much lower in 2006 than in 2005; continuing the decreasing nesting trend that has been observed in recent years (See Figure 2). Data from 2006 suggest that it was the lowest leatherback nesting season since the Leatherback Program began in 1995.

The two methods used for estimating the number of leatherback nests showed quite large differences; weekly track surveys = 199 nests compared to 332 nests from the 3-day surveys. These could have been due to the fact that with such low levels of nesting the weekly track surveys were more likely to underestimate the actual numbers of turtles coming ashore; the more frequent surveys conducted by the FC and RAs might have given a more realistic estimation of nesting in 2006. However, the range associated with the estimation from the weekly counts (90 – 334 nests within 95% confidence limits) includes the estimate derived from the 3-day surveys, suggesting that the weekly surveys are still an appropriate method for determining nesting numbers throughout the leatherback nesting season.

Illegal poaching of turtle nests occurred throughout the 2006 Leatherback Program. Levels of poaching were higher for all three species of turtle than in the previous two years; representing between 18.9 – 26.3% of nests (See Table 1). What was especially discouraging to observe was that poaching levels within and outside Tortuguero National Park were almost identical; previously poaching had been focused in areas outside the protected area, between the Jalova lagoon and Parismina, but in 2006 there was a marked increase in the extent of poaching within the protected area. This confirms the need for increased patrols by Tortuguero National Park staff to ensure enforcement of protective legislation for sea turtle nests. In addition it would be highly beneficial to conduct patrols south of the Jalova lagoon, as this area is still subject to high levels of poaching during the months of the Leatherback Program.

4.3 Tagging of Nesting Sea Turtles

The period of tagging patrols from mid-March to mid-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 turtles encountered during nightly patrols ($n = 101$) was much lower than the number encountered in 2005 despite similar patrol effort on behalf of the FC and RAs during the two years. Results from the track surveys confirm that 2006 was a low nesting year for leatherbacks and hence it wasn't due to lack of patrol effort that fewer turtles were encountered. The number of green turtles encountered ($n = 66$), was three times greater than the number recorded in 2005; signifying an earlier start to the nesting season for this species.

Half of the leatherbacks encountered with tags had originally been tagged in Tortuguero; which was a much higher percentage than in 2005. Turtles were also recorded that had been tagged at several other nesting beaches within Costa Rica and Panama; as in other years. This highlights the extent to which leatherbacks move between nesting beaches, within and between nesting

seasons. It also emphasizes the need for improved communication between research projects working on these different beaches to facilitate the transfer of important data regarding leatherback turtle nesting beach utilization.

The return of a leatherback that had been fitted with a satellite transmitter in 2004 was very interesting; the transmitter was not still attached, and the female did not have any obvious scars on her carapace that could have been caused by the harness.

One hawksbill was encountered with tags that suggest she had originally been tagged on the nesting beach at Mondonguillo, in southern Costa Rica.

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 149.7 cm (See Table 2), which was between the two mean values calculated for females with complete and incomplete caudal projections in 2005.

The inconsistency with which the majority of females encountered on more than one occasion had their caudal projection categorized highlights the need to clearly define the definition of 'complete' and 'incomplete' during the orientation of new RAs in future Leatherback Programs.

The precision of leatherback carapace measurements was higher than that observed in previous years (0.2 cm). A similar level of precision was recorded for all species of turtles encountered during the 2006 Leatherback Program. 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).

4.5 Determination of Nest Survivorship and Hatching Success

Overall hatching and emerging success of leatherback nests were much higher in 2006 than in 2005, 43.5% and 42.1%, respectively. Fortunately none of the marked nests were poached, however, overall hatching and emerging success were undoubtedly affected by the fact that one nest had very low hatching success due to repeated inundation during the incubation period and three nests were completely washed out before they could hatch.

During the 2006 Leatherback Program a master's student from Sweden conducted a study of factors effecting leatherback hatching success at Tortuguero, including the distance of the nest from the high tide line at the time of laying. The results of that research revealed that leatherback nests laid below the high tide line had a significantly lower hatching and emerging success than those laid above it (Runemark, 2006). It also showed that the distance of the nest above the high tide had little effect on nest success. These findings imply that relocation of leatherback nests laid below the high tide line might be a useful management strategy to help improve the success of leatherback nests at Tortuguero. However, a preliminary investigation into the effect of relocation on nest survival and hatching success would be an appropriate next step before implementing a relocation program in future years.

4.6 Physical Data Collection

Rainfall during the 2006 Leatherback Program was slightly higher than that observed in 2005;

and this was reflected in sand temperatures that were lower for most months. This may, in part, have resulted in the higher hatching success that was observed in leatherback nests in 2006; sand temperatures remained below levels that could possibly cause embryo mortality. Unlike 2005, in 2006 there was not such a great variability in total rainfall between the months when leatherback nesting was observed; monthly totals only ranged between 264.5 – 408.7 mm (See Table 8). There were no months that were significantly wetter or drier than others. It would be interesting to conduct a more detailed study of environmental variables that may be of significance to nesting success of leatherbacks in Tortuguero.

4.7 Collection of Human Impact Data

Tourism visitation to Tortuguero continues to grow each year; in 2006 more than 87,000 visitors paid the entrance fee to Tortuguero National Park (See Table 10). The numbers of national visitors was seen to decrease from 2005, while international visitation continued to increase. There was also a dramatic increase in the number of visitors registered at the CCC Natural History and Visitor Center (See Table 11). This increase was seen throughout the year in 2006, and was not limited to peak tourist months.

Despite this positive trend in visitation, there is a great deal that could be improved within the Visitor Center. Funds are urgently required to improve the infrastructure of the Visitor Center as well as the content and format of the displays. This should be seen as a priority for CCC in future years, as it is an 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.

The increase in tourism has led to additional construction in the communities of Tortuguero and San Francisco, and expansion of the lodges north of Tortuguero. This in turn has caused an increase in artificial lights that are visible on the nesting beach. It would be of great benefit to conduct an awareness campaign focused on the negative impact of artificial lights on nesting turtles and hatchlings, to try and improve lighting conditions on the beach, particularly among house owners and small businesses (cabanas and restaurants) that border the beach between mile markers 2 7/8 and 3 2/8.

4.8 Dead Turtles

The number of green turtles that were killed by jaguars during the 2006 Leatherback Program was within the range observed in previous years, though it was considerably higher than that recorded in 2005. It was also very unfortunate that two of the few hawksbill turtles were also killed by jaguars (See Table 13). As has been seen in other years, three turtles that were killed by jaguars were subsequently taken by poachers shortly after they were killed.

The two turtles that were encountered dead on the beach with no obvious cause of death apparent were unusual. The stranded juvenile hawksbill is the second such individual to have washed ashore in Tortuguero within the last few years; in 2002 a similar-sized turtle was found alive by researchers during a morning survey, and subsequently released. It would be beneficial to not only long the occurrence of stranded turtles during future programs, but also to obtain permission from MINAE to perform necropsies of dead turtles, to not only try and determine the cause of death, but also gain information about the health status and demographics of turtles within the region.

4.9 Environmental Education Activities

All of the environmental education events held in Tortuguero and San Francisco were much appreciated by all those who took part, both from the community and the RAs. It was informative for the students, especially, to receive information about sea turtle conservation activities that are being conducted in other countries, to contrast with what is happening in their local area, and to appreciate all that CCC is doing in Tortuguero. In future years it would be very beneficial to continue these types of activities; prospective RAs could be invited to talk about their prior experiences in other turtle conservation projects around the world.

Environmental activities within the schools could be better organized with advanced planning. Relevant themes could be discussed with the school/high school director's at the start of the Leatherback Program. These activities should include a variety of different themes, and be adapted to suit the different age of students. In addition to sea turtles, they should incorporate other related topics such a recycling or conservation of other species of flora and fauna that are under threat in the area. It would also be ideal to expand the outreach activities to other sectors of the community, and not focus only on students.

5. References

- Campbell, C.L., Lagueux, C.J., Mortimer, J.A. 1996. Leatherback turtle, *Dermochelys coriacea*, nesting at Tortuguero, Costa Rica, in 1995. *Chel. Cons. Biol.* 2(2), 169-172.
- Carr, A., Carr, M.H., Meylan, A.B. 1978. The ecology and migrations of sea turtles, 7. The west Caribbean green turtle colony. *Bull. Amer. Mus. Nat. Hist.* 162, 1-46.
- Runemark, A. 2006. Spatial distribution and temperature effects on hatching success of the leatherback turtle *Dermochelys coriacea*: implications for conservation. Unpublished MSc thesis, Uppsala University, Sweden.
- Troëng, S., Chacón, D., Dick, B. 2004. Possible decline in leatherback turtle *Dermochelys coriacea* nesting along the coast of Caribbean Central America. *Oryx* 38(4), 395-403.

6. Appendices

Appendix 1. Daily sea turtle encounters for the 2006 Leatherback Program.

Date	Leatherback				Green Turtle				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
6 Mar		1		1				0				0
7 Mar				1				0				0
8 Mar				1				0				0
9 Mar				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	2				0				0
16 Mar		1		3				0				0
17 Mar				3				0				0
18 Mar	1			4	1			1				0
19 Mar	1			5				1				0
20 Mar	2	2		9	2			3				0
21 Mar				9				3				0
22 Mar				9	1			4				0
23 Mar	3			12	5			9				0
24 Mar				12				9				0
25 Mar				12				9				0
26 Mar				12				9				0
27 Mar				12				9				0
28 Mar				12	2			11				0
29 Mar				12				11				0
30 Mar				12	1			12				0
31 Mar				12				12				0
1 Apr		1		13				12				0
2 Apr	1			14				12				0
3 Apr				14		1		13				0
4 Apr		1		15	2	1		16				0
5 Apr		2	1	18				16				0
6 Apr				18	1			17				0
7 Apr		1		19				17				0
8 Apr			1	20				17				0
9 Apr				20	2			19				0
10 Apr				20	1		1	21				0
11 Apr		1		21	3			24				0
12 Apr	1			22				24				0
13 Apr				22	1			25				0
14 Apr			1	23	1			26				0
15 Apr				23	3		1	30				0
16 Apr			1	24				30				0
17 Apr	1		1	26			1	31				0
18 Apr		3		29	1			32				0
19 Apr	1	6		36	1			33				0
20 Apr	1			37				33				0

21 Apr	1		1	39	2		1	36				0
22 Apr		2		41	1			37				0
23 Apr				41				37				0
24 Apr				41	2			39				0
25 Apr				41	1		1	41				0
26 Apr				41	1		2	44				0
27 Apr		2		43	1			45				0
28 Apr	2	1		46	2			47				0
29 Apr		1		47			1	48				0
30 Apr	1		1	49				48				0
1 May	1	1		51				48				0
2 May		2		53	1			49				0
3 May		2	1	56	3			52				0
4 May	1		1	58	1		1	54				0
5 May	1			59				54				0
6 May			1	60			1	55				0
7 May		1		61			1	56				0
8 May			2	63			1	57	1			1
9 May		1		64				57	1			2
10 May	1	1	2	68			1	58				2
11 May			1	69				58				2
12 May				69				58				2
13 May			2	71				58				2
14 May				71				58				2
15 May	2			73	1		1	60	1			3
16 May	1	2	2	78				60				3
17 May			1	79				60				3
18 May			1	80	1			61				3
19 May			1	81	1			62				3
20 May	1		1	83				62				3
21 May		1	1	85	1			63				3
22 May				85				63				3
23 May		1		86	1		1	65				3
24 May		2		88				65	1		1	5
25 May	1	1	1	91				65		1		6
26 May		1	2	94				65				6
27 May				94				65				6
28 May	1			95				65				6
29 May				95				65				6
30 May		1		96	1			66				6
31 May			3	99				66				6
1 June			2	101				66				6
2 June				101				66				6
3 June				101				66				6
4 June				101				66				6
5 June				101				66				6
Total	26	42	33	101	49	2	15	66	4	1	1	6

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

Appendix 2. Observations and Anecdotal Information on Illegal take of turtles and nests.

An increase in the level of poaching of nests was observed during the 2006 Leatherback Program, for all species of turtle. In addition to nests there was also evidence that nesting females were taken from the nesting beach.

On 11 occasions during track surveys conducted by the FC and RAs, signs that a turtle had been poached were observed; of these 10 were green turtles and one was a hawksbill. The hawksbill was believed to have originally been killed by a jaguar but taken by poachers afterwards as no body was discovered, and drag marks were observed. The evidence was typically drag marks, indicating that the turtle having been flipped over and taken off the beach, often by boat, although on one occasion the head and plastron of a recently killed turtle were discovered on the beach.

Twice during night patrols close to the Jalova lagoon RAs reported that turtles had been illegally taken; on 13 April, the remains of a freshly killed turtle were discovered in the vegetation close to mile 15 and on 21 April a turtle was presumed killed by a jaguar, but the body was never encountered and was believed to have been taken by people.

All of the turtles that were poached were taken within Tortuguero National Park, between miles 6 – 17; four of which were taken within one mile (12 – 12 4/8) in the centre of the park.

Throughout the 2006 Leatherback Program boats were observed very close to shore during track surveys, typically in the middle of the national park far from either of the two river mouths. Often people were seen on the beach at the same time; frequently they showed very suspicious behavior by hiding from the FC or RAs in the vegetation. In addition there were signs of poaching activity or evidence of temporary construction on the beach.