

REPORT
ON THE 2000 LEATHERBACK PROGRAM
AT TORTUGUERO, COSTA RICA



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and
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by

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TABLE OF CONTENTS

| | |
|--|-----------|
| TABLE OF CONTENTS..... | 2 |
| LIST OF FIGURES | 4 |
| LIST OF TABLES | 4 |
| ACKNOWLEDGEMENTS | 5 |
| 1. INTRODUCTION..... | 6 |
| 2. METHODS..... | 6 |
| 2.1 PREPARATIONS..... | 6 |
| 2.2 TRACK SURVEYS | 6 |
| 2.3 TAGGING OF NESTING FEMALES..... | 7 |
| 2.4 BIOMETRIC DATA COLLECTION..... | 7 |
| 2.5 DETERMINATION OF NEST SURVIVORSHIP AND HATCHING SUCCESS..... | 7 |
| 2.6 PHYSICAL DATA COLLECTION..... | 8 |
| 2.7 COLLECTION OF HUMAN IMPACT DATA | 8 |
| 2.8 DEAD TURTLES | 8 |
| 2.9 ENVIRONMENTAL EDUCATION ACTIVITIES | 8 |
| 3. RESULTS..... | 9 |
| 3.1 PREPARATIONS..... | 9 |
| 3.2 TRACK SURVEYS | 9 |
| 3.3 TAGGING OF NESTING SEA TURTLES | 10 |
| 3.4 BIOMETRIC DATA COLLECTION..... | 10 |
| 3.5 DETERMINATION OF NEST SURVIVORSHIP AND HATCHING SUCCESS..... | 11 |
| 3.6 PHYSICAL DATA COLLECTION..... | 13 |
| 3.7 COLLECTION OF HUMAN IMPACT DATA | 14 |
| 3.8 DEAD TURTLES | 15 |
| 3.9 ENVIRONMENTAL EDUCATION ACTIVITIES | 16 |
| 4. DISCUSSION..... | 16 |
| 4.1 PREPARATIONS..... | 16 |
| 4.2 TRACK SURVEYS | 16 |
| 4.3 TAGGING OF NESTING SEA TURTLES | 17 |
| 4.4 BIOMETRIC DATA COLLECTION..... | 17 |
| 4.5 DETERMINATION OF NEST SURVIVORSHIP AND HATCHING SUCCESS..... | 17 |
| 4.6 PHYSICAL DATA COLLECTION..... | 17 |
| 4.7 COLLECTION OF HUMAN IMPACT DATA | 18 |
| 4.8 DEAD TURTLES | 18 |
| 4.9 ENVIRONMENTAL EDUCATION ACTIVITIES | 18 |
| 5. REFERENCES..... | 19 |
| 6. RECOMMENDATIONS | 20 |
| 6.1 PREPARATIONS..... | 20 |
| 6.2 TRACK SURVEYS | 20 |
| 6.3 TAGGING OF NESTING SEA TURTLES | 20 |
| 6.4 BIOMETRIC DATA COLLECTION..... | 20 |
| 6.5 DETERMINATION OF NEST SURVIVORSHIP AND HATCHING SUCCESS..... | 20 |
| 6.6 PHYSICAL DATA COLLECTION..... | 20 |

6.7 COLLECTION OF HUMAN IMPACT DATA20
6.8 DEAD TURTLES20
6.9 ENVIRONMENTAL EDUCATION ACTIVITIES20
6.10 OTHER RECOMMENDATIONS21
APPENDIX 1. SEA TURTLE ENCOUNTERS.26
APPENDIX 2: OBSERVATIONS AND ANECDOTAL INFORMATION ON ILLEGAL HARVEST ...28

LIST OF FIGURES

- Figure 1. Seasonal distribution of leatherback nesting activity as determined from track surveys, Tortuguero rivermouth (mile -3/8) - Jalova lagoon (mile 18).
Figure 2a. Leatherback nesting activity from Tortuguero river mouth to the mile 5 marker.
Figure 2b. Leatherback nesting activity from the mile 5 marker to Juana López path.
Figure 2c. Leatherback nesting activity from Juana López path to Jalova lagoon.
Figure 2d. Leatherback nesting activity from Jalova lagoon to Parismina river mouth.
Figure 3. Temperature (°C) at 70 cm depth, open zone.
Figure 4. Ground water level.

LIST OF TABLES

- Table 1. Number of nests and poached nests as determined from total counts by RAs and FC.
Table 2. Mean carapace length and clutch size of leatherbacks.
Table 3. Mean carapace length and clutch size of green turtles.
Table 4a. Precision of carapace measurements.
Table 4b. Precision of carapace measurements for leatherbacks encountered more than once.
Table 5. Fate, hatching and emerging success of marked leatherback nests.
Table 6a. Results of nest excavations.
Table 6b. Incidence of twin and deformed leatherback embryos.
Table 7. Rainfall, November 1999-July 2000.
Table 8. Air temperature, November 1999-July 2000.
Table 9. Mean monthly sand temperatures.
Table 10. Number of Paying Visitors to Tortuguero National Park, 1997-1999.
Table 11. Visitors to the CCC Natural History and Visitors Center, January 1998-August 2000.
Table 12. Room and bed capacity of the hotels and cabinas in the Tortuguero area.
Table 13. Artificial lights visible from the beach, Tortuguero river mouth to Mile 5.
Table 14. Dead turtles.

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1. INTRODUCTION

Caribbean Conservation Corporation (CCC) has organized an annual leatherback (*Dermochelys coriacea*) program in Tortuguero since 1995. In 1998, the monitoring protocol was revised by CCC staff and Scientific Advisory Committee. The 2000 Leatherback Program represents the sixth consecutive nesting season of leatherback monitoring and the third year of implementing the new monitoring protocol. The leatherback program is implemented in order to fulfill CCC's scientific mission in Tortuguero: "*CCC will provide the scientific information necessary to conserve the populations of sea turtles that nest at Tortuguero, Costa Rica, so that they fulfill their ecological roles*".

This report summarizes the methods and results of the 2000 Leatherback Program. The results are discussed and recommendations for future leatherback programs and for research and conservation activities in Tortuguero are given.

2. METHODS

2.1 Preparations

The Research Coordinator (RC), Field Coordinator (FC) and Research Assistants (RAs) arrived in Tortuguero 13 March 2000. During the first week the RAs were given lectures in sea turtle biology and the monitoring protocol was explained in detail by the research and field coordinators. The RAs also received training in nest marking, tagging and data collection during the first week of the program. Most of the nightly training was conducted on the beach section between mile 14 and Jalova lagoon (=mile 18) in order to maximize the number of encounters with leatherbacks.

The positions of the mile markers along the 22 miles of beach (Tortuguero river mouth to Parismina river mouth) were verified using a 300 feet fiberglass measuring tape. Mile markers were posted every 1/8 of a mile between Tortuguero river mouth (mile -3/8) and mile 5. Between mile 5 and Parismina (mile 21 4/8) mile markers were posted every 4/8 of a mile. Three posts were put up at each mile marker position to ensure the mile markers could be seen during dark and cloudy nights.

2.2 Track Surveys

Track surveys between the Tortuguero river mouth and Jalova lagoon were conducted approximately weekly by track surveyor Eddy Rankin. These track surveys started at Tortuguero village at 4:30 AM - 5:00 AM and were completed at Jalova lagoon at 9:30 AM. The section between the Tortuguero river mouth and village were surveyed the same afternoon (3:00 PM - 5:00 PM) by the same track surveyor. Only tracks from the previous night were counted. Notes were also kept on the number of turtles depredated by jaguars.

Track surveys were also conducted between the Tortuguero and Parismina river mouths, every 2-6 days between 20 March-2 May 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 path (close to the mile 15 marker), Juana López path-Jalova lagoon (mile 18) and Jalova

lagoon-Parismina river mouth (mile 21 4/8). All tracks since the previous track survey were counted. The tracks were marked with double lines and plastic debris in order to avoid counting the same track at more than one survey. Notes were also kept on jaguar depredation, turtles turned by poachers and the number of poached fresh nests.

2.3 Tagging of Nesting Females

Nightly tagging patrols were conducted 16 March-2 May 2000 and also 4 May, 8 May and 1 June. Four beach sections were patrolled with varying frequency: Tortuguero river mouth-CCC station, CCC station-mile 5, mile 5-mile 7 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 turtles (*Chelonia mydas*) were tagged axillary, close to the first scale of the front flippers. Tag numbers, evidence of old tag holes or notches, species, date, time and activity when encountered were noted for each encounter. The location of the nest was defined as open (=open beach without any vegetation), border (=vines or other sparse vegetation partly shading the nest) or vegetation (=continuous vegetation behind the beach with complete shading of the nest).

Tags used during the 2000 Leatherback Program include National Band&Tag Company (NBTC) Monel #49 tags no. 79501-79523, 79526-79550, 79551-79568, 79574-79583 and Inconel #681 tags no. 85701-85704, 85726-85727, 85751-85752.

2.4 Biometric Data Collection

If the turtle was encountered before oviposition then the eggs were counted as they were laid into the egg chamber. The eggs were counted by a person wearing a plastic glove to avoid contaminating the nest. Normal sized and yolkless eggs were counted separately.

CCLmin (=from the nuchal notch to the end of the caudal projection NEXT TO the central ridge) was recorded for leatherbacks. For leatherbacks, the caudal projection was classified as complete if no irregularities occurred and incomplete if the caudal projection was irregular or parts of it was missing. CCLmin (=from where the skin meets the carapace by the nuchal notch to the posterior notch between the supracaudals, along the midline) was recorded for green turtles. Measurements were recorded to the closest millimeter. All measurements were repeated three times in order to determine precision. 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 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 leatherbacks encountered previous to covering the eggs, three pieces of flagging tape attached to the vegetation behind the nest were used to mark the nest. The location of the nest could then be determined by triangulation. The third piece of flagging tape ensured that nests could be located 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 and poaching was noted and resulted in termination of monitoring the 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 hatching or 75 days after oviposition, to determine hatching and emerging success. The number of empty eggshells, pipped eggs, live and dead hatchlings, unhatched eggs without embryo, unhatched eggs with embryo, unhatched eggs with fully developed embryo, depredated eggs, yolkless eggs, twins, deformed and albino embryos were determined for each excavated nest. Only egg shells amounting to more than 50% of an egg were recorded as an egg. The distances from the sand surface to the top egg as well as to the bottom of the eggchamber were recorded for each excavated nest.

2.6 Physical Data Collection

Rainfall (to the closest 0.1 mm) and temperature (current, minimum and maximum, to the closest 0.5°C) were recorded daily at 9 AM.

The level of the ground water was measured daily at 9 AM. The water level was determined to the closest millimeter from three PVC pipes (8.5 cm x 160 cm) inserted in the sand in front of the John H. Phipps Biological Field Station, at 5, 10 and 15 m distance from the high tide line (as of 15 March 1998).

Sand temperature was measured using dataloggers located at 30, 50 and 70 cm depth in the open, border and vegetation zones in front of the CCC station.

2.7 Collection of Human Impact Data

The number of visitors to Tortuguero for 1996-1999 were provided by staff at the ACTo office in Guápiles.

The number of visitors to the CCC natural history museum and visitors centre was recorded by Grethel Zamora, Fredy Piedra and Wagner Quíros.

The lodges and cabinas in Tortuguero were visited and the name of the lodge/cabinas, number of beds and number of rooms were recorded.

A light surveys was conducted 3 April 2000. 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 light source was identified. The location of the light source, i.e. Tortuguero (=beach) side or mainland (=lagoon) side was also noted for each light.

2.8 Dead Turtles

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

Students from the Tortuguero school and high school were encouraged to participate in nightly beach patrols.

Other awareness activities were conducted opportunistically when time and special events allowed.

3. RESULTS

3.1 Preparations

No mile marker was posted at mile 18 as it would have been too close to the river opening at Jalova lagoon.

Two of the RAs were mugged by three men, in front of the village (mile 3) during a night patrol on 22 April. One RA was fondled and received cuts from a sharp object and the day-pack with equipment was stolen. Fortunately, the RAs were not seriously affected by the event. The perpetrators were apprehended by rural police shortly after the incident and some of the stolen equipment was returned (the field books were permanently lost). The perpetrators were released the following day. Another day later, two of the three muggers were once again apprehended for breaking into the village church. As it became clear that the perpetrators were not leaving the village (although they are not permanent Tortuguero residents), it was decided to press charges against them. As a result they were sent to prison for a period of no less than two and a half months.

Other incidents relating to security in the Tortuguero area resulted in the early termination of the 2000 Leatherback Program on 3 May in order to review security routines during monitoring activities.

3.2 Track Surveys

Leatherback nesting was recorded from early February to early July (Figure 1) with peak nesting occurring in March. March-May were the months with most intense leatherback nesting.

Table 1. Number of nests and poached nests as determined from total counts by RAs and FC.

| Date | Leatherback Nests | Minimum Poached Leatherback Nests | Min. % Poached | Green Turtle Nests | Minimum Poached Green Turtle Nests | Min. % Poached |
|--------------|-------------------|-----------------------------------|----------------|--------------------|------------------------------------|----------------|
| 20 March | 99 | 29 | 29.3 | 16 | 2 | 12.5 |
| 23 March | 37 | 2 | 5.4 | 8 | 0 | 0 |
| 26 March | 58 | 6 | 10.3 | 9 | 1 | 11.1 |
| 30 March | 67 | 16 | 23.9 | 10 | 3 | 30.0 |
| 3 April | 62 | 13 | 21.0 | 17 | 0 | 0 |
| 5 April | 38 | 10 | 26.3 | 11 | 0 | 0 |
| 8 April | 53 | 8 | 15.1 | 17 | 6 | 35.3 |
| 11 April | 24 | 2 | 8.3 | 2 | 0 | 0 |
| 14 April | 57 | 19 | 33.3 | 10 | 1 | 10.0 |
| 17 April | 72 | 18 | 25.0 | 13 | 6 | 46.2 |
| 23 April | 83 | 19 | 22.9 | 13 | 1 | 7.7 |
| 26 April | 77 | 24 | 31.2 | 6 | 0 | 0 |
| 29 April | 43 | 5 | 11.6 | 7 | 0 | 0 |
| 2 May | 59 | 8 | 13.6 | 7 | 0 | 0 |
| Total | 829 | 179 | 21.6 | 146 | 20 | 13.7 |

All nests laid and poached since previous track surveys were recorded.

A minimum of 21.6 % of leatherback nests and 13.7 % of the green turtle nests were poached (Table 1). The beach section between Jalova lagoon (mile 18) and the Parismina river mouth

(mile 21 4/8) was most affected by poaching (Figure 2a-2d). Least poaching was observed between the mile 5 marker and the Juana López path (Figure 2a-2d).

A comparison between the total track counts carried out by the FC and the RAs and extrapolations from Eddy Rankin’s approximately weekly surveys show clear differences (Figure 2a-2d). Consistently fewer nests were recorded during Eddy Rankin’s surveys, in particular along beach sections surveyed later during the survey (i.e. Juana López path-mile 18 and Tortuguero river mouth-mile 3).

Observations and anecdotal information regarding illegal harvest are summarized in Appendix 2.

3.3 Tagging of Nesting Sea Turtles

A total of 529 teamhours were spent on the beach from 16 March to 1 June. During this time a total of 69 leatherbacks and 7 green turtles were recorded (Appendix 1). This is equal to 0.130 leatherbacks, and 0.013 green turtles encountered per team hour on the beach.

The encountered turtles correspond to 55 individual female leatherbacks and 4 female green turtles. A total of 38 % of the leatherbacks were previously tagged. The previously tagged leatherbacks (n=21) were originally tagged on the beaches of Tortuguero (n=9), Pacuare/Mondonguillo (n=9) (B. Dick pers. comm., C. Fernández pers. comm.), Gandoca/Manzanillo (n=2) (D. Chacón pers. comm.) and San San, Bocas del Toro, Panama (n=1) (D. Chacón pers. comm.). A total of 9 % (n=3) of the newly tagged leatherbacks (n=34) showed evidence of old tag holes or notches when they were encountered for first time during the program.

A total of 82.6 % of the encountered leatherback females laid eggs in the open beach section (n=57), 13.0 % nested in the border zone (n=9) and 4.3 % did not lay eggs (n=3).

3.4 Biometric Data Collection

The mean clutch size and carapace length (CCLmin) for leatherbacks are shown in Table 2. Leatherbacks with incomplete caudal projections are significantly shorter in terms of carapace length in comparison with leatherbacks with complete caudal projection (one tailed t-test $p < 0.05$; one tailed Mann-Whitely test $p < 0.05$). Hence, data from leatherbacks with incomplete and complete caudal projections have been not been pooled.

Table 2. Mean carapace length and clutch size of leatherbacks.

| Caudal projection | Carapace length | | Clutch size | | |
|-------------------|-----------------|----------------------|-------------|---------------|------------------------|
| | N | × CCLmin (cm) ± S.D. | n | × eggs ± S.D. | × yolkless eggs ± S.D. |
| Complete | 48 | 152.7 ± 7.7 | 36 | 70.8 ± 19.2 | 30.2 ± 13.4 |
| Incomplete | 5 | 146.1 ± 5.9 | 4 | 81.5 ± 14.4 | 36.8 ± 6.6 |

Female leatherbacks measured at more than one encounter (n=11) were consistently diagnosed as having complete caudal projections in 100 % (n=11) of cases.

The mean carapace length and clutch size of green turtles was CCLmin=101.5 cm and 104 eggs/nest (Table 3).

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

| Species | Carapace length | | Clutch size | |
|---------|-----------------|----------------------|-------------|---------------|
| | N | × CCLmin (cm) ± S.D. | N | × eggs ± S.D. |
| Green | 4 | 101.5 ± 3.5 | 5 | 104.0 ± 22.0 |

The precision of the CCLmin carapace measurement for leatherbacks was 0.8 cm and for green turtles 1.1 cm (Table 4a).

Table 4a. Precision of carapace measurements.

| Species | n | × precision for CCLmin (cm) ± S.D. |
|-------------|----|------------------------------------|
| Leatherback | 53 | 0.8 ± 0.9 |
| Green | 4 | 1.1 ± 0.7 |

The precision of the carapace measurement for leatherbacks encountered more than once was 2.1 cm for two encounters and 3.1 cm for three encounters (Table 4b).

Table 4b. Precision of carapace measurements for leatherbacks encountered more than once.

| Encounters | n | × precision for CCLmin (cm) ± S.D. | Range (cm) |
|------------|---|------------------------------------|------------|
| 2 | 8 | 2.1 ± 1.0 | 1.1-4.0 |
| 3 | 2 | 3.1 ± 0.6 | 2.6-3.5 |

3.5 Determination of Nest Survivorship and Hatching Success

A total of 30 leatherback nests were marked between 18 March and 26 April 2000. For four marked nests all flagging tapes were lost. As the fate of those nests cannot be determined with certainty, they have been excluded from further analysis. Eight leatherback nests were poached (six within one day of oviposition). Fate, hatching and emerging success of marked nests are shown in Table 5.

Table 5. Fate, hatching and emerging success of marked leatherback nests.

| Fate | N | % of total | Hatching success (%) | Emerging success (%) |
|-----------------------------|-----------|------------|----------------------|----------------------|
| <i>Undisturbed</i> | | | | |
| 1. Undisturbed | 11 | 42.3 | 75.6 | 61.6 |
| <i>Disturbed</i> | | | | |
| 2. Poached | 8 | 30.8 | 0 | 0 |
| 3. Disturbed after hatching | 2 | 7.7 | 53.3 (87.7) * | 37.0 (71.3) * |
| 4. Invaded by roots | 1 | 3.8 | 56.8 (88.6) * | 56.8 (88.6) * |
| 5. Partly washed out | 1 | 3.8 | 83.9 (98.6) * | 83.9 (98.6) * |
| 6. Washed out | 3 | 11.5 | 0 | 0 |
| TOTAL | 26 | 100 | | |
| (7. Flagging lost | 4 | | | |

*Based on $\times=70.4$ eggs/nest, numbers in brackets refer to hatching and emerging success in the unlikely event of all eggs that could not be accounted for hatched and the resulting hatchlings emerged

Table 6a. Results of nest excavations.

| Fate | Empty Shells | Pipped eggs | Live hatchlings | Dead hatchlings | Unhatch. no embryo | Unhatch. Embryo | Unhatch. Full embryo | Depredated | Total eggs | × eggs/nest |
|--------------|--------------------|-------------|-----------------|-----------------|--------------------|-----------------|----------------------|------------|------------|-------------|
| Marked nests | | | | | | | | | | |
| 1 | 585 | 3 | 6 | 102 | 112 | 46 | 6 | 22 | 774 | 70.4 |
| 3 | 75 (135) * | 0 | 22 | 1 | 3 | 2 | 0 | 1 | ? | ? |
| 4 | 40 (62) * | 0 | 0 | 0 | 5 | 2 | 1 | 0 | ? | ? |
| 5 | 59 (69) * | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ? | ? |
| ALL | 759 (851) * | 3 | 28 | 103 | 120 | 50 | 7 | 24 | 774 | 70.4 |

Fate 1=Undisturbed, 3=Disturbed after hatching, 4=Invaded by roots, 5=Partly washed out

*Numbers in brackets refer to number of shells in the unlikely event of all unaccounted for eggs hatched and the resulting hatchlings emerged

It is assumed that all leatherback nests had the same mean number of eggs as the excavated undisturbed nests (×=70.4 eggs/nest) hence the total number of eggs for all marked nests = 1,829 eggs (70.4 x 26). Therefore, the overall hatching success was 41.5-46.5 % for monitored leatherback nests (759-851 empty shells from 1,829 eggs). It is worth noting that if poaching had been completely eliminated the overall hatching success would have been 59.9-67.2 % (i.e.759-851 empty shells from 1,267 eggs from 18 nests).

Emerging success for monitored leatherback nests, using the same assumption as above, was between 34.3 % and 39.4 % (628-720 hatchlings emerged from nests with a total of 1,829 eggs).

The distance from the sand surface to the top egg at the time of excavation for undisturbed nests (n=11) varied between 53-80 cm with a mean of 67 cm. The distance from the sand surface to the bottom of the egg chamber for the same nests varied between 70-109 cm with a mean of 86 cm.

The incubation period for monitored leatherback nests for which emerging was observed (n=12) varied between 60-67 days with a mean of 63 days.

The washed out and partly washed out leatherback nests (for which was noted the distance between the nest and the high tide line at the time of laying) were located less than 11 meters from the high tide line. However, 8 leatherback nests laid within 11 meters of the high tide line hatched undisturbed, including one nest that was located only 2 m from the high tide line at the time of oviposition.

Table 6b. Incidence of twin and deformed leatherback embryos.

| | N | % of eggs |
|------------------|----------|-------------|
| Twins | 2 | 0.26 |
| Deformed embryos | 1 | 0.13 |
| TOTAL | 3 | 0.39 |

Eggs containing twin and deformed embryos accounted for 0.39 % of leatherback eggs from undisturbed nests (Table 6b).

3.6 Physical Data Collection

Rainfall was heaviest in December. March was the month with least rain (Table 7).

Table 7. Rainfall, November 1999-July 2000.

| Month | Total rainfall (mm/month) | × rainfall (mm/24hrs) |
|--------------|--------------------------------------|----------------------------------|
| November | 733.3 | 24.4 |
| December | 1083.5* | 36.1 |
| January | 545.1* | 22.7 |
| February | 363.3** | 12.5 |
| March | 128.6 | 4.1 |
| April | 435.1*** | 14.5 |
| May | 506.3** | 16.3 |
| June | 572.7 | 19.1 |
| July | 549.5** | 17.7 |

*No data for 31 December, 1-7 January

**Data for 48 hours for 22-23 February, 25-26 February, 4-5 May, 24-25 May, 28-29 May, 10-11 July, 14-15 July, 23-24 July, 28-29 July

***Data for 72 hours for 25-27 April

Mean minimum and maximum air temperatures were lowest in December (Table 8). Mean minimum air temperature was highest in May and mean maximum air temperature was highest in April (Table 8).

Table 8. Air temperature, November 1999-July 2000.

| Month | × minimum temp. (°C) * | × maximum temp. (°C) * |
|--------------|-----------------------------------|-----------------------------------|
| November | 23.7 | 29.2 |
| December | 22.3* | 26.1* |
| January | 22.6* | 28.1* |
| February | 22.8* | 30.0* |
| March | 23.5 | 32.6 |
| April | 24.2* | 33.3* |
| May | 24.8* | 32.8* |
| June | 24.5 | 31.0 |
| July | 24.5 | 31.4 |

*No data for 31 December, 1-7 January, 22 February, 25 February, 4 May, 24 May, 28 May, 10 July, 14 July, 23 July, 28 July, 25-26 April

High tides washed out the dataloggers located in the open zone on 15 April. The dataloggers were relocated in the open zone, 5 m closer to the vegetation on 16 April.

Increased shading caused a decrease in the mean monthly sand temperature. Shallow dataloggers (30 cm depth) registered a higher mean temperature in comparison with dataloggers located at 50 cm and 70 cm depth (Table 9).

The sand temperature at 70 cm depth in the open zone (where 25 of 30 marked leatherback nests were deposited) is shown in Figure 3. After heavy rains the ground water reached levels that could be detected in the PVC pipes (Figure 4). Only in late June did ground water levels reach a level that may have interfered with deep leatherback nests (Figure 4).

Table 9. Mean monthly sand temperatures.

| Zone | Field station | | | Field station | | | Field station | | |
|--------------------------------------|-------------------|-------------------|-------------------|---------------------|-------|-------|---------------|------|------|
| | Open | Open | Open | Bord. | Bord. | Bord. | Veg. | Veg. | Veg. |
| <i>Depth (cm)</i> | 30 | 50 | 70 | 30 | 50 | 70 | 30 | 50 | 70 |
| January, × temp (°C) | 26.4 | 26.2 | 26.2 | | 25.1 | 25.1 | 24.5 | 24.3 | 24.4 |
| February, × temp (°C) | 27.8 | 27.6 | 27.5 | | 26.4 | 26.2 | 25.2 | 25.1 | 25.2 |
| March, × temp (°C) | 29.1 | 28.8 | 28.4 | (28.5) ^b | 27.2 | 26.9 | 26.4 | 26.0 | 25.9 |
| <i>Retrieval depth (cm) 12 March</i> | 32 | 55 | 72 | | 50 | 71 | 29 | 47 | 65 |
| <i>Depth (cm) 12 March</i> | 30 | 50 | 70 | 30 | 50 | 70 | 30 | 50 | 70 |
| April, × temp (°C) | 29.9 ^a | 29.9 ^a | 29.9 ^a | 28.3 | 28.2 | 28.1 | 27.6 | 27.3 | 27.2 |
| May, × temp (°C) | 30.2 | 30.1 | 29.9 | 28.1 | 28.0 | 28.0 | 27.4 | 27.2 | 27.2 |
| June, × temp (°C) | 29.0 | 29.0 | 29.1 | 27.3 | 27.4 | 27.5 | 26.7 | 26.6 | 26.8 |
| <i>Retrieval depth (cm) 2 July</i> | 34 | 53 | 75 | 28.5 | 50 | 70 | 30 | 51 | 68.5 |
| <i>Depth (cm) 2 July</i> | 30 | 50 | 70 | 30 | 50 | 70 | 30 | 50 | 70 |
| July, × temp (°C) | 28.7 | 28.5 | 28.5 | 27.1 | 27.2 | 27.1 | 26.6 | 26.5 | 26.6 |
| <i>Retrieval depth (cm) 26 Oct.</i> | 30 | 49.5 | 70 | 32.5 | 52 | 69 | 31 | 49 | 67.5 |

^a High tides washed out the dataloggers located in the open zone on 15 April. The dataloggers were relocated in the open zone (5 m closer to the vegetation line) on 16 April

^b Data from 12 March onwards

3.7 Collection of Human Impact Data

The number of paying visitors coming to Tortuguero National Park has continuously increased since 1997 (Table 10).

Table 10. Number of Paying Visitors to Tortuguero National Park, 1997-1999.

| Year | CR Visitors | Foreign Visitors | Total |
|------|----------------|---------------------|--------|
| 1997 | 2,274 | 10,757 | 13,031 |
| 1998 | 2,685 | 12,313 | 14,998 |
| 1999 | 5,767 | 32,863 | 38,630 |

Information from ACTo.

Table 11. Visitors to the CCC Natural History and Visitors Center, January 1998-August 2000.

| Month | 1998 | | 1999 | | 2000 | |
|--------------|--------------|-----------|--------------|-----------|-------------------|-----------|
| | Total | × Per Day | Total | × Per Day | Total | × Per Day |
| January | 2086 | 67 | 2282 | 74 | 1681 [*] | 67 |
| February | 2024 | 72 | 1967 | 70 | 2427 | 84 |
| March | 1812 | 58 | 2068 | 67 | 2582 | 83 |
| April | 1953 | 65 | 1475 | 49 | 1742 | 58 |
| May | 852 | 27 | 1006 | 32 | 1365 | 44 |
| June | 1432 | 48 | 1093 | 36 | 1437 | 48 |
| July | 2555 | 82 | 2567 | 83 | 2899 | 94 |
| August | 2809 | 91 | 2740 | 88 | 2645 | 80 |
| September | 1565 | 52 | 1640 | 55 | | |
| October | 1006 | 32 | 1574 | 51 | | |
| November | 1437 | 48 | 1984 | 66 | | |
| December | 1398 | 45 | 1163 | 38 | | |
| TOTAL | 20929 | 57 | 21559 | 59 | 16778 | 70 |

^{*} Visitor Center closed 1-6 January 2000 due to illness

The number of visitors to the CCC Natural History and Visitors Center has remained stable over the last two years. May and June are the months with least visitors arriving to Tortuguero (Table 11). During the first eight months of 2000, more tourists have visited the Visitors Center than during the first eight months of 1998 or 1999 (Table 11).

Several of the hotels increased their capacity in terms of rooms and beds in 2000, although one hotel slightly decreased its room capacity due to renovation (Table 12).

Table 12. Room and bed capacity of the hotels and cabinas in the Tortuguero area.

| Hotels/Lodges | Rooms | Beds | Cabinas | Rooms | Beds |
|-----------------------|--------------|-------------|------------------------|--------------|-------------|
| Mawamba | 54 | 137 | Ms Junie | 12 | 30 |
| Pachira | 48 | 103 | Sabina * | 32 | 80 |
| Tortuga | 24 | 55 | Tortuguero | 5 | 15 |
| Caribbean Magic | 16 | 38 | Pancana ** | - | - |
| Ilan-Ilan | 24 | 54 | Aracari | 13 | 25 |
| El Manati | 11 | 17 | Pisulin/Tropical Lodge | 5 | 20 |
| Laguna | 51 | 153 | Joruki | 6 | 12 |
| Jungle | 43 | 129 | Tu y Yo | 3 | 6 |
| Caribe | 9 | 17 | (CCC | 7 | 32) |
| <i>Total – Hotels</i> | <i>280</i> | <i>703</i> | <i>Total – Cabinas</i> | <i>83</i> | <i>220</i> |
| | | | TOTAL | 363 | 923 |

*Data from 1999

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

The mile sections with artificial lighting did not increase between the 1999 Green Turtle Program and the 2000 Leatherback Program (Table 13). However, new buildings in Tortuguero village have increased the number and intensity of lights in the beach section between mile 2 7/8 and mile 3 2/8 (pers. obs.).

Table 13. Artificial lights visible from the beach, Tortuguero river mouth to Mile 5.

| Mile | Light source | Beach side | Lagoon side | April |
|----------------------|------------------------------|-------------------|--------------------|--------------|
| 6/8 | Tortuga Lodge | | X | X |
| 1 1/8 | Ilan-Ilan Lodge | | X | X |
| 1 2/8 | Ilan-Ilan Lodge + House | X | X | X |
| 1 3/8 | Manati + Laguna Lodge | X | X | X |
| 1 4/8 | Laguna Lodge | X | | X |
| 2 3/8 | Mawamba Lodge | X | | X |
| 2 4/8 | CCC | X | | X |
| 2 5/8 | CCC | X | | X |
| 2 6/8 | Houses | X | | X |
| 2 7/8 | Houses + Street Lights | X | | X |
| 3 | Houses + Street Lights | X | | X |
| 3 1/8 | Houses + Street Lights | X | | X |
| 3 2/8 | Houses + Street Lights | X | | X |
| 1/8-6/8, 1 1/8-4 6/8 | Street lights (m2 7/8-3 2/8) | X | | X |

3.8 Dead Turtles

The majority of dead turtles encountered during the 2000 leatherback program were nesting green turtles killed by jaguars (n=5) or poachers (n=2). An exception is the leatherback that was found washed up dead on the beach at the end of May (Table 14).

Table 14. Dead turtles.

| Date | Species | Sex | CCLmin | Comments |
|----------|---------|-----|--------|---|
| 26 March | CM | F | | Remains from poached turtle. |
| 5 April | CM | F | | Killed by jaguar. |
| 11 April | CM | F | | Remains from poached turtle. |
| 23 April | CM | F | 113.0 | Killed by jaguar. |
| 26 April | CM | F | | Tracks indicating that the turtle was killed by a jaguar. Strong smell from the vegetation behind the beach and plenty of vultures. |
| 29 April | CM | F | 102.0 | Killed by jaguar. |
| 13 May | CM | F | | Killed by jaguar. |
| 28 May | DC | F | | Washed up dead, cause of death unknown. Tag#77609, originally tagged at Playa Bluff, Panama (D. Chacón pers. comm.). |

CM=green turtle, DC=leatherback

3.9 Environmental Education Activities

Students from the Tortuguero school and high school participated in tagging patrols during the leatherback program.

4. DISCUSSION

4.1 Preparations

The mile markers were revised and repaired along the entire 22 miles of beach between Tortuguero river mouth and Jalova lagoon. Termites, high tides and heavy wave action were responsible for many of the markers needing renovation. It is suggested that this practise is continued during future programs. Clearly visible mile markers are also of critical importance to the track surveyors.

The incident when two RAs were mugged stressed the importance of reviewing security routines for the nightly tagging work. More rural guards have been posted in Tortuguero village following other security incidents (unrelated to the CCC) in April and May 2000. Tagging teams are now carrying pepper spray and radios to allow rapid communication with park rangers and the CCC station. The mugging incident occurred during Easter week when outside visitors are plentiful in the area. During future leatherback programs it is suggested that the tagging teams should be larger (four persons) during Easter week and/or tagging should be concentrated along the Jalova lagoon-mile 14 beach section where outside visitors are less commonly encountered.

4.2 Track Surveys

The beginning and peak nesting of leatherback nesting occurred relatively early in 2000 (Figure 1, Appendix 2). However, there was still considerable nesting activity in late May after nightly tagging patrols had been terminated. Therefore it is suggested that nightly tagging patrols be continued (perhaps with fewer teams) in the time period between mid-May until the onset of the green turtle program in mid-June.

Comparison between Eddy Rankin's and the FC/RAs track surveys shows that approximately weekly track surveys underestimate the total number of leatherback nests, in particularly along sections of beach patrolled later during the day. Leatherback tracks remain visible for an extended period of time and once the sand has dried it is difficult to differentiate between a

fresh and an old track. For this reason it is suggested that RAs continue regular track surveys during future leatherback programs, counting all nests since the last survey. This will provide a comparison with the approximately weekly surveys and will also be useful when estimating the total number of leatherback nests per season.

Poaching of leatherback and green turtle eggs prevailed throughout the leatherback program (Table 1) although at lower levels than during previous years. Regular park ranger patrols by foot or ATV are suggested in order to minimize poaching during future leatherback seasons. Patrols should begin at the end of February at the latest and continue throughout the leatherback and green turtle nesting seasons.

4.3 Tagging of Nesting Sea Turtles

No within-season tag loss was observed but 9 % of newly tagged turtles showed evidence of prior tagging. It appears that Monel tags perform sufficiently well to fulfill the monitoring objectives for the leatherback program and no change in tags or tagging techniques are suggested.

4.4 Biometric Data Collection

Leatherbacks with incomplete and complete caudal projections were found to be significantly different in carapace length (Table 2). It is therefore suggested that the practice to characterize the caudal projection as complete or incomplete be continued in future leatherback programs.

4.5 Determination of Nest Survivorship and Hatching Success

Hatching success for undisturbed leatherback nests was up to an encouraging 75.6%. There are many potential explanations for this high value. Firstly, the lack of heavy rainfall during the incubation period may have resulted in less compact sand or fewer inundated nests (Figure 4). Secondly, the slightly lower mean number of eggs/nests (Table 5) in comparison to previous years may have resulted in lower oxygen demand per nest that in turn may have resulted in higher hatching success (Table 2). Thirdly, the lower mean sand temperature may have resulted in developing embryos not suffering from excess heat and hence resulting in higher hatching success (Table 9 and Figure 3). Any or all of these factors may have contributed to the high hatching success observed during the 2000 Leatherback Program.

It appears clear that increased park ranger patrols result in fewer nests being poached and consequently the overall hatching success may increase. Increased ranger patrols should be preferred before constructing a hatchery. It is our opinion that natural conditions and nest locations should be the norm for incubating nests.

Due to the unpredictability of beach erosion and accretion there is no such thing as a “doomed” leatherback nest in Tortuguero as shown by the fates of leatherback nests deposited close to the high tide line.

4.6 Physical Data Collection

A total of 83 % of the marked leatherback nests were deposited in the open beach zone where there is no shading from vegetation. The pivotal temperature for leatherbacks nesting in French Guiana has been estimated at 29.5 °C and the transitional range of temperature (TRT)

that produces hatchlings of both sexes has been estimated to be very narrow at 0.12 °C for TRT_{5%} (Girondot 1999). There are no significant differences in mtDNA haplotype frequencies between leatherbacks nesting in French Guiana and Tortuguero (Dutton et al. 1999). If the pivotal temperature and TRT are the same for French Guiana and Tortuguero leatherbacks, then a majority of hatchlings produced in Tortuguero in 2000 must have been male (Figure 4).

Research aimed at determining the pivotal temperature and TRT_{5%} for leatherbacks in Tortuguero should be strongly encouraged.

4.7 Collection of Human Impact Data

The number of visitors paying the entrance fee to Tortuguero National Park is continuously increasing (Table 10). There are still tourists visiting the area that do not pay the park fee (pers. obs.). However, ACTo has recently (August 2000) increased spot checks on tour boats in the park and such a control is likely to increase the compliance with park regulations and should be encouraged.

The hotels and cabins in the Tortuguero area are increasing their capacity (Table 12). An encouraging sign is the increased capacity of local cabins as this may contribute to an increased percentage of income from tourism staying with the Tortuguero community.

4.8 Dead Turtles

The dead leatherback washed up in May and carrying tags from Playa Bluff, Bocas del Toro province, Panama (Table 14) illustrates the importance of regional coordination of tag information. Efforts are underway to improve coordination and to compare results for leatherback tagging projects along the Caribbean coast of Costa Rica and Panama.

Counts of dead turtles are best carried out in association with track surveys. The location of each dead turtle should be noted to avoid double counting carcasses.

4.9 Environmental Education Activities

The cooperation with the Tortuguero school and high school should be continued in future programs as it provides a good channel for exchange between research assistants and members of the Tortuguero community.

It is suggested that a thorough tour guide training course be carried out in 2001 to give more local people an opportunity to benefit from sea turtle tourism and also to inform experienced guides about new research findings and recent conservation initiatives.

5. REFERENCES

- Dutton, P.H., B.W. Bowen, D.W. Owens, A. Barragan, and S.K. Davis. 1999. Global phylogeny of the leatherback turtle (*Dermochelys coriacea*). *J. Zool. Lond.* **247**: 397-409.
- Girondot, M. 1999. Statistical description of temperature-dependent sex determination using maximum likelihood. *Evol. Eco. Res.* **1**:479-486.

6. RECOMMENDATIONS

6.1 Preparations

- ⇒ Mile markers along the 22 miles of beach between the Tortuguero and Parismina river mouths should be renovated at the beginning of the leatherback program.
- ⇒ Security is a major concern. Tagging teams should always be equipped with pepper spray and radios. During Easter week tagging teams should consist of at least four persons.

6.2 Track Surveys

- ⇒ Leatherback monitoring should be conducted until the onset of the green turtle program.
- ⇒ RAs should conduct track surveys every three days (total counts) as part of the leatherback program.

6.3 Tagging of Nesting Sea Turtles

- ⇒ Leatherbacks should be tagged with monel tags.

6.4 Biometric Data Collection

- ⇒ The practice of classifying the caudal projection of leatherbacks as complete or incomplete should be continued.

6.5 Determination of Nest Survivorship and Hatching Success

- ⇒ Increased park ranger patrols are suggested (rather than hatcheries) in order to increase hatching and emerging success.
- ⇒ Leatherback nests should not be relocated.

6.6 Physical Data Collection

- ⇒ Research aimed at determining the pivotal temperature and the transitional range of temperatures that produce both sexes for leatherbacks in Tortuguero is strongly encouraged.

6.7 Collection of Human Impact Data

- ⇒ Spot checks of tour boats within the national park should be continued as a means of ensuring compliance with national park regulations.

6.8 Dead Turtles

- ⇒ Increased coordination of tag information from leatherback programs along the Caribbean coast of Costa Rica and Panama should be encouraged.

6.9 Environmental Education Activities

- ⇒ Continue cooperation with the Tortuguero school and high school.
- ⇒ CCC should increase training activities for local guides and update guides with regards to new research findings and recent conservation initiatives.

6.10 Other Recommendations

⇒ Park ranger patrols should begin in late February and continue throughout the leatherback and the green turtle nesting seasons.

Figure 1. Seasonal distribution of leatherback nesting activity as determined from track surveys, Tortuguero rivermouth (mile -3.8) - Jalova lagoon (mile 18).

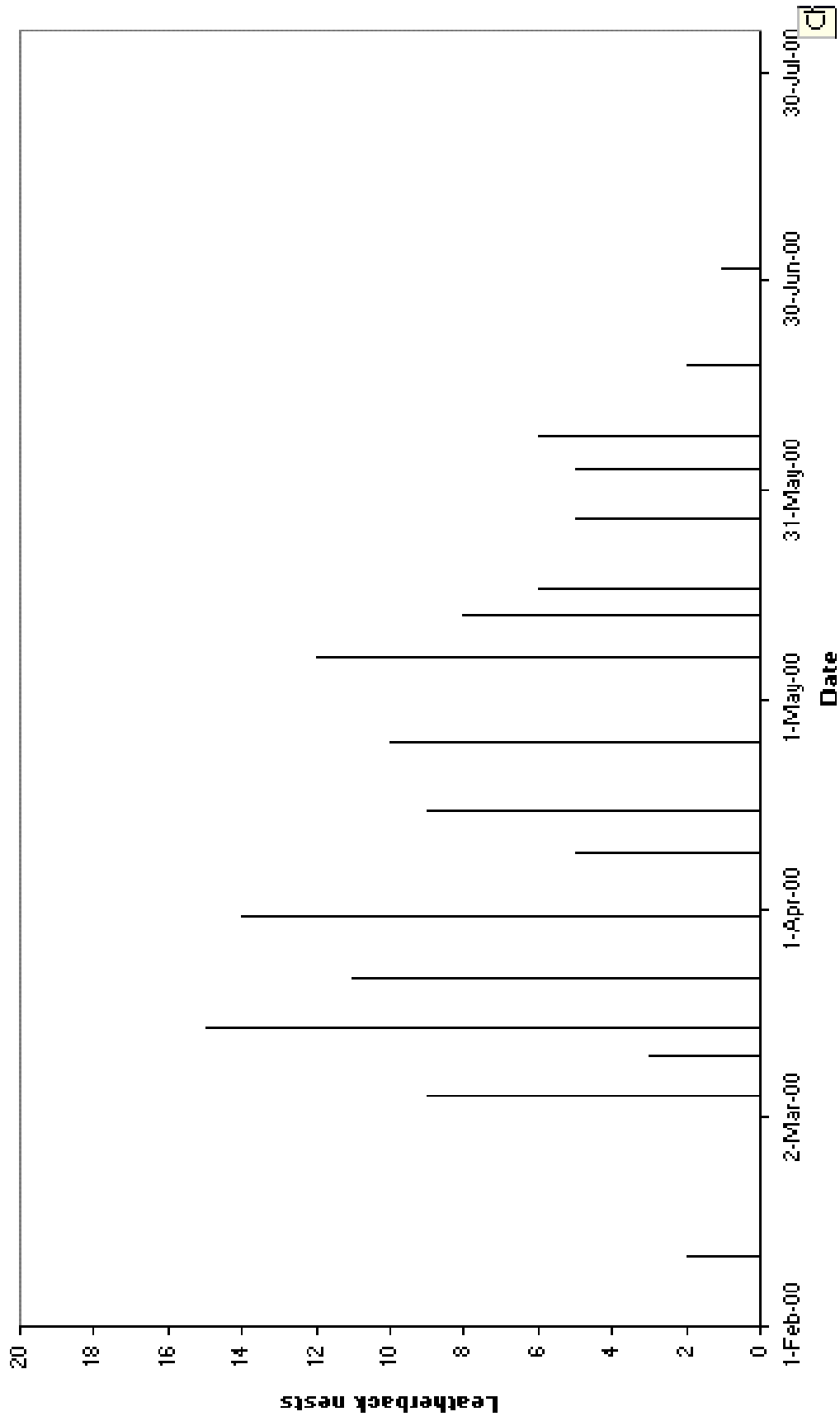


Figure 2a. Leatherback nesting activity from Tortuguero river mouth to the mile 5 marker.

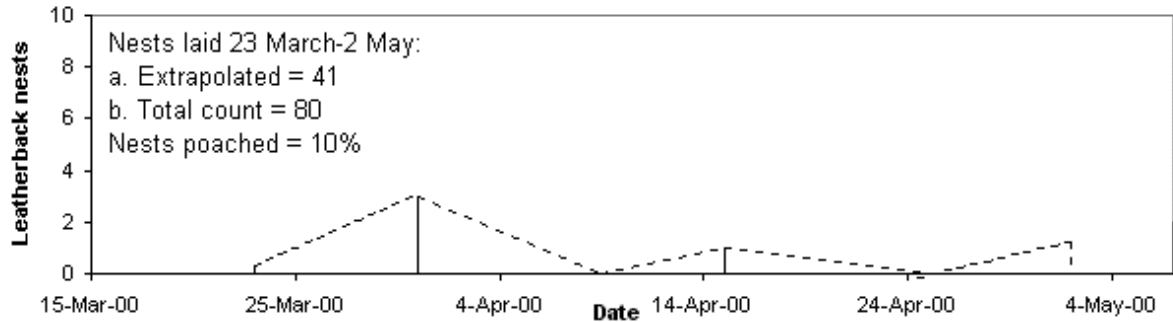


Figure 2b. Leatherback nesting activity from the mile 5 marker to Juana López path.

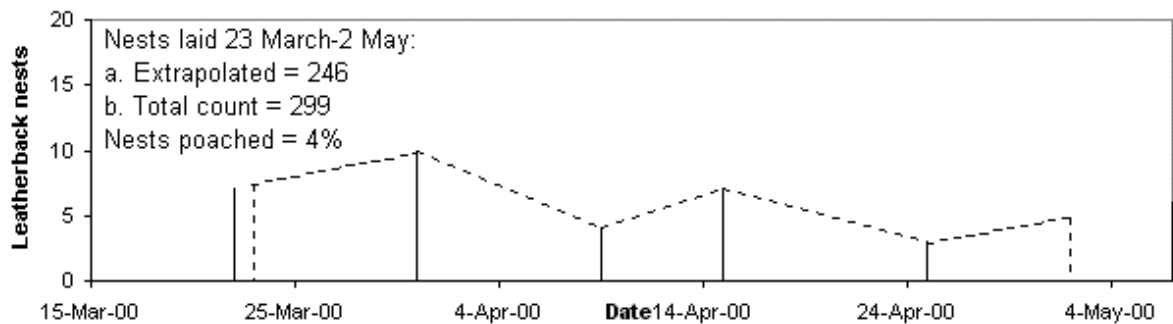


Figure 2c. Leatherback nesting activity from Juana López path to Jalova lagoon.

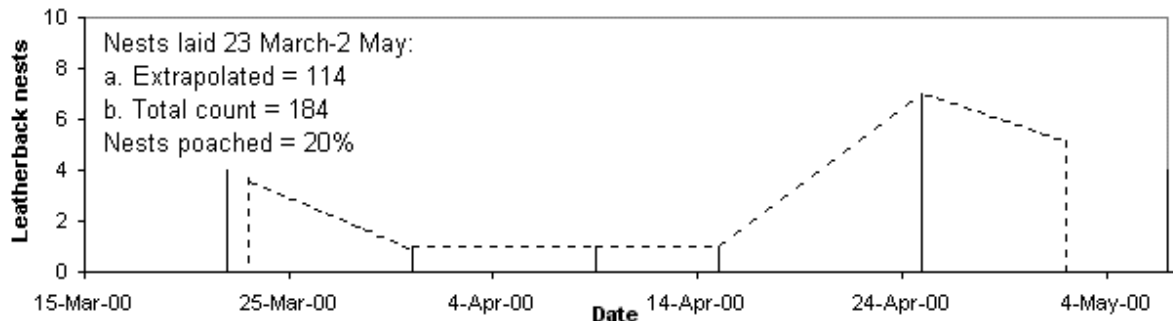


Figure 2d. Leatherback nesting activity from Jalova lagoon to Parismina river mouth.

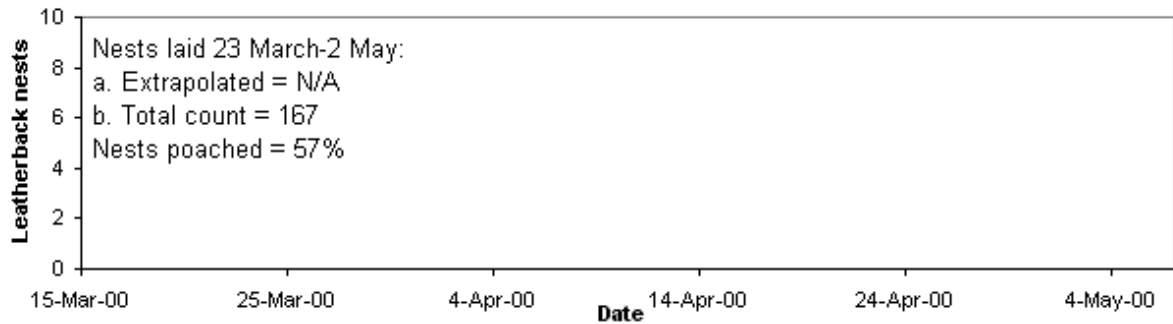


Figure 3. Temperature (°C) at 70 cm depth, open zone.

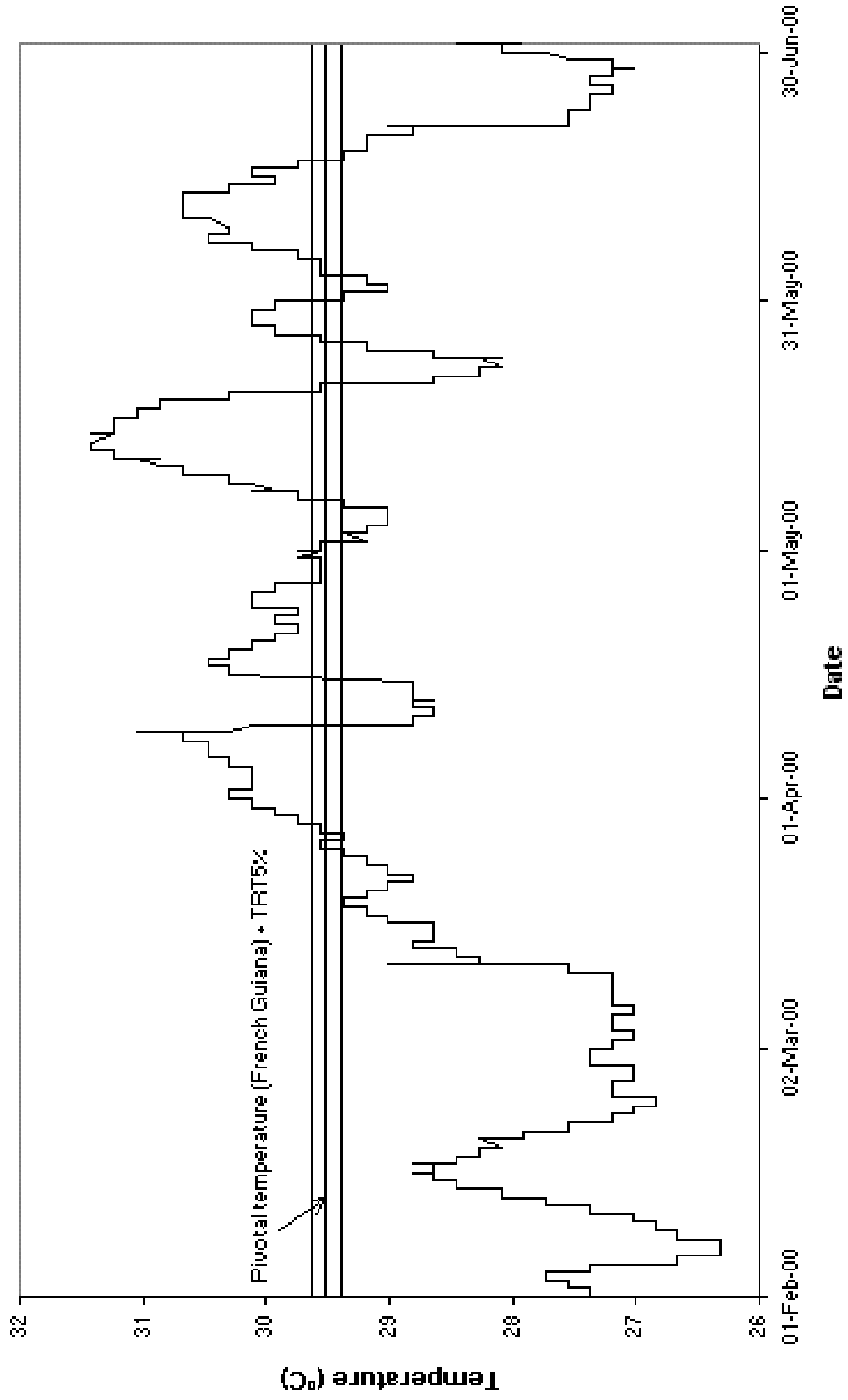
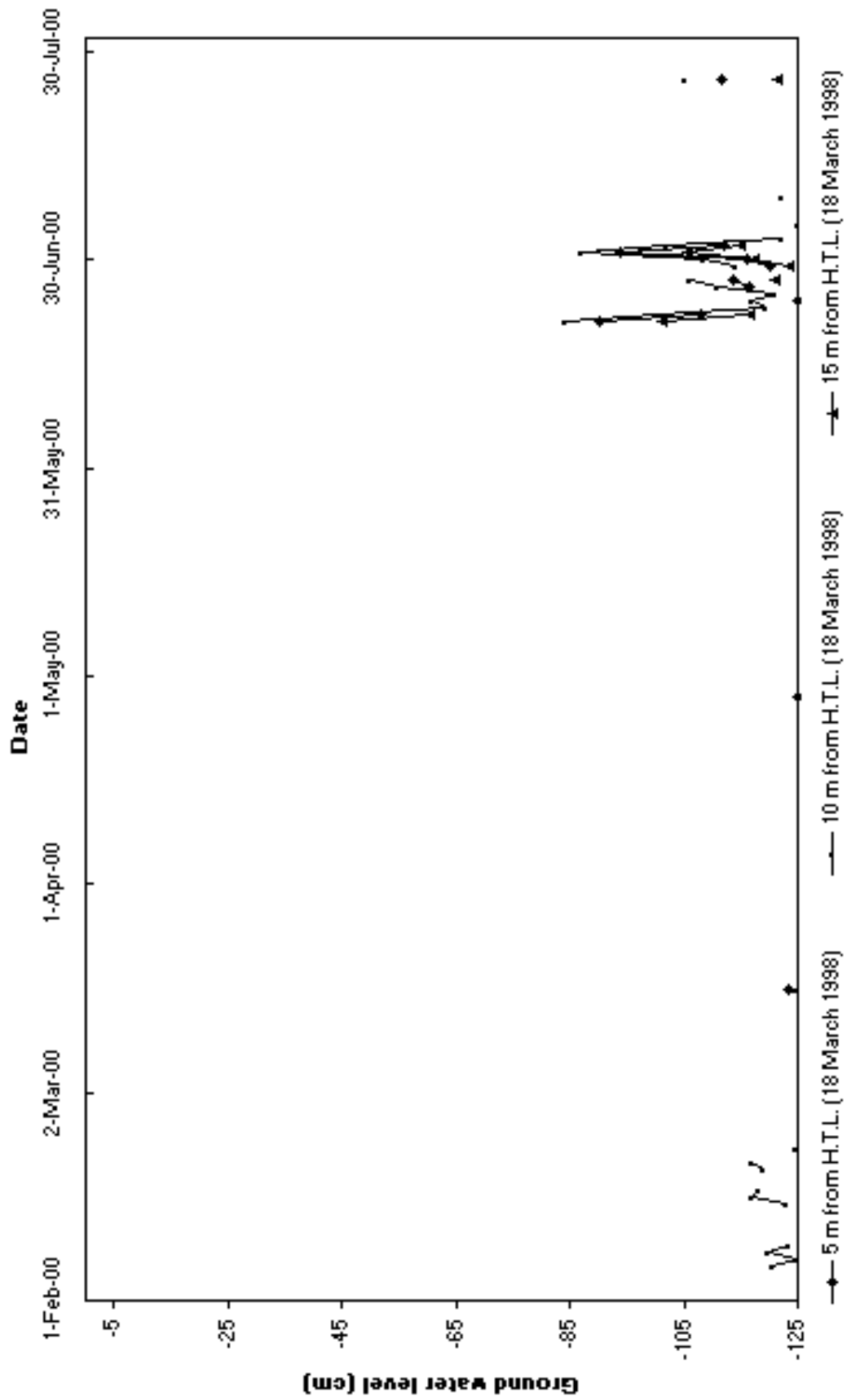


Figure 4. Ground water level.



APPENDIX 1. SEA TURTLE ENCOUNTERS.

| Date | Leatherbacks | | | | Greens | | |
|-----------|----------------------|---------------------------|-----------|-------|----------------------|-----------|-------|
| | Newly tagged turtles | Previously tagged turtles | Renesters | Total | Newly tagged turtles | Renesters | Total |
| 16-Mar-00 | 1 | 2 | | 3 | | | 0 |
| 17-Mar-00 | 3 | | | 6 | 1 | | 1 |
| 18-Mar-00 | 1 | | | 7 | | | 1 |
| 19-Mar-00 | 2 | | | 9 | | | 1 |
| 20-Mar-00 | 1 | | 1 | 11 | 1 | | 2 |
| 21-Mar-00 | | | | 11 | | | 2 |
| 22-Mar-00 | 1 | | | 12 | | | 2 |
| 23-Mar-00 | 2 | | | 14 | | | 2 |
| 24-Mar-00 | | | | 14 | | | 2 |
| 25-Mar-00 | | | | 14 | | | 2 |
| 26-Mar-00 | | | | 14 | | | 2 |
| 27-Mar-00 | 1 | | | 15 | | | 2 |
| 28-Mar-00 | 1 | 1 | 2 | 19 | | | 2 |
| 29-Mar-00 | 2 | 1 | | 22 | | | 2 |
| 30-Mar-00 | 1 | 2 | | 25 | | 1 | 3 |
| 31-Mar-00 | 1 | 1 | | 27 | | | 3 |
| 01-Apr-00 | | | | 27 | | | 3 |
| 02-Apr-00 | 1 | 1 | | 29 | 1 | | 4 |
| 03-Apr-00 | | | | 29 | | | 4 |
| 04-Apr-00 | | | | 29 | | | 4 |
| 05-Apr-00 | 1 | | 1 | 31 | | | 4 |
| 06-Apr-00 | 1 | | | 32 | | | 4 |
| 07-Apr-00 | | | | 32 | | | 4 |
| 08-Apr-00 | | 1 | | 33 | | | 4 |
| 09-Apr-00 | | | | 33 | | | 4 |
| 10-Apr-00 | 1 | | 1 | 35 | | | 4 |
| 11-Apr-00 | 2 | 2 | | 39 | | | 4 |
| 12-Apr-00 | | 1 | 2 | 42 | | | 4 |
| 13-Apr-00 | 2 | | | 44 | | | 4 |
| 14-Apr-00 | | 1 | | 45 | | 1 | 5 |
| 15-Apr-00 | | | 1 | 46 | | | 5 |
| 16-Apr-00 | | | | 46 | | | 5 |
| 17-Apr-00 | 1 | | 1 | 48 | | | 5 |
| 18-Apr-00 | | 1 | | 49 | | | 5 |
| 19-Apr-00 | 1 | 1 | 1 | 52 | | | 5 |
| 20-Apr-00 | 2 | | 1 | 55 | | | 5 |
| 21-Apr-00 | 1 | | | 56 | 1 | | 6 |
| 22-Apr-00 | | | | 56 | | | 6 |
| 23-Apr-00 | | | | 56 | | | 6 |
| 24-Apr-00 | 2 | | | 58 | | | 6 |
| 25-Apr-00 | | | | 58 | | | 6 |
| 26-Apr-00 | 1 | 2 | 1 | 62 | | | 6 |
| 27-Apr-00 | | | | 62 | | | 6 |
| 28-Apr-00 | | | | 62 | | | 6 |
| 29-Apr-00 | | 1 | | 63 | | | 6 |
| 30-Apr-00 | | | | 63 | | | 6 |
| 01-May-00 | | | | 63 | | | 6 |

| | | | | | | | |
|--------------|-----------|-----------|-----------|-----------|----------|----------|----------|
| 02-May-00 | | 1 | | 64 | | 1 | 7 |
| 03-May-00 | | | | 64 | | | 7 |
| 04-May-00 | | 1 | 2 | 67 | | | 7 |
| 05-May-00 | | | | 67 | | | 7 |
| 06-May-00 | | | | 67 | | | 7 |
| 07-May-00 | | | | 67 | | | 7 |
| 08-May-00 | 1 | | | 68 | | | 7 |
| 09-May-00 | | | | 68 | | | 7 |
| 10-May-00 | | | | 68 | | | 7 |
| 11-May-00 | | | | 68 | | | 7 |
| 12-May-00 | | | | 68 | | | 7 |
| 13-May-00 | | | | 68 | | | 7 |
| 14-May-00 | | | | 68 | | | 7 |
| 15-May-00 | | | | 68 | | | 7 |
| 16-May-00 | | | | 68 | | | 7 |
| 17-May-00 | | | | 68 | | | 7 |
| 18-May-00 | | | | 68 | | | 7 |
| 19-May-00 | | | | 68 | | | 7 |
| 20-May-00 | | | | 68 | | | 7 |
| 21-May-00 | | | | 68 | | | 7 |
| 22-May-00 | | | | 68 | | | 7 |
| 23-May-00 | | | | 68 | | | 7 |
| 24-May-00 | | | | 68 | | | 7 |
| 25-May-00 | | | | 68 | | | 7 |
| 26-May-00 | | | | 68 | | | 7 |
| 27-May-00 | | | | 68 | | | 7 |
| 28-May-00 | | | | 68 | | | 7 |
| 29-May-00 | | | | 68 | | | 7 |
| 30-May-00 | | | | 68 | | | 7 |
| 31-May-00 | | | | 68 | | | 7 |
| 01-Jun-00 | | 1 | | 69 | | | 7 |
| Total | 34 | 21 | 14 | 69 | 4 | 3 | 7 |

APPENDIX 2: Observations and Anecdotal Information on Illegal Harvest

The majority of leatherback eggs poached in Tortuguero National Park are taken by outsiders from the Puerto Limón area. In 2000, poachers arrived infrequently to the nesting beach. Leatherback nests laid between Jalova lagoon and the Parismina river mouth are predominantly collected by poachers from Parismina (pers. obs.).

Puerto Limón is the major market for Tortuguero leatherback eggs but eggs are also sold elsewhere in Limón province. Some poachers sell the eggs to an intermediary who prepares the eggs and organize the sale of them. Eggs are mainly sold in the market and by persons walking around the bars offering eggs for sale. The price of a cooked leatherback egg in Limón (yolkless eggs are not consumed) varies between 100-150 colones/egg.