



REPORT
ON THE 2003 LEATHERBACK PROGRAM
AT TORTUGUERO, COSTA RICA



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EXECUTIVE SUMMARY

Monitoring and Research Activities Conducted

1. A total of 25 track surveys were conducted between the Tortuguero rivermouth and Jalova lagoon between February and July 2003.
2. Peak nesting was recorded on 22 May when a total of 16 fresh leatherback nests were recorded.
3. The Field Coordinator (FC) and the Research Assistants (RAs) conducted a total of 30 additional track surveys between the Tortuguero and Parismina rivermouths between 17 March and 12 June 2003. Poaching was estimated to a minimum of 21.5 % of leatherback nests and 15.6 % of green turtle nests.
4. Comparison between the extrapolated leatherback nest estimate based on the track surveyor's results and the results from surveys conducted by the FC and RAs between Tortuguero rivermouth and Jalova lagoon between 18 March-12 June showed clear difference with estimates of 806 leatherback nests and 680 leatherback nests, respectively.
5. A total of 52 leatherback turtles were newly tagged, 47 leatherback turtles from previous years and/or other nesting beaches, and 36 renesting leatherback turtles were encountered during 1,003 hours of night patrols between 6 March and 11 June 2003. In addition, four green turtles and six hawksbill turtles were newly tagged and one green turtle and one hawksbill turtle with tags from previous years were encountered during the night patrols.
6. A total of 47 % of female leatherback turtles were previously tagged. Previously tagged leatherback turtles (n=47) were originally tagged on the beaches of Tortuguero (n=13), Pacuare/Mondonguillo (n=26), Lagunas de Urpiano/Matina (n=2), Gandoca/Manzanillo (n=3), Playa Negra (n=1) and Playa Bluff/Playa Larga, Panama (n=2).
7. A total of 15 % of newly tagged leatherback turtles showed evidence of old tag holes or notches when they were encountered for the first time.
8. A total of 85.9 % of encountered leatherback turtles laid eggs in the open beach zone (n=116), 4.4 % nested in the border zone (n=6) and 9.6 % did not lay eggs (n=13).
9. Mean carapace length (CCLmin) for leatherback turtles with complete caudal projection (n=93) was 153.5 cm and for turtles with incomplete caudal projection (n=5) was 146.7 cm. Mean clutch size was 78 normal and 30 yolkless eggs for females with complete caudal projection (n=62) and 75 normal and 28 yolkless eggs for females with incomplete caudal projection (n=3).
10. Mean carapace length (CCLmin) for green turtles (n=5) was 104.9 cm and for hawksbill turtles (n=7) was 90.1 cm.
11. Precision of the CCLmin measurement during the same encounter was 0.3 cm for leatherback (n=128) and hawksbill turtles (n=7) and 0.1 cm for green turtles (n=5).
12. Precision of the CCLmin measurement for leatherback turtles measured during more than one encounter was 1.6 cm for two encounters (n=17), 1.5 cm for three encounters (n=7) and 2.1 cm for four encounters (n=1).
13. A total of 50 leatherback nests were marked for monitoring. The fate of three of the nests could not be determined and they were excluded from further analysis.
14. Overall hatching success for monitored leatherback nests was 18.4 % and overall emerging success was 11.6-17.4 %.

15. Mean distance between the sand surface and the top egg at the time of excavation for undisturbed nests (n=1) was 61 cm and the mean distance between the sand surface and the bottom of the eggchamber was 80 cm.
16. The incubation period for leatherback nests for which emergence was observed (n=2) varied between 60-63 days with a mean of 62 days.
17. Eggs containing twin embryos accounted for 0.06 % of eggs in leatherback nests that were undisturbed, washed over or depredated by dogs.
18. Rainfall was heaviest in May (987.7 mm) and March was the month with least rain (86.2 mm).
19. Mean minimum air temperature was lowest in January (23.7°C) and highest in March (25.9°C), mean maximum air temperature was lowest in January (28.2°C) and highest in March (32.8°C).
20. Mean monthly sand temperatures were lowest in January and February and highest in April.
21. A total of 50,339 visitors paid to enter Tortuguero National Park in 2002.
22. The visitation at the CCC Natural History and Visitors' Center increased in 2003 and August 2003 was the month with the highest visitation since the Center opened.
23. Hotels and cabinas increased their capacity in 2003 to a total of 468 rooms and 1,081 beds.
24. The number of artificial lights in Tortuguero village continues to increase but the Costa Rican Electricity Institute (ICE) shaded village street lights in July 2003.
25. All dead green (n=4) and hawksbill (n=1) turtles encountered during the program had been killed by jaguars or taken by poachers.
26. Environmental education activities (n=5) concerning sea turtle biology, conservation issues and impacts of pollution were conducted with 4th, 5th and 6th grade students from the Tortuguero School.

Conclusions

1. Radio communication on the beach close to Jalova lagoon will not improve until there is a taller antenna at the park ranger station at Jalova or a more powerful repeater is installed.
2. The difference in total leatherback nests estimates for the two methods could in part be explained by some tracks being washed out before the FC and the RAs had a chance to count them.
3. Night patrols by RAs resulted in lower poaching along the patrolled beach sections.
4. Poaching is lower inside Tortuguero National Park than on adjacent beaches outside the National Park so park ranger patrols are having some effect.
5. In spite of increased income from tourism, the investment in leatherback protection is decreasing in Tortuguero National Park.
6. Low site fidelity of nesting leatherback turtles means that increased cooperation between turtle conservation projects along the Caribbean coast of Costa Rica and Panama as well as Panamanian and Costa Rican government institutions is needed to achieve successful leatherback conservation.
7. Poaching and possibly high embryonic mortality resulting from high sand temperature contributed to low hatching success of leatherback nests in Tortuguero in 2003.
8. Tourism in Tortuguero is increasing and at least some of the profits are invested to increase the capacity of hotels and cabins in the area.
9. Jaguars and poachers prefer to take green and hawksbill turtles but ignore nesting leatherback turtles.
10. Despite initial problems establishing a regular schedule with the Tortuguero School, the environmental education activities were successful.

Recommendations

1. The new protective bags were successful in conserving the handheld radios and should be used in future programs.
2. Increased institutional presence by the Ministry of the Environment and Energy or other government institutions aimed at reducing poaching would be highly desirable during future leatherback nesting seasons.
3. Night patrols should be conducted from mid-March through mid-June during future leatherback nesting seasons.
4. Classification of the leatherback caudal projections as complete or incomplete should be continued.
5. A study to determine the presence of pesticides or other agricultural chemicals in the beach would be desirable.
6. The old dataloggers should be phased out with new TidBit dataloggers in protective casings as the old loggers fail.
7. The Costa Rican Electricity Institute (ICE) should be encouraged to continue to shade streetlights in Tortuguero village in order to reduce hatchling disorientation.
8. It would be desirable to include at least one person from the leatherback conservation community project in Parismina in the RA team during future leatherback programs.
9. In future years, a more structured schedule of environmental education activities at the Tortuguero school would be advisable. It would be beneficial to expand the program to include both younger and older students, if possible.

1. INTRODUCTION

Sea turtle research and conservation was initiated in Tortuguero in 1955 (Carr *et al.* 1978). Caribbean Conservation Corporation (CCC) began an annual leatherback (*Dermochelys coriacea*) program in Tortuguero in 1995 (Campbell *et al.* 1996). 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*". CCC staff and Scientific Advisory Committee revised the monitoring protocol in preparation for the 1998 Leatherback Program. The 2003 Leatherback Program represents the ninth consecutive leatherback program and the sixth year of implementing the new monitoring protocol.

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

2. METHODS

2.1 Preparations

The Field Coordinator arrived in Tortuguero the first week of March to prepare for the 2003 Leatherback Program. The Research Assistants (RAs) arrived in Tortuguero on 10 March 2003. During the first week of the 2003 Leatherback Program, RAs received training in sea turtle biology and conservation, and the Tortuguero monitoring protocol was explained in detail. RAs also received practical training in sea turtle tagging, nest marking and other data collection from the Field Coordinator (FC) and the Scientific Director. In addition to practise night patrols along beach sections close to the field station, training was also conducted between Jalova lagoon and mile 14 on 14-15 March 2003.

The positions of mile markers along the 22 miles of beach between the Tortuguero and Parismina river mouths were verified using a 300 feet 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 rivermouth (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 were conducted approximately weekly by CCC track surveyor Enrique Vargas. Track surveys started near Tortuguero rivermouth at 5:00 AM and were completed at Jalova lagoon at approximately 10:30 AM. Only 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 by integrating between nest counts using the trapezoidal rules (Whittaker & Robinson 1967).

Track surveys were also conducted between the Tortuguero and Parismina river mouths, every 3 days from 17 March to 12 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 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 survey were recorded in order to get a total count of all nests. Nests were marked by a line through the track and by putting two sticks in a cross formation over the nest. Notes were also kept on jaguar predation, turtles turned by poachers and the number of poached fresh nests.

2.3 Tagging of Nesting Sea Turtles

Nightly tagging patrols were conducted 6 March-11 June 2003 (with the exception of 7-9, 12-13, 31 March, 12, 15, 24, 27, 30 May, and 2, 8 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. 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 2003 Leatherback Program were National Band&Tag Company (NBTC) Monel #49 tags no. VA2001-93, VA2801-18 and VA2851-73, and Inconel #681 tags no.95001-06, 95026-35, and 95051-65.

2.4 Biometric Data Collection

If the turtle was encountered before oviposition, 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 contamination of 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 were 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 and hawksbill 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 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 and poaching were 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 (if no hatchling tracks were observed), 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 air 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 1 July 2002).

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 National Park Administrator Eduardo Chamorro provided data on the number of visitors to Tortuguero National Park 2000-2002.

Alexander Castillo, Sergio Campos and Teresa Alfaro recorded the number of visitors at the CCC Natural History and Visitors Center.

Light surveys were conducted on 2 April and 2 May and 1 June 2003. 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

Following consultation with the Director of the Tortuguero school in March, a weekly program of activities incorporating sea turtle biology and conservation was devised for

students in 4th, 5th and 6th grades. Groups of RA's attended the school one morning or afternoon a week, for between 1 - 3 hours, depending on the activity. Students were also invited to accompany RA's on night-time beach patrols to learn more about leatherbacks and the research methods of the CCC.

3. RESULTS

3.1 Preparations

The mile markers lasted well during the 2003 Leatherback Program and there was no need to repaint or replace markers until the beginning of the 2003 Green Turtle Program.

3.2 Track Surveys

Leatherback nesting was recorded during track surveys conducted from mid-February to late June (Figure 1). However, observations of nesting females during night patrols indicate that leatherback nesting continued into July. Peak nesting with 16 leatherback nests in one night was recorded during the 22 May track survey (Figure 1).

The poaching of leatherback and green turtle nests increased in 2003 and represented at least 21.5 % for leatherback nests and 15.6 % for green turtle nests (Table 1). Poaching of leatherback nests was higher outside of Tortuguero National Park (Figure 2d) than on beaches in the National Park (Figure 2a-c).

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

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
17 March	26	0	0.0	5	0	0.0
20 March	12	0	0.0	1	0	0.0
23 March	15	0	0.0	4	0	0.0
26 March	8	0	0.0	2	0	0.0
29 March	18	0	0.0	0	0	0.0
1 April*	22	0	0.0	0	0	0.0
4 April	7	0	0.0	0	0	0.0
7 April	29	0	0.0	0	0	0.0
10 April	20	1	5.0	3	0	0.0
13 April	20	3	15.0	1	1	100.0
16 April	29	11	37.9	3	0	0.0
19 April	18	1	5.6	2	0	0.0
22 April	33	14	42.4	2	0	0.0
25 April	41	22	53.7	2	1	50.0
28 April	46	8	17.4	3	0	0.0
1 May	40	13	32.5	2	2	100.0
4 May*	51	6	11.8	2	0	0.0
7 May*	55	16	29.1	4	0	0.0
10 May*	40	8	20.0	5	0	0.0
13 May*	20	1	5.0	3	0	0.0
16 May*	26	9	34.6	3	1	33.3
19 May*	47	16	34.0	4	2	50.0
22 May	39	3	7.7	9	1	11.1
25 May	22	10	45.5	11	3	27.3
28 May	22	11	50.0	5	4	80.0
31 May	21	3	14.3	10	1	10.0
3 June	18	9	50.0	12	7	58.3
6 June	18	3	16.7	17	1	5.9
9 June	16	0	0.0	24	0	0.0
12 June	11	2	18.2	15	0	0.0
Total	790	170	21.5	154	24	15.6

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

* Heavy rain and high tides may have affected track count.

3.3 Tagging of Nesting Sea Turtles

In total, 1,003 team of hours of night patrols were conducted between 6 March and 11 June 2003.

During these patrols a total of 135 leatherback encounters, 5 green and 7 hawksbill turtle encounters were recorded (Appendix 1). This is equal to a mean of 0.135 leatherback, 0.005 green and 0.007 hawksbill turtles encountered per patrol hour.

The sea turtles encountered correspond to 99 individual female leatherback turtles, five female green turtles and seven female hawksbill turtles. A total of 47 % of female leatherback turtles were tagged previously to the first encounter in Tortuguero during the 2003 nesting season (Appendix 1).

Previously tagged leatherback turtles (n=47) were originally tagged on the beaches of Tortuguero (n=13), Pacuare/Mondonguillo (n=26), Lagunas de Urpiano/Matina (n=2), Gandoca/Manzanillo (n=3), Playa Negra (n=1) and Playa Bluff/Playa Larga, Panama (n=2).

Evidence of holes or notches were found on 15 % (n=8) of newly tagged leatherback turtles (n=52) when they were encountered for the first time during the 2003 Leatherback Program.

A total of 85.9 % of encountered leatherback turtles nested in the open beach zone (n=116), 4.4 % nested in the border zone (n=6) and 9.6 % did not lay eggs (n=13).

3.4 Biometric Data Collection

CCLmin for leatherback turtles with complete and incomplete caudal projections were compared and found to be significantly different (Mann-Whitney test $CM=107.0$, $p>0.05$, $n=98$). Hence, data for the two categories were not pooled but instead kept as two separate samples of 93 female leatherback turtles with complete caudal projection (CCLmin= 153.5 cm) and five female leatherback turtles with incomplete caudal projection (CCLmin= 146.7 cm) (Table 2).

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

Caudal projection	Carapace length		Clutch size		
	n	\bar{x} CCLmin (cm) \pm S.D.	n	\bar{x} eggs \pm S.D.	\bar{x} yolkless eggs \pm S.D.
Complete	93	153.5 \pm 6.7	62	78 \pm 15	30 \pm 11
Incomplete	5	146.7 \pm 6.0	3	75 \pm 2	28 \pm 8

Leatherback turtles sighted more than once (n=27) had their caudal projection consistently identified as complete (n=24) in 88.9 % of cases, 3.7 % was consistently identified as incomplete (n=1) and 7.4 % of cases were varyingly identified as complete and incomplete (n=2).

Mean carapace length (CCLmin) for green turtles encountered during the 2003 Leatherback Program (n=5) was 104.9 cm and the one clutch for which eggs were counts contained 103 eggs (Table 3). The seven hawksbill turtles that were measured had a mean carapace length (CCLmin) of 90.1 cm and the three hawksbill clutches that were counted had a mean of 176 eggs (Table 3).

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

Species	Carapace length		Clutch size	
	n	\bar{x} CCLmin (cm) \pm S.D.	n	\bar{x} eggs \pm S.D.
Green	5	104.9 \pm 4.6	1	103
Hawksbills	7	90.1 \pm 3.3	3	176 \pm 7

The precision of the CCLmin measurement during the same encounter was higher for green turtles (a mean of 0.1 cm) than for leatherback and hawksbill turtles (means of 0.3 cm) (Table 4a).

The precision of the CCLmin carapace measurements for leatherback turtles measured during more than one encounter was 1.6 cm for two encounters, 1.5 cm for three encounters and 2.1 cm for four encounters (Table 4b).

Table 4a. Precision of carapace measurements.

Species	n	\bar{x} precision for CCLmin (cm) \pm S.D.
Leatherback	128	0.3 \pm 0.3
Green	5	0.1 \pm 0.1
Hawksbills	7	0.3 \pm 0.5

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

Encounters	n	\bar{x} precision for CCLmin (cm) \pm S.D.	Range (cm)
2	17	1.6 \pm 0.9	0.1-3.2
3	7	1.5 \pm 1.0	0.6-3.1
4	1	2.1 \pm N/A	N/A

3.5 Determination of Nest Survivorship and Hatching Success

Leatherback nests for females with complete caudal projection a mean clutch size of 78 normal eggs and 30 yolkless eggs (Table 2). Nests laid by female leatherback turtles with incomplete caudal projection contained a mean of 75 normal eggs and 28 yolkless eggs (Table 2). A total of 50 leatherback nests were marked between 24 March and 4 June 2003. The fate of three nests could not be determined with certainty and hence those nests were excluded from further analysis.

The incubation period for monitored leatherback nests for which emerging was observed (n=2) varied between 60-63 days with a mean of 62 days.

The fate, hatching and emerging successes of 47 marked and monitored leatherback nests are summarized 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	13	27.7	42.8	39.4
<i>Disturbed</i>				
2. Washed over	8	17.0	0.9	0.9
3. Washed out	12	25.5	0.5	0.5
4. Poached	10	21.3	0.4	0.4
5. Depredated by dogs	4	8.5	70.2	0 - 70.2*
TOTAL	47	100	18.4	11.6-17.4
(6. Unknown	3)			

*Depending on the number of hatchlings emerging before the dogs depredated the nest

Table 6a. Results of nest excavations.

Fate	Empty Shells	Pipped	Live	Dead	Unhatch.	Unhatch.	Unhatch.	Depredated	Total eggs	_
	eggs	eggs	hatchlings	hatchlings	No embryo	Embryo	Full embryo			× eggs/nest
Marked nests										
1	413	7	22	11	258	163	75	48	964	74.2
2	5	0	0	0	471	8	28	41	553	69.1
3	4	0	0	0	0	0	0	0	4	?
4	3	0	0	0	1	0	0	0	4	?
5	198	0	0	0	48	17	2	17	282	70.5
ALL	623	7	22	11	778	188	35	106	?	72.0

Fate 1=Undisturbed, 2=Washed over, 3=Washed out, 4=Poached, 5 =Depredated by dogs

Table 6b. Incidence of twin leatherback embryos.

	n	% of eggs
Twin embryos	1	0.06
TOTAL	1	0.06

The total number of eggs for all marked nests is estimated at 3,382 eggs (72.0 x 47). Overall hatching success was 18.4 % for monitored leatherback nests (623 empty shells from 3,382 eggs). Emerging success for monitored leatherback nests is estimated at 11.6-17.4 % (392-590 emerged hatchlings from 3,382 eggs in 47 nests).

The distance from the sand surface to the top egg at the time of excavation for undisturbed nests (n=12) varied between 49-72 cm with a mean of 61 cm. The distance from the sand surface to the bottom of the egg chamber for the same nests varied between 65-104 cm with a mean of 80 cm.

All monitored leatherback nests that were washed out (n=12) were located within 15 m of the high tide line at the time of oviposition. However, 13 monitored leatherback nests laid within 15 m of the high tide line hatched and emerged undisturbed, including one nests that was located only 3.05 m from the high tide line at the time of oviposition.

Eggs containing twin embryos accounted for 0.06 % of eggs in leatherback nests that were undisturbed, washed over or depredated by dogs (Table 6b).

3.6 Physical Data Collection

Rainfall during months with leatherback nesting (February-July) was heaviest in May (Table 7). March was the month with least rain (Table 7).

Table 7. Rainfall, December 2002-September 2003.

Month	Total rainfall (mm/month)*	$\bar{\times}$ rainfall (mm/24hrs)*
December	281.2	9.1
January	677.4	21.9
February	125.6	4.5
March	86.2	2.8
April	317.0	10.6
May	987.7	31.9
June	407.3	13.6
July	721.6	23.3
August	675.2	21.8
September	282.4	9.4

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

Mean minimum and maximum air temperatures were lowest in February and highest in March (Table 8).

Table 8. Air temperature, December 2002-September 2003.

Month	$\bar{\times}$ minimum temp. (°C)*	$\bar{\times}$ maximum temp. (°C)*
December	24.3	29.8
January	23.7	28.2
February	24.8	31.0
March	25.9	32.8
April	24.1	32.3
May	24.8	30.7
June	25.2	30.3
July	24.8	30.0
August	24.7	30.4
September	25.1	31.8

*No data for 17 May, 3-4, 7, 16 June, 5 July, 29 August, 6, 11 September

Sand temperatures were higher in the open beach zone than in the border and vegetation zones (Table 9). The sand temperature at 70 cm depth in the open zone peaked during the first days of May, at just below 33°C (Figure 3). Heavy rainfalls in early May reduced the sand temperature at 70 cm depth in the open zone to below 27°C by the second half of May.

Table 9. Mean monthly sand temperatures.

Zone	_ Open × temp (°C)			_ Border × temp (°C)			_ Vegetation × temp (°C)		
<i>Depth (cm)</i>	30 ^e	50 ^{a,e}	70	30	50 ^b	70	30 ^c	50	70 ^d
December	29.1	N/A	28.2	N/A	27.2	26.9	25.5	N/A	25.9
January	27.5	N/A	27.4	N/A	26.5	26.5	24.7	N/A	25.5
February	30.4	N/A	28.5	N/A	27.0	26.6	25.6	N/A	25.4
<i>Retrieval depth (cm) 7 March</i>	N/A	N/A	N/A	N/A	48	65	23	43	63
<i>Depth (cm) 7 March</i>	N/A	N/A	N/A	N/A	50	70	N/A	N/A	70
March	32.0	N/A	30.6	N/A	28.5	28.1	N/A	N/A	27.0
April	32.2	N/A	31.1	N/A	28.3	28.2	N/A	N/A	27.4
May	29.1	N/A	29.1	N/A	27.4	27.5	N/A	N/A	26.5
June	30.6	N/A	29.9	N/A	N/A	28.0	N/A	N/A	26.8
<i>Retrieval depth (cm) 20 June</i>	31	51	76	N/A	41	68	N/A	50	68
<i>Depth (cm) 20 June</i>	30	50	70	N/A	50	70	30	50	70
July	28.7	28.9	28.7	N/A	N/A	27.6	25.8	N/A	26.4
August	30.3	29.5	28.8	N/A	N/A	27.1	25.8	N/A	26.1
<i>Retrieval depth (cm) 8 Sept.</i>	12	36	63	N/A	49	67	36	47	60
<i>Depth (cm) 8 Sept.</i>	30	50	70	N/A	N/A	70	N/A	50	70

^a Data from 20 June onwards

^b Data until 20 June only

^c No data for 6 March-19 June

^d No data for 19 June

^e Datalogger moved to a shallower depth by a nesting turtle on August 2

During the 2003 Leatherback Program, the ground water did not reach levels that could be detected in the PVC pipes.

3.7 Collection of Human Impact Data

The number of paying visitors coming to Tortuguero National Park has continuously increased since 2000 and totalled 50,339 paying visitors in 2002 (Table 10).

Table 10. Number of Paying Visitors to Tortuguero National Park, 2000-2002.

Year	CR Visitors	Foreign Visitors	Total
2000	5,543	36,354	41,897
2001	6,175	39,057	45,232
2002	5,745	44,594	50,339

Information from ACTo.

Tour guides taking tourists on turtle walks reported two leatherback renesters during the 2003 Leatherback Program.

The number of paying visitors registered at the CCC Natural History and Visitors Center increased in 2003 (Table 11). For every month with the exception of September, the 2003 visitation levels have been the highest for that month for any year. August 2003 was the month with the highest mean daily visitation to the CCC Natural History and Visitors Center since it was opened (Table 11).

Table 11. Visitors to the CCC Natural History and Visitors Center, January 2001-September 2003.

Month	2001		2002		2003	
	Total	× Per Day	Total	× Per Day	Total	× Per Day
January	1846	60	1756	57	2230	72
February	2277	81	2108	75	2855	102
March	2301	74	2581	83	2921	94
April	2002	67	1738	58	2591	86
May	1208	39	1239	40	1410	45
June	1334	44	1463	49	1575	53
July	2720	88	2673	86	3272	106
August	2858	92	3419	110	3864	125
September	1440	48	2043	68	1706	57
October	1597	52	2104	68		
November	1550	52	2276	76		
December	1472	47	2124	69		
TOTAL	22605	62	25524	70	22424	82

The capacity of both hotels and cabins in the Tortuguero area increased in 2003 (Table 12). The overall room and bed capacity of the hotels is approximately three times the capacity of the cabins.

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

Hotels/Lodges	Rooms	Beds	Cabins	Rooms	Beds
Caribe	3	5	All Rankin Lodge	6	22
Evergreen	20	43	Aracari	10	24
Hotel Vista del Mar	20	40	Casa Marbella	4	11
Ilan-Ilan	24	54	La Casona	-	-
Jungle	46	94	Chanu	5	17
Laguna	52	110	Ella y Yo	3	5
El Manati	10	20	Joruki	9	20
Mawamba	54	140	Meryscar	20	45
Pachira	56	116	Ms Miriam	14	42
Samoa Lodge*	15	36	Miss Junnie Hotel	12	30
Tortuga	26	60	Sabina	27	58
Turtle Beach Lodge	18	39	Tortuguero	7	18
<i>Total – Hotels</i>	<i>344</i>	<i>757</i>	(CCC)	7	32)
Cabins	Rooms	Beds	<i>Total – Cabins</i>	<i>124</i>	<i>324</i>
Pisulin/Tropical Lodge**	-	-			
Pancana***	-	-	TOTAL	468	1081

* Previously called Caribbean Magic

** Will reopen in late 2003 or early 2004

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

The beach sections with artificial lights remain the same but the number of lights in front of the village (mile 2 6/8-3 3/8) has increased. In July, the Costa Rican Electricity Institute (ICE) staff shaded the village streetlights located close to the beach. The lights are still visible but their intensity is reduced and they can no longer be seen from a long distance.

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

Mile	Light source	Beach side	Lagoon side	April*	May**	June***
5/8	Tortuga Lodge					X
6/8	Tortuga Lodge		X	X	X	X
1 1/8	Ilan-Ilan Lodge		X		X	
1 1/8	House	X		X		X
1 2/8	All Rankin Lodge	X		X	X	X
1 3/8	Manati Lodge		X			X
1 3/8	Laguna Lodge	X		X	X	
1 4/8	Laguna Lodge	X			X	X
2 2/8	Mawamba Lodge					X
2 3/8	Mawamba Lodge	X		X	X	X
2 4/8	CCC	X				X
2 5/8	CCC	X		X		X
2 6/8	Houses + Street Lights	X		X	X	X
2 7/8	Houses + Street Lights	X		X	X	X
3	Houses + Street Lights	X		X	X	X
3 1/8	Houses + Street Lights	X		X	X	X
3 2/8	Houses + Street Lights	X		X	X	X
1/8-6/8, 1 1/8-5	Red light from mast (m2 6/8)	X			X	X

*No beach between mile -2/8 to 6/8.

** No beach between mile -2/8 to 0.

*** No beach between mile -2/8 to 3/8.

3.8 Dead Turtles

Five dead turtles (four greens and one hawksbill) were recorded during track surveys conducted in the 2003 Leatherback Program (Table 14). Of these five turtles, all of which were found in TNP between the mile 5 marker and Jalova, four were predated by jaguars and the fifth was taken by poachers.

Table 14. Dead turtles.

Date	Species	Sex	Mile	Comments
7 May	Ei	F	12	Drag marks from turtle leading to the sea, so turtle was possibly taken by poachers.
31 May	Cm	F	16	Turtle killed by jaguar and left on the open beach.
3 June	Cm	F	10 4/8	Uptrack and no down track. Head and left flipper found in the vegetation behind the track.
6 June	Cm	F	11	Uptrack and no down track. Turtle found in the vegetation. Probably from night of 4 June
12 June	Cm	F	11 4/8	Turtle found in center of beach. More than 2 days old, missing head.

Ei=hawksbill turtle, Cm=green turtle

3.9 Environmental Education Activities

The FC and RA's worked with students from the Tortuguero school on five occasions during the Leatherback Program 2003 (Table 15)

Table 15. Activities conducted at the Tortuguero school from April – June 2003.

Date	Number of Students	Activities
4 April	32	Initial test (4 th and 6 th grade) Video of the sea turtles of Costa Rica Initial test (5 th grade)
9 April	52	Species of sea turtle found in Tortuguero The life cycle of sea turtles Why conserve sea turtles?
25 April	16	Video of the work of the CCC Predators and dangers to sea turtles
5 May	52	Conservation of sea turtles in other countries
9 May	36	Beach clean

Activities on 4 and 25 April were conducted in the visitor centre at the CCC field station. On 9 April and 5 May RA's visited the school to give presentations about sea turtle biology and conservation. The final activity on 9 May involved a presentation on the dangers of litter to sea turtles and a beach clean along the stretch on beach in front of the school and the village. A group of three students from the 6th grade joined a night-time beach patrol in April.

4. DISCUSSION

4.1 Preparations

The mile markers put up in March 2003 were very useful and limited erosion meant that the majority of posts were still present at the end of the 2003 Leatherback Program. The mile markers are indispensable for night patrols and track surveys but are also used by park rangers to locate themselves on the beach.

Radio communication at the southern end of the beach, close to Jalova remained difficult and is unlikely to improve unless a taller antenna is placed at the park ranger station or MINAE installs a more powerful repeater unit on the Irazú volcano. At the northern end, the quality of radio communication varied widely with some locations on the beach providing a better reception and other locations not providing any reception.

The newly purchased bags used to protect the handheld radios from rain and sand proved very durable. However, the bags affected the quality of the reception and it is necessary to remove the radios from the bags in order to be able to communicate efficiently.

4.2 Track Surveys

Leatherback nesting was observed from February through July with peak nesting during the March-June period (Figure 1, pers. obs.). Track surveys conducted by RAs and the FC coincide with the period of heaviest leatherback nesting (Figure 1, Table 1).

The two methods used for estimating the number of leatherback nests show differences for individual beach sections (Figure 2a-c) as well as for the total estimates of 806 leatherback nests and 680 leatherback nests (Figure 2a-c). It may be that high tides erased some of the tracks before the FC and the RAs could count them (Table 1). This could explain why the FC

and RAs nest counts were lower than the nest estimate derived from the results of the track surveyor who only recorded fresh nests.

Poaching of leatherback nests was higher during the 2003 Leatherback Program than during any of the three previous leatherback turtle nesting seasons. The trend of increasing leatherback nest poaching in 2003 compared to previous years was also observed at other projects along the coast (D. Chacón, B. Dick pers. comm.) and is likely the result of a decrease in protection efforts by the Ministry of Environment and Energy. It is discouraging to see that the Ministry's investments in sea turtle protection are decreasing in spite of increased tourism in Tortuguero National Park (Table 10-12).

Track survey results indicate that the beach section outside Tortuguero National Park, between Jalova lagoon and the Parismina river mouth, is most affected by poaching (Figure 2a-d). The results suggest that protection efforts in Tortuguero National Park are at least having some effect, in particular along the beach sections where RA night patrols are regular.

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 (Figure 1) and it is suggested that night patrols be conducted during the same period in future years.

The low site fidelity of leatherback turtles along the Caribbean coast of Costa Rica and Panama is highlighted by the number of leatherback turtles encountered in Tortuguero that were originally tagged on other nesting beaches. This movement between different beaches demonstrates the value of continuing to improve communication between conservation projects and government institutions in both Costa Rica and Panama in an effort to successfully conserve the leatherback population in these two countries. To aid this information transfer, a regional Access database for leatherback turtle nesting data is currently being compiled for projects along the Caribbean coast.

Two areas which should be a priority for conservation action are the beach sections between Jalova lagoon – Parismina and between Lagunas Urpiano – Moin, as these stretches have very limited institutional presence combined with high levels of poaching.

4.4 Biometric Data Collection

The mean carapace length (CCL_{min}) of female leatherback turtles with complete caudal projection was significantly larger than the mean carapace length (CCL_{min}) of females with incomplete caudal projections. It is therefore suggested that the classification of the leatherback turtles' caudal projection be continued in future years.

4.5 Determination of Nest Survivorship and Hatching Success

The overall hatching success of the monitored leatherback nests was low at 18.4 % (Table 5). The relatively high levels of poaching contributed to the low hatching success. However, embryonic death is reportedly high in leatherback turtles (Bell *et al.* 2003) and may have lowered the hatching success. High sand temperatures of almost 33°C during the first days of May could also have adversely affected egg survivorship in nests laid before sand temperatures decreased in mid-May (Figure 3).

Although only one twin leatherback embryo was encountered during excavations (Table 6b), it represents 0.06 % of all eggs in undisturbed and washed over nests. The occurrence of twin and deformed embryos could be a result of chemical contamination. It would be highly desirable to research the presence of pesticides and other agricultural chemicals in the nesting beach to determine if such chemicals represent a threat to leatherback egg survivorship.

4.6 Physical Data Collection

As a result of the heavy rains in May (Table 7), the sand temperature at 70 cm depth in the open beach zone dropped as much as 6.2°C between 6 May and 18 May (Figure 3). If the pivotal temperature for leatherback turtles nesting at Tortuguero is the same as the estimated pivotal temperature for leatherback turtles in French Guiana (Figure 3; Girondot 1999) then it is probable that both male and female hatchlings were produced during the 2003 leatherback nesting season. Nests incubating during the first part of the nesting season, from March through early May, are likely to have produced most of the female hatchlings (Figure 3).

The temperature dataloggers are being replaced with new TidBit dataloggers (Onset Computer Corporation) in protective casings. The protective casing reduces the likelihood of dataloggers failing due to high temperature coupled with high humidity. So far, none of the new TidBit dataloggers have failed.

4.7 Collection of Human Impact Data

Tourism in the Tortuguero area continues to increase and (Table 10-11). Some of the profits from the tourism businesses are being reinvested as seen by the increase in capacity of hotels and cabins in the Tortuguero area (Table 12). Hopefully, the increase in tourism means that more people will benefit economically from turtle related ecotourism activities in Tortuguero.

The high levels of visitation recorded at the CCC Natural History and Visitor Center in 2003 are probably due to both an actual increase in tourism as well as increased efficiency in the reporting of tourists by the new visitor center administrator.

Artificial lights are increasing in the Tortuguero village (Table 13). Therefore, it is encouraging to see that the Costa Rican Electricity Institute (ICE) has begun to shade streetlights in order to minimize the disorientation of hatchlings.

4.8 Dead Turtles

The number of dead turtles encountered during the 2003 Leatherback Program was low at four green turtles and one hawksbill (Table 14). It is unfortunate that the jaguars killed one of the hawksbill turtles, particularly as this species is now very scarce at Tortuguero. However, it is encouraging to see that jaguars and poachers do not seem to take any interest in the nesting leatherback turtles.

4.9 Environmental Education Activities

Several difficulties were encountered while trying to conduct the education program with the school, which resulted in the FC and RA's only being able to complete some of the planned activities. Some of these problems were the result of poor communication between the director and the teachers, and thus RA's arrived at the school unannounced to find the

students occupied in other activities. In addition, the students schedule was quite erratic and often changed with little notice, so on more than one occasion RA's arrived to find that lessons had been cancelled.

Many students expressed an interest in joining RA's out on the beach at night, but often were unable to participate due to the concerns of their parents about their safety when returning home after the shift. This could be overcome by holding a meeting with the parents to introduce all the RA's and to confirm that students would be escorted home after leaving the beach.

Despite these minor problems many of the students showed an interest in the activities and appeared to have a good knowledge of sea turtle biology, issues regarding their conservation and protection, and the negative impacts of litter on the beach.

5. REFERENCES

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Figure 1. Seasonal distribution of leatherback nesting activity as determined from track surveys, Tortuguero rivermouth (mile -3/8) - Jalova lagoon (mile 18).

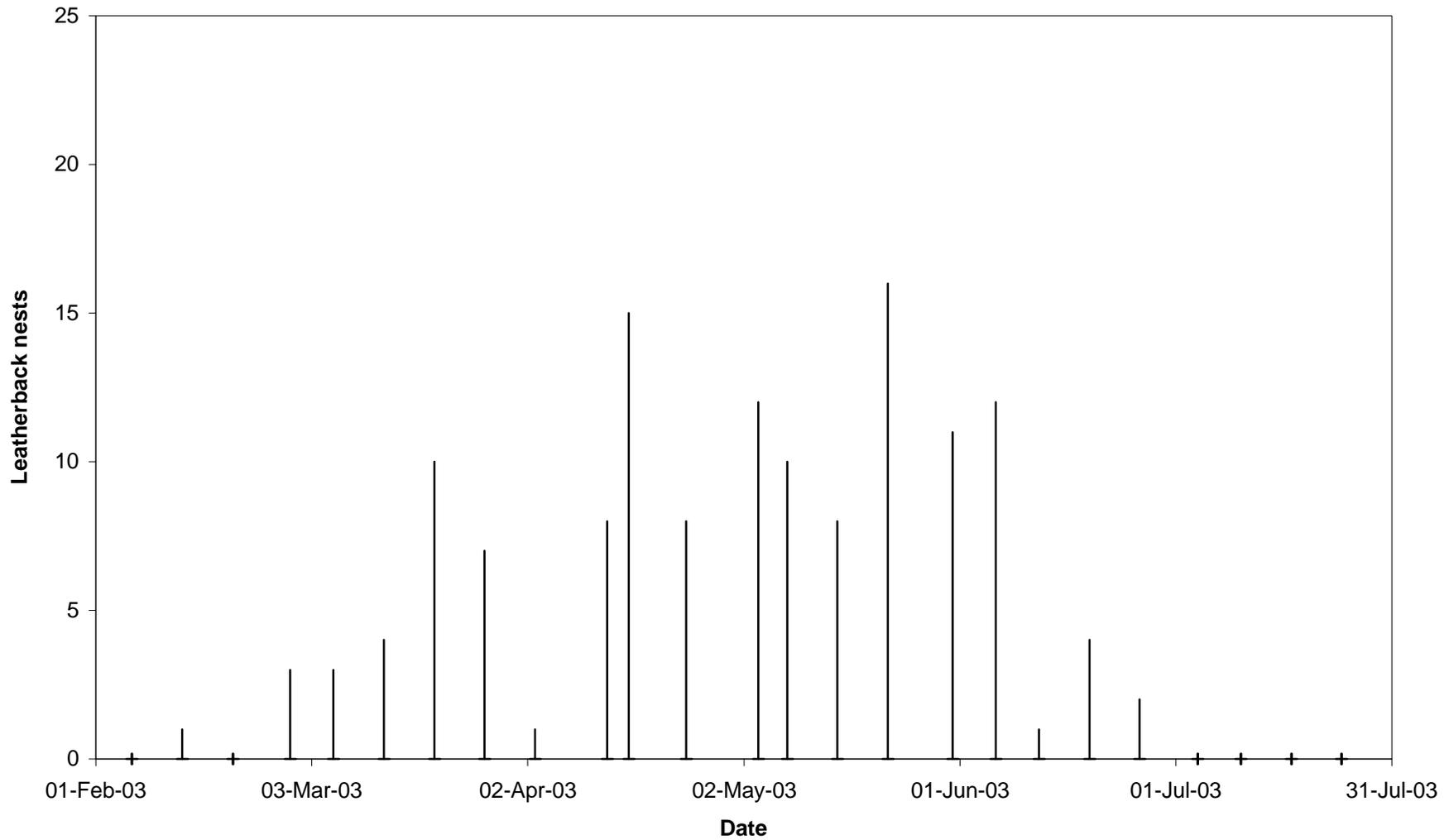


Figure 2a. Leatherback nesting activity from Tortuguero river mouth to the mile 5 marker.

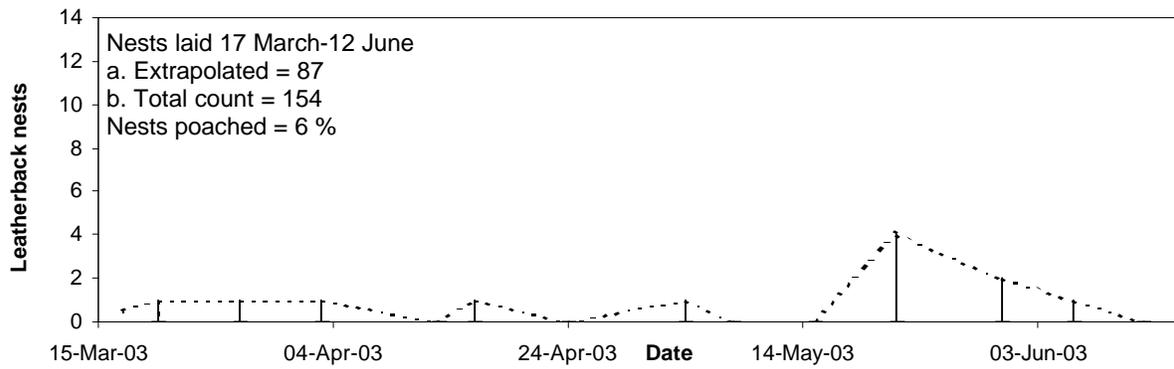


Figure 2b. Leatherback nesting activity from the mile 5 marker to Juana López path.

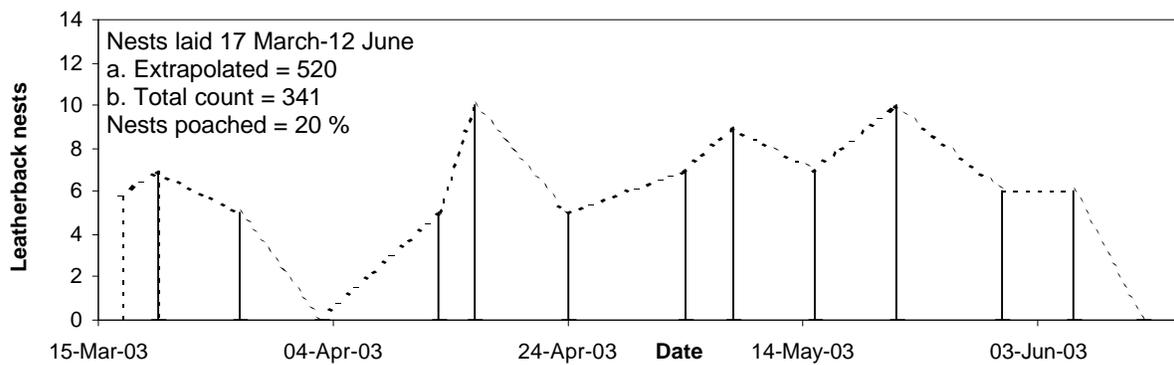


Figure 2c. Leatherback nesting activity from Juana López path to Jalova lagoon.

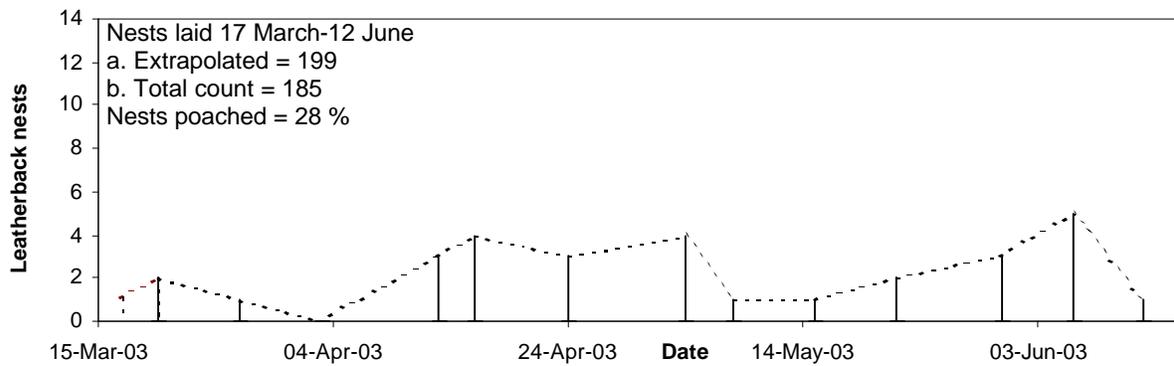


Figure 2d. Leatherback nesting activity from Jalova lagoon to Parismina river mouth.

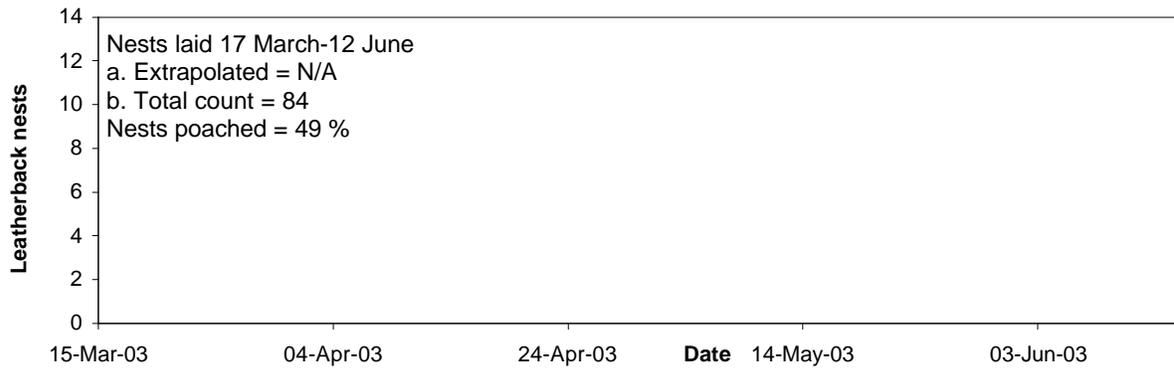
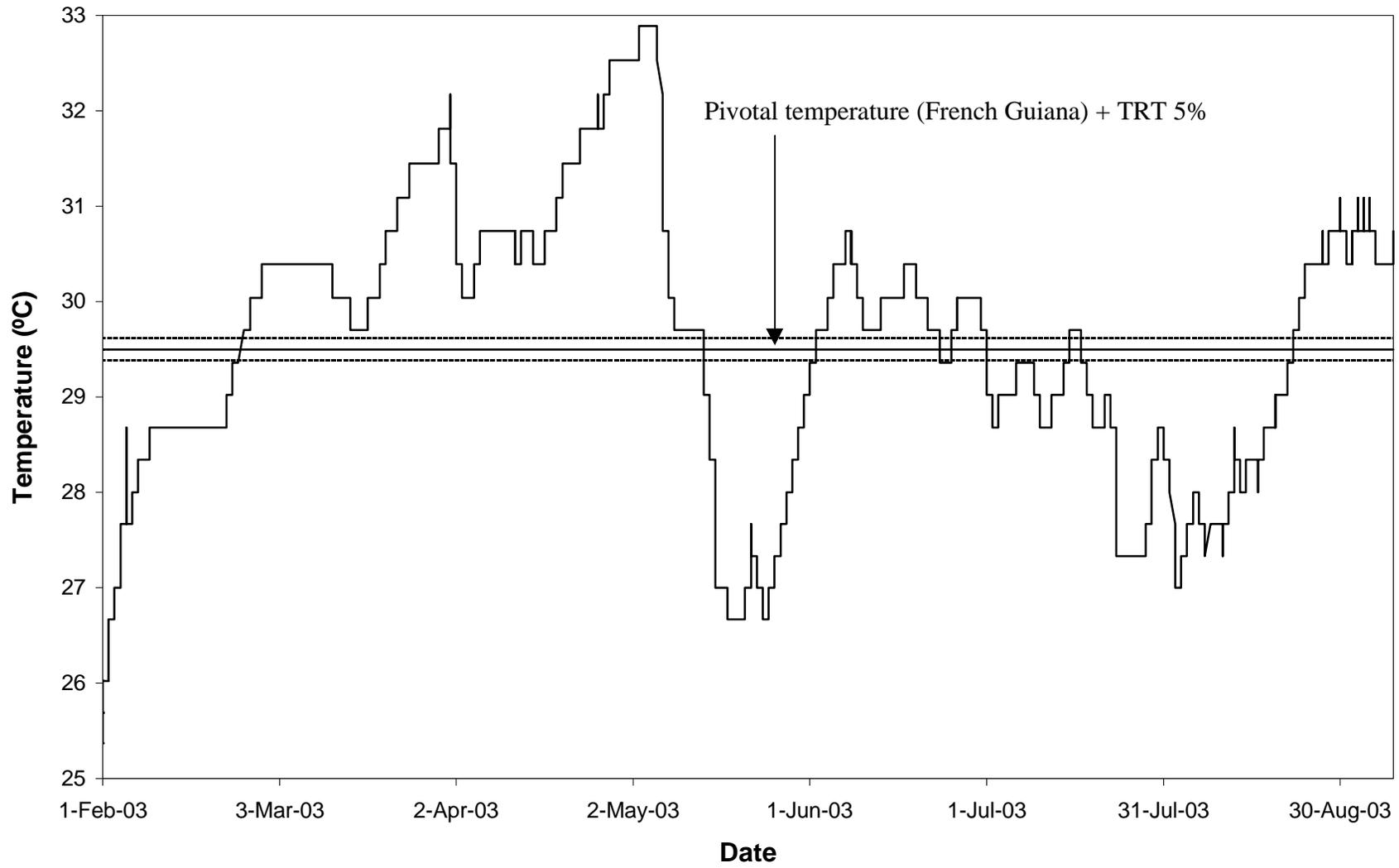


Figure 3. Temperature (°C) at 70 cm depth, open zone.



APPENDIX 1. SEA TURTLE ENCOUNTERS.

Date	Leatherbacks			Greens			Hawksbills			
	Newly tagged turtles	Previously tagged turtles	Renesters	Total	Newly tagged turtles	Previously tagged turtles	Total	Newly tagged turtles	Previously tagged turtles	Total
06-Mar-03				0			0			0
07-Mar-03				0			0			0
08-Mar-03				0			0			0
09-Mar-03				0			0			0
10-Mar-03				0			0			0
11-Mar-03				0			0			0
12-Mar-03				0			0			0
13-Mar-03				0			0			0
14-Mar-03	1	1		2	1		1			0
15-Mar-03				2			1			0
16-Mar-03				2			1			0
17-Mar-03				2			1			0
18-Mar-03				2			1			0
19-Mar-03				2			1			0
20-Mar-03				2			1			0
21-Mar-03	1	2		5			1			0
22-Mar-03				5			1			0
23-Mar-03	2			7			1			0
24-Mar-03	1	1	2	11			1			0
25-Mar-03				11			1			0
26-Mar-03	1			12			1			0
27-Mar-03				12			1			0
28-Mar-03				12			1			0
29-Mar-03	2			14			1			0
30-Mar-03	1	3		18			1			0
31-Mar-03				18			1			0
01-Apr-03				18			1			0
02-Apr-03		1		19			1			0
03-Apr-03		2	1	22			1			0
04-Apr-03	1		1	24			1			0
05-Apr-03	1	1		26			1			0
06-Apr-03	2	1		29			1			0
07-Apr-03				29			1			0
08-Apr-03			2	31			1			0
09-Apr-03				31			1			0
10-Apr-03	1		2	34			1			0
11-Apr-03				34			1			0
12-Apr-03				34			1			0
13-Apr-03	2	1		37			1			0
14-Apr-03		1	1	39			1			0
15-Apr-03	1	1		41			1			0
16-Apr-03				41			1			0
17-Apr-03				41			1			0
18-Apr-03	1		1	43			1			0
19-Apr-03	1			44			1			0
20-Apr-03	1		1	46			1			0
21-Apr-03				46			1			0

22-Apr-03	1	2		49			1		0
23-Apr-03	1			50			1		0
24-Apr-03	1	1	1	53			1		0
25-Apr-03		4		57	1		2		0
26-Apr-03	1	1	1	60			2		0
27-Apr-03	1	1	1	63			2		0
28-Apr-03	1	2		66			2		0
29-Apr-03	4	2	1	73			2		0
30-Apr-03		3		76			2		0
01-May-03	1	1	1	79			2		0
02-May-03	3		1	83			2		0
03-May-03				83			2		0
04-May-03		5	4	92	1		3		0
05-May-03	4	2	1	99			3		0
06-May-03	1	1		101			3		0
07-May-03		1	1	103			3		0
08-May-03	1			104	1		4		0
09-May-03	1	2	1	108			4		0
10-May-03			1	109			4		0
11-May-03		1		110			4	1	1
12-May-03				110			4		1
13-May-03				110			4		1
14-May-03				110			4		1
15-May-03				110			4		1
16-May-03	3		1	114			4		1
17-May-03	1		1	116			4		1
18-May-03				116			4	1	2
19-May-03			3	119			4	1	3
20-May-03	1			120			4		3
21-May-03				120			4		3
22-May-03		1		121			4		3
23-May-03	1			122			4		3
24-May-03				122			4		3
25-May-03				122			4		3
26-May-03	1		2	125			4		3
27-May-03				125			4		3
28-May-03			1	126			4		3
29-May-03				126			4		3
30-May-03				126			4		3
31-May-03				126			4	1	4
01-Jun-03	1		1	128			4		4
02-Jun-03				128			4		4
03-Jun-03	2	1		131			4		4
04-Jun-03			1	132			4	1	5
05-Jun-03	1			133			4		5
06-Jun-03				133			4	1	6
07-Jun-03		1	1	135			4		6
08-Jun-03				135			4		6
09-Jun-03				135			4		6
10-Jun-03				135	1		5	1	7
11-Jun-03				135			5		7
12-Jun-03				135			5		7
Total	52	47	36	135	4	1	5	6	7

APPENDIX 2: Observations and Anecdotal Information on Poaching

According to local sources, the organized group involved in turtle and egg poaching has access to fast boats and attempt to visit the beach within Tortuguero National Park every couple of days during the leatherback nesting season. The eggs and green turtles that are poached are then transported out of the area, mainly to the city of Limón. Eggs are sold for approximately ₡150/egg (~US\$0.40) by persons that walk from bar to bar in Limón offering eggs for sale to customers frequenting the bars. Green turtle meat is sold by persons that walk around residential neighbourhoods in Limón offering meat for sale or through personal contacts.

Poaching increased during the 2003 Leatherback Program in comparison to previous years. This trend appears to have extended the entire coast and is likely to be the result of a decrease in the institutional presence by the Ministry of the Environment and Energy on leatherback nesting beaches. Preliminary results from the 2003 Leatherback Program that indicated an increase in poaching of leatherback nests were presented at the National Forum for Protected Areas in April 2003. The Minister of Environment and Energy, senior officials with the Conservation Area System and representatives of all major environmental NGOs active in Costa Rica were present at the Forum. Later, CCC's National Director met with the Director of the Tortuguero Conservation Area to express dismay at the increase in leatherback nest poaching and to request increased anti-poaching efforts by the authorities. CCC's National Director also had a private meeting with the Minister of the Environment and Energy to share information on leatherback turtle poaching trends. The Minister expressed support for increased conservation action.

CCC's National and Scientific Directors have met repeatedly with representatives of environmental NGOs in order to develop a strategy for increasing funding to protected areas including those that host leatherback turtle nesting beaches. CCC's National Director and four other representatives of Costa Rican environmental NGOs met with Costa Rican President Dr. Abel Pacheco in August to express concern about the current problem facing protected areas and endangered species in Costa Rica. Preliminary results from the 2003 Leatherback Program were used to emphasize the need for increasing funding to protection efforts.