REPORT ON

THE 1998 LEATHERBACK PROGRAM

AT TORTUGUERO, COSTA RICA

Submitted to

Caribbean Conservation Corporation
and
the Ministry of Environment and Energy of Costa Rica.
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by

Sebastian Troëng, Research Coordinator

and

Alexander Castillo, Research Assistant
Verónica Duque, Research Assistant
Judd Klement, Research Assistant
Cristina Ordoñez, Research Assistant
Thomas Alonso Rankin, Track Surveyor

CARIBBEAN CONSERVATION CORPORATION

Address:	**4424 NW 13th St. Suite A-1**	**Apartado Postal 246-2050**
	Gainesville, FL 32609	**San Pedro**
	USA	**COSTA RICA**
Ph:	**INT+ 1 352 373 6441**	**INT+ 506 224 9215**
Fax:	**INT+ 1 352 375 2449**	**INT+ 506 225 7516**
Email:	**ccc@cccturtle.org**	**baulas@sol.racsa.co.cr**
Webpage:	**http://www.cccturtle.org**	

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1. INTRODUCTION

Caribbean Conservation Corporation (CCC) has been organizing and implementing an annual leatherback (*Dermochelys coriacea*) program in Tortuguero since 1995. The staff and Scientific Advisory Committee of the CCC updated the monitoring protocol for the 1998 Leatherback Program in response to concerns that changes in illegal harvest, land use, and tourism trends may have resulted in additional challenges for the nesting leatherbacks and their eggs. The new monitoring protocol was developed to be consistent with international standards for sea turtle monitoring and to produce data comparable to those collected in previous years in Tortuguero and at other leatherback nesting beaches on the Caribbean coast of Costa Rica.

This report summarizes the methods and results of the 1998 Leatherback Program. Further, the report provides a discussion of the results and recommendations for future leatherback programs and conservation activities in Tortuguero.

2. METHODS

2.1 Preparations

The Research Coordinator (RC) and Research Assistants (RAs) arrived in Tortuguero on 12-13 March 1998. During the first week, the positions of all mile markers from Boca del Rio Tortuguero (mile -3/8) to Laguna Jalova (mile 18) were verified using a 300-foot fiberglass measuring tape. Missing and termite ridden posts were replaced and all posts were painted white and with appropriate mile numbers. Two or three posts, depending on the beach width, were placed at each marker position to make the markers easier to find on moonless and cloudy nights.

Mile markers were placed every 1/8 mile from Boca del Rio Tortuguero to the mile 5 marker and every half mile from the mile 5 marker to Laguna Jalova. The old mile markers from 1997 were used as reference points for the beach section between Laguna Jalova and Boca del Río Parismina.

During the first week of the program the RAs were given lectures in marine turtle biology and training regarding the monitoring protocol and rationale. Codes of conduct for field station residents and consequences of personal behaviour on conservation success were also discussed in detail.

A two day camping trip was organized 18-20 March in an effort to encounter more nesting leatherbacks. A tent to house the RAs and the RC, was put up next to the remains of “Casa Baula”, the ranger station by mile 11 6/8 that was burned down shortly before Christmas 1997.

2.2 Track Surveys

Track surveys were conducted approximately twice weekly throughout the duration of the program. All track surveys commenced at dawn (5:00 am) and were completed before 12:30 am, the same day. Track surveys were conducted from Boca del Río Tortuguero to either

Laguna Jalova or Boca del Río Parismina. Each track survey was conducted by one person, either by Sr. Thomas Alonso Rankin González or the RC.

For each track survey, the number of sea turtles emerging the previous night was recorded. For each track, species, nest or false crawl, was recorded and also if illegal harvest of the turtle had taken place. The RC also recorded the number of fresh nests that had been illegally harvested.

2.3 Tagging of Nesting Sea Turtles

Tagging of female turtles was conducted nightly from 16 March to 15 May 1998. One to three teams worked each night, depending on the number of staff and participants present at the field station. The teams worked from 8pm-12pm when patrolling the northern 5 2/8 miles of beach, and from 6.30pm-5.30am when patrolling beach sections between mile 9 and Laguna Jalova.

Turtles were tagged after completing oviposition. Leatherbacks were tagged in the rear flippers and greens (*Chelonia mydas*), hawksbills (*Eretmochelys imbricata*) and loggerheads (*Caretta caretta*) were tagged axillary, proximal to the first scale, in the front flippers. All turtles were double tagged. Tag number; species; date; time and activity at encounter; mile; zone; tagger; and additional comments were recorded for each encounter.

2.4 Biometric Data Collection

If turtles were encountered previous to oviposition, the eggs of the turtle were counted as they were being laid. Turtles were measured to the closest mm providing sufficient time was available. All measurements were taken three times so that the precision of the measurements could be estimated. Precision, in this report, is defined as the difference between the longest and the shortest of the three measurements taken from the turtle during the same encounter.

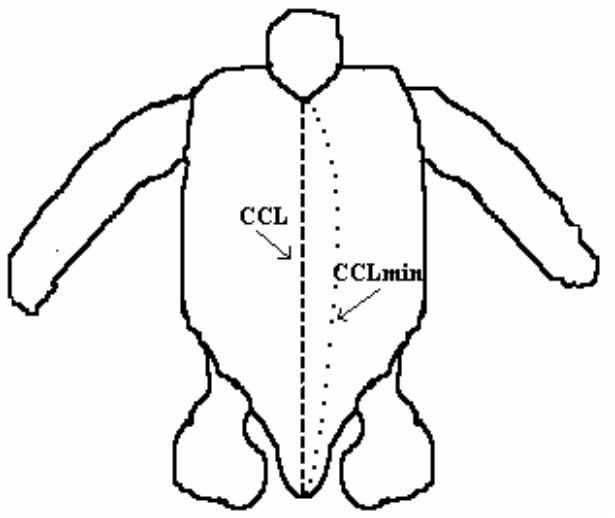


Figure 1. Carapace measurements for leatherbacks.

For leatherbacks, CCLmin (=nuchal notch to the end of the caudal projection adjacent to the central ridge) was recorded (Figure 1). In addition, CCL (=nuchal notch to the end of the caudal projection over the central ridge) was also recorded (Figure 1). The caudal projection of leatherbacks was classified as being incomplete if its shape was irregular or if part of the caudal projection appeared to be missing, or complete if no irregularities were observed.

For green turtles and loggerheads, CCLmin (=nuchal notch to the posterior notch between the supracaudals along the carapace midline) was recorded.

For hawksbills CCL (=nuchal notch to the end of the supracaudals along the carapace midline) was recorded.

2.5 Determination of Nest Survivorship and Hatching Success

If a turtle was encountered previous to covering the egg-chamber, the nest was marked by attaching two pieces of flagging tape to the vegetation behind the nest. The location of the nest could then be determined by triangulation. Each morning the marked nests were inspected so that the fate of the eggs could be determined. Predation or illegal harvest of a nest resulted in a cessation of the inspections of that nest.

The marked nests were excavated after hatching to determine the hatching success. The number of empty eggshells, pipped eggs, live and dead hatchlings, unhatched eggs without embryo, unhatched eggs with obvious embryo, unhatched eggs with fully developed embryo, and depredated eggs were determined for each excavated nest. Only eggshells 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 over the past 24hrs and temperature (current, minumum and maximum during the last 24 hours) was recorded daily at 9am, starting 18 March.

The level of the ground water was measured daily at 9am, starting 18 March. The water level was determined from three PVC pipes (8.5cm x 160cm) dug down in the beach in front of the John H. Phipps Biological Field Station, at 5, 10 and 15m distance from the high tide line (as of 15 March).

Sand temperature was measured using dataloggers located at 70cm depth at two metres distance from the PVC ground water pipes, i.e. at 5, 10 and 15m distance from the high tide line (as of 15 March).

2.7 Collection of Human Impact Data

Human impact data were collected in order to monitor trends in tourism, economic development and presence of artificial light on the nesting beach.

The number of visitors to Tortuguero for 1995-1997 were provided by staff at the ACTo station in Tortuguero.

The number of visitors to the CCC natural history museum and visitor centre was recorded by Grethel Monge (until 28 February 1998) and Fredy Piedra Pochet, Rachel Minch, Celena Olden and Mario Zamora (after 28 February 1998).

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

2.8 Dead Turtles

Dead turtles encountered during work activities were measured and an attempt was made to determine the cause of death. Other relevant characteristics were also duly noted.

2.9 Environmental Education Activities

Environmental education activities were carried out when the schedules and activities, of the monitoring program and the Tortuguero school, allowed. The emphasis of the educational activities was put on the importance of local participation in conservation activities and the importance of maintaining protected habitats intact within Tortuguero National Park. An effort was also made to include school children in the nightly work of CCC.

Environmental education activities involving the Costa Rican Coast Guard were also conducted by CCC staff on request.

3. RESULTS

3.1 Preparations

The mile 4 1/8 section exceeded 660 feet and the mile 4 6/8 section was shorter than 660 feet. Subsequently, the mile markers between the mile 4 1/8 marker and the mile 5 marker were moved so that all 1/8 mile sections were equally long.

During the preparatory camping trip only one leatherback was encountered.

3.2 Track Surveys

The seasonal distribution of leatherback nesting activity is presented in Figure 2a and 2b. The results of the track surveys by Thomas Alonso Rankin González and the RC are shown separately. Leatherback nesting commenced in early March and continued until the first part of July with peak nesting in April and May.

The spatial distribution of the leatherback nesting activity is shown in Figure 3a and 3b. Leatherback nesting was densest in mile 10 and from mile 12 to mile 17.
The number of fresh leatherback nests and the number and percentage of poached nests are shown in Table 1. The percentage of poached nests varied from zero to as much as 80% with a mean of 35.1%. The track surveyors noted an increase in the number of boats with poachers that visited the beach as the leatherback season progressed. The ranger stations in Jalova and Tortuguero were informed each time CCC staff encountered poachers or evidence of poaching on the beach.

Figure 2a. Seasonal distribution of leatherback nesting activity as determined from track surveys conducted by Thomas Alonso Rankin.

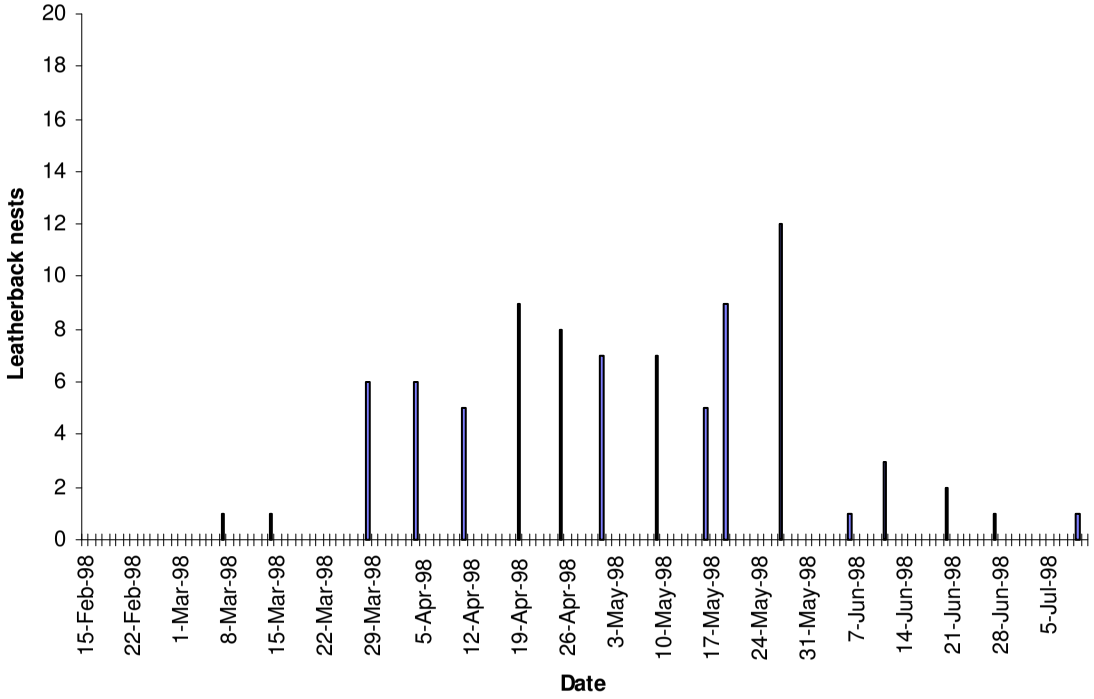


Figure 2b. Seasonal distribution of leatherback nesting activity as determined from track surveys conducted by Sebastian Troëng.

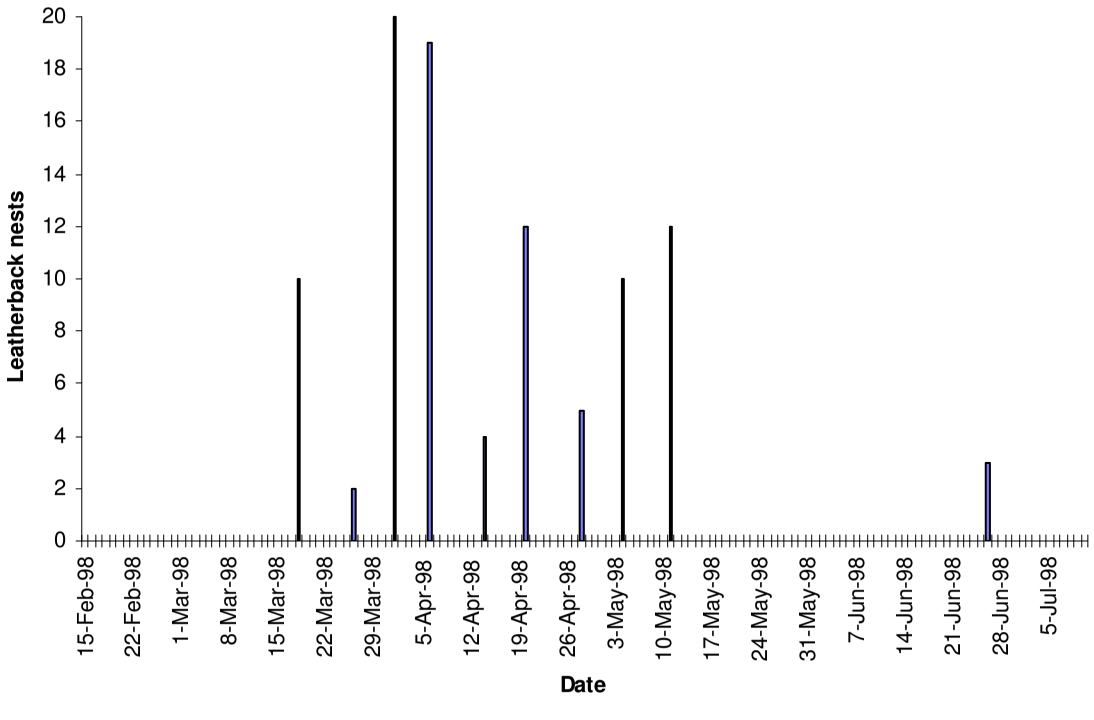


Figure 3a. Spatial distribution of leatherback nesting activity as determined from track surveys by Thomas Alonso Rankin.

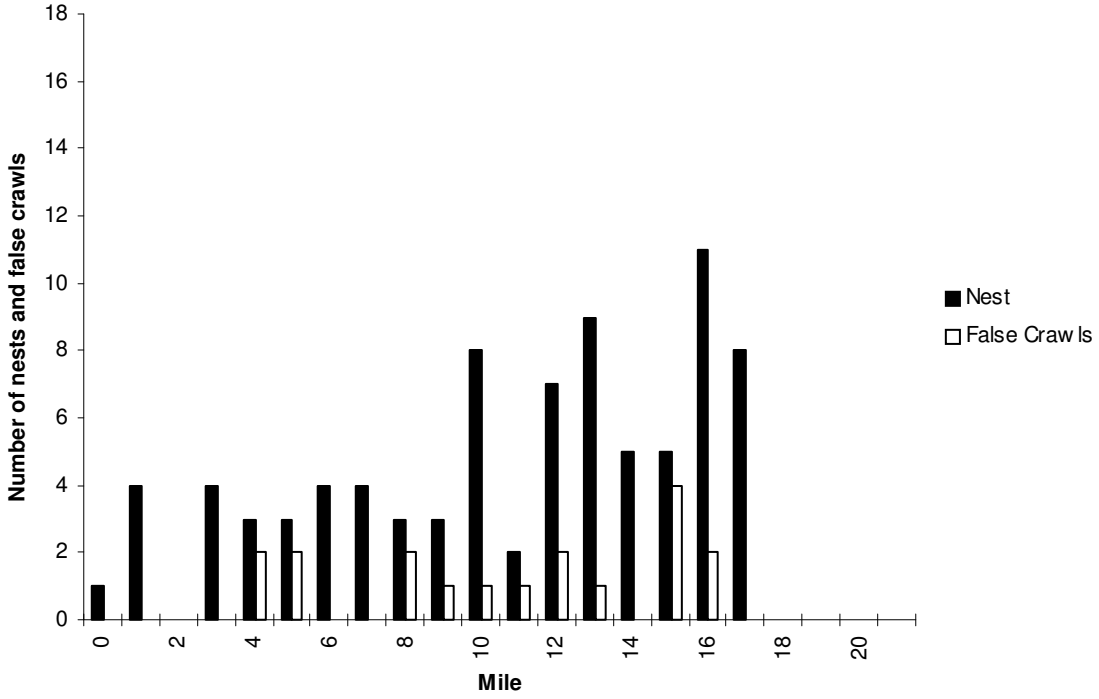


Figure 3b. Spatial distribution of leatherback nesting activity as determined from track surveys by Sebastian Troëng.

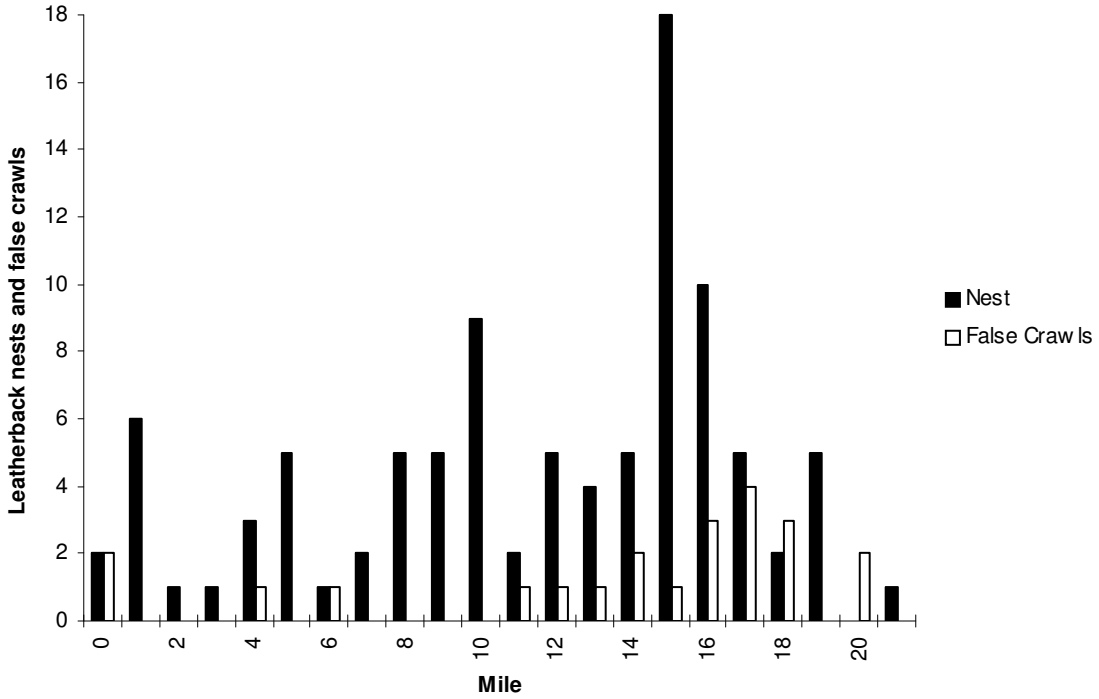


Table 1. Number of leatherback nests and poached nests from Boca del Río Tortuguero to Boca del Río Parismina as determined from track surveys.

Date	Fresh Nests	Poached Fresh Nests	% Poached
18-March	10	1	10.0
26-March	2	0	0.0
1-April	20	7	35.0
6-April	19	1	5.3
14-April	4	3	75.0
20-April	12	8	66.7
28-April	5	1	20.0
4-May	10	8	80.0
11-May	12	4	33.3
Total	**94**	**33**	**35.1**

Observations and anecdotal information regarding illegal harvest are summarized in Appendix 3.

3.3 Tagging of Nesting Sea Turtles

A total of 560 teamhours were spent on the beach from 16 March to 15 May. During this time a total of 53 leatherback, ten green, two loggerhead and one hawksbill encounters were recorded (Appendix 1). This is equal to 0.095 leatherbacks, 0.018 greens, 0.004 loggerheads and 0.002 hawksbills encountered per team hour on the beach.

Another leatherback and green turtle were encountered after 15 May in conjunction with other monitoring activities. The green turtle carried a tag applied in 1987, but was originally tagged in Tortuguero during the 1977 green turtle season, a reproductive lifespan of at least 21 years!

The encountered turtles correspond to 45 individual female leatherbacks, ten greens, two loggerheads and one hawksbill. A total of 42% (n=19) of the leatherbacks were previously tagged. Only previously tagged females had holes or notches indicating lost tags (n=5). The previously tagged leatherbacks (n=19) were originally tagged on the beaches of Tortuguero, Pacuare/Mondonguillo, Gandoca/Manzanillo and Bocas del Toro province in Panama (D. Chacón pers.comm., Leslie *et al.* 1996).

A total of 93% of the leatherback females laid eggs in the open beach section (n=50) and 7% did not lay eggs (n=4).

The time of first encounter and encounters/team hour from 6:00 PM to 5:00 AM are shown in Figure 4.

Figure 4. Time of encounter.

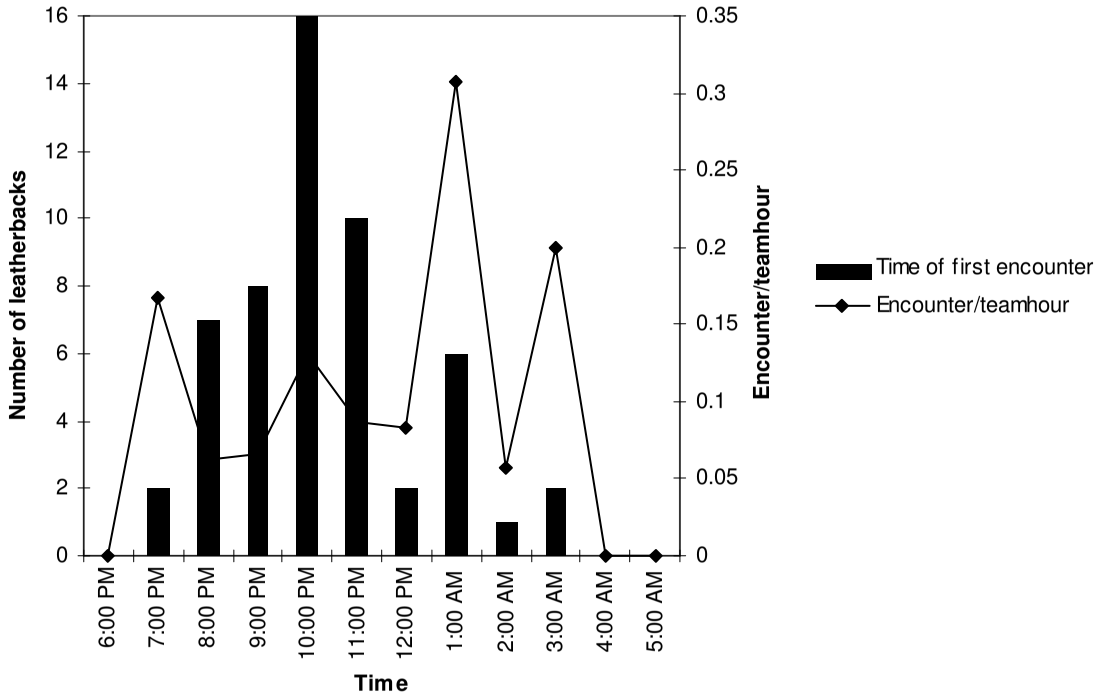
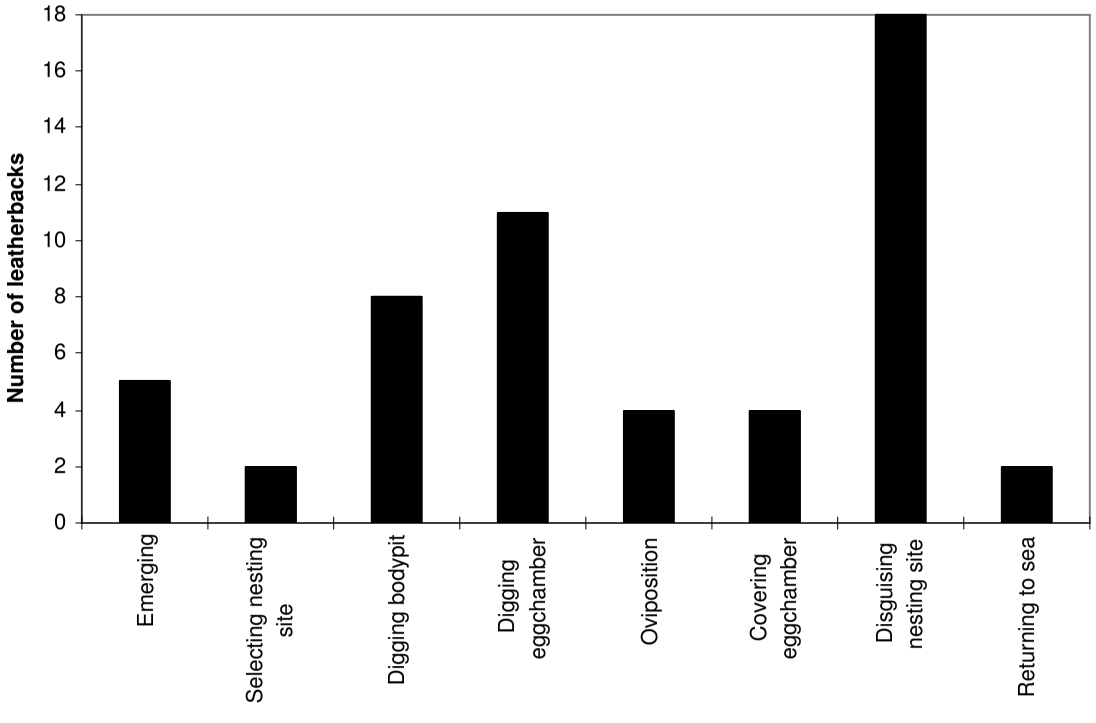


Figure 5. Activity at first encounter.



The activity of leatherbacks at the time of encounter is summarized in Figure 5.

3.4 Biometric Data Collection

The mean carapace length (CCLmin and CCL) and clutch size for leatherbacks are shown in Table 2. Leatherbacks with incomplete caudal projections are not significantly different in terms of carapace length or clutch size from leatherbacks with complete caudal projection (independent t-test $p>0.05$). Hence, data from leatherbacks with incomplete and complete caudal projections have been pooled to determine the overall mean carapace length and clutch size.

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

	Carapace length			Clutch size		
Caudal projection	**n**	**□ CCLmin (cm) ± S.D.**	**□ CCL (cm) ± S.D.**	**n**	**□ eggs ± S.D.**	**□ yolkless eggs ± S.D.**
Complete	33	151.2±6.7	153.3±7.0	16	82.1±22.1	27.5±16.2
Incomplete	10	155.6±8.0	157.6±8.1	5	80.4±19.1	29.4±20.4
Total	**43**	**152.2±7.2**	**154.3±7.4**	**21**	**81.7±20.5**	**28.0±16.6**

Female leatherbacks that were encountered more than once (n=6) were consistently diagnosed as having complete caudal projections in 50% (n=3) of cases, and varyingly diagnosed as having complete and incomplete caudal projections in 50% (n=3) of cases.

The mean carapace length of green, hawksbill and loggerhead turtles are shown in Table 3. Only one of the two loggerheads that were encountered was measured.

Table 3. Mean carapace length (cm) of green, hawksbill and loggerhead turtles.

Species	**n**	**□ CCLmin (cm) ± S.D.**	**□ CCL (cm) ± S.D.**
Green	10	105.5±6.9	
Hawksbill	1		87.6
Loggerhead	1	101.6	

The precision of the carapace measurements are shown in Table 4. The precision of the CCLmin and CCL measurements for leatherbacks was not significantly different for females with complete and incomplete caudal projection (independent t-test $p>0.05$). Therefore, the measurement data were pooled and the precision of the CCLmin and CCL measurements were compared. A paired t-test showed that the precision of the CCLmin measurement was significantly higher than the precision of the CCL measurement ($p<0.05$).

Table 4. Precision of carapace measurements.

Species	**n**	**□ precision for CCLmin (cm) ± S.D.**	**□ precision for CCL (cm) ± S.D.**
Leatherback	43	0.53±0.45	0.81±0.65
Green	10	0.42±0.32	

3.5 Determination of Nest Survivorship and Hatching Success

A total of 16 leatherback nests were marked between 17 March and 23 May 1998. Three of the nests were illegally harvested within one day of oviposition. Four marked nests were not found when attempts were made to determine hatching success. This might have been due to

nest predation that was not observed. As the fate of these nests cannot be determined with certainty, they have been excluded from further analysis.

Fate of marked nests and hatching success for the excavated nests are shown in Table 5a and 5b.

Table 5a. Fate of marked nests.

Fate	**Nests**	**%**
Poached	3	25
Washed out	1	8
Excavated	8	67
(*Lost*	*4*)	
Total	**12**	**100**

Table 5b. Hatching success of leatherback nests.

Nest	Shells	Live hatchlings	Dead hatchlings	Unhatched -embryo	Unhatched -full embryo	Unhatched -no embryo	Depredated	Yolkless	Hatching success	Emerging success
Marked nests										
1	28	0	3	10	5	22	0	4	43.1%	38.5%
2	19	4	3	23	11	22	0	17	25.3%	21.3%
3	13	0	0	4	6	53	0	43	17.1%	17.1%
4	1	0	0	57	11	24	0	40	1.1%	1.1%
5	0	0	0	0	0	81	0	46	0%	0%
6	2	0	0	4	0	66	0	49	2.8%	2.8%
7	1	0	0	1	31	3	0	10	0.9%	0%
8	57	0	0	5	5	10	2	44	72.2%	69.6%
🗀	*15.1*	*0.5*	*1.1*	*16.8*	*5.1*	*43.9*	*0.3*	*31.6*	*20.3%*	*18.8%*
Nests located from hatchling tracks										
1	66	0	5	6	1	29	0	32	64.7%	59.8%
2	30	0	1	4	6	26	0	40	45.5%	43.9%
🗀	*48*	*0*	*3*	*5*	*3.5*	*27.5*	*0*	*36*	*55.1%*	*51.9%*

The marked nest had a lower hatching and emerging success than nests that were located from hatchling tracks (Figure 5b).

3.6 Physical Data Collection

Precipitation is shown in Figure 6 and Table 6. Periods of heavy rain were interspersed with periods of no rain from March to early June. Thereafter low levels of rainfall were recorded for most days with occasional heavy rains. Air temperature is shown in Figure 6 and Table 6. Sand temperature until the end of May is shown in Figure 7. Rainfall generally caused a drop in air temperature (Figure 6).

Ground water level is shown in Figure 8. Initially there was a problem of sand filling the pipes. Therefore on 10 April, the pipes were dug up, emptied, cleaned and returned to their original positions. Wooden lids were then used to cover the top of the pipes. On two more occasions (11 and 27 May) the pipes were again filled with sand, presumably by children playing on the beach. The pipes were emptied and replaced.

Figure 6. Precipitation and air temperature.

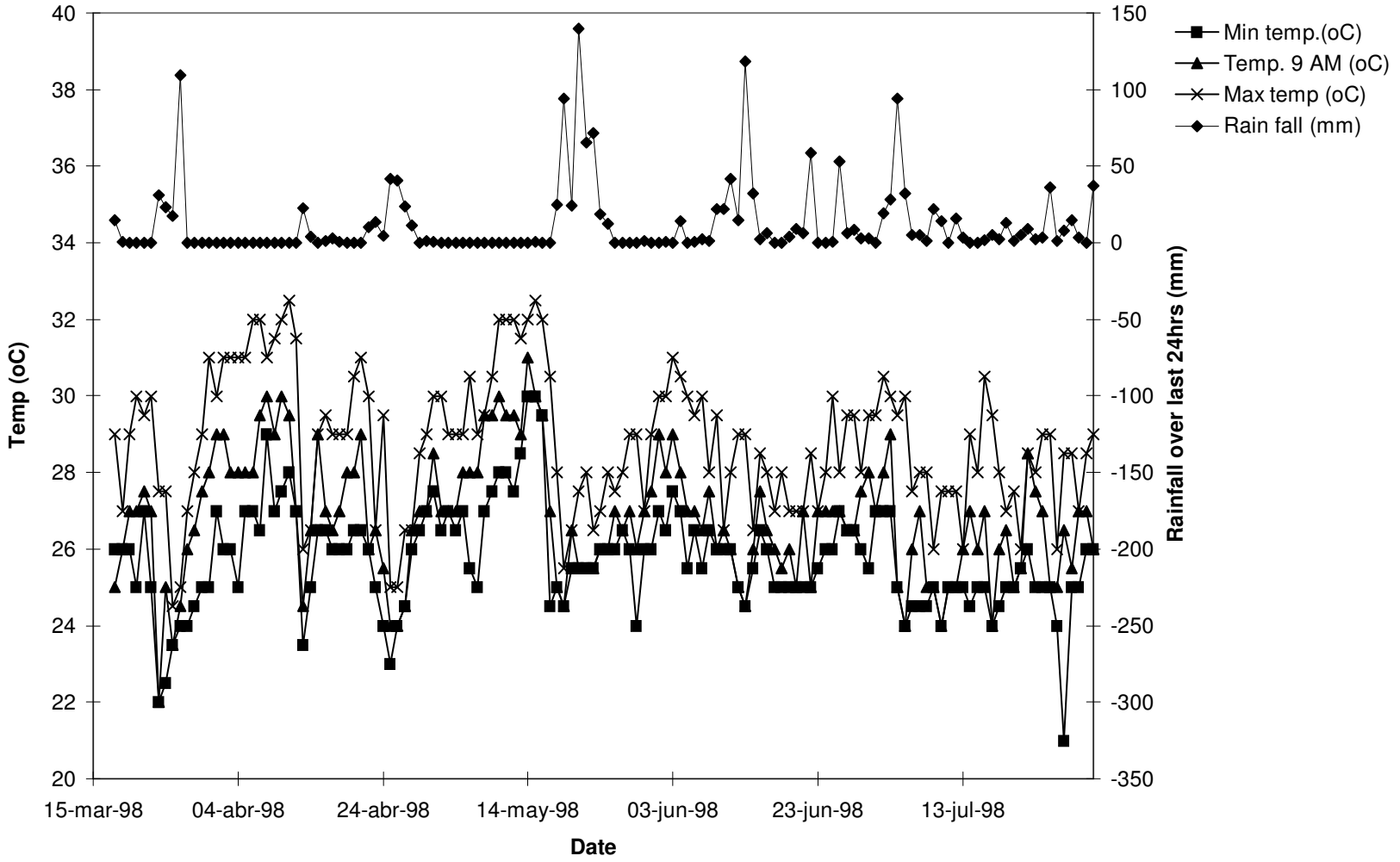


Figure 7a. Sand temperature at 70cm (5m from high tide line)

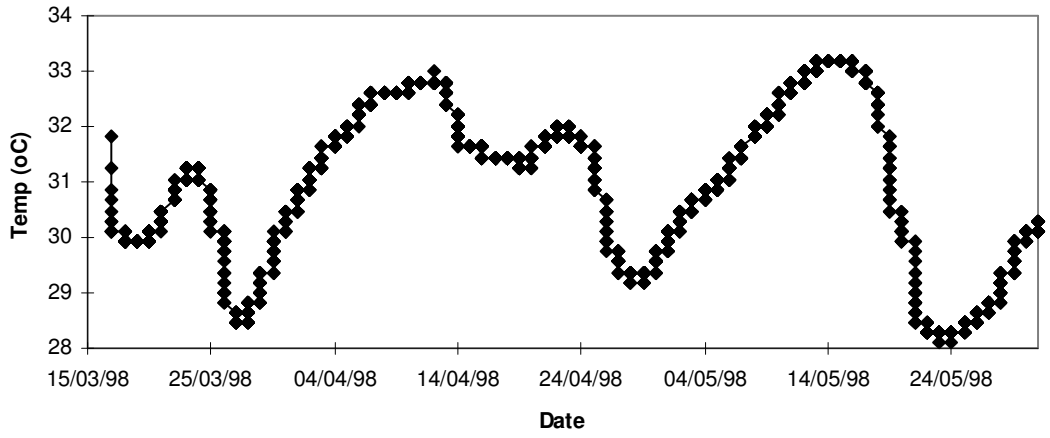


Figure 7b. Sand temperature at 70cm (10m from high tide line)

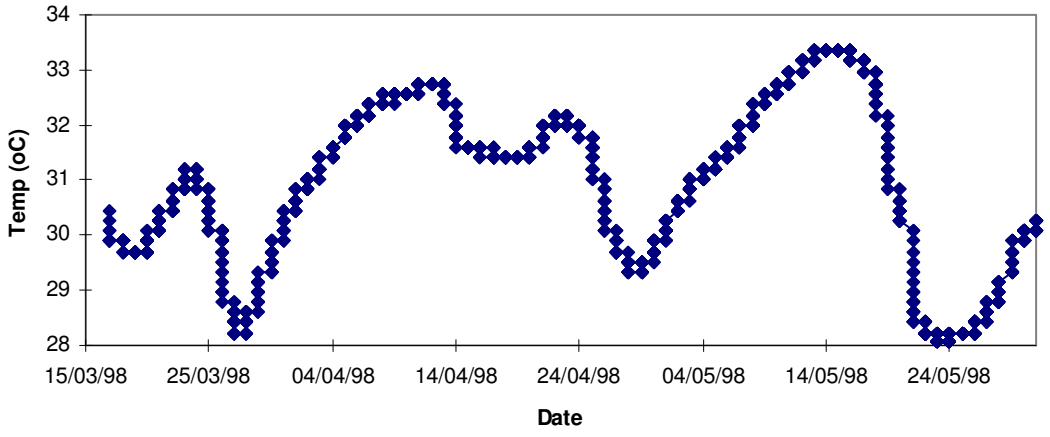


Figure 7c. Sand temperature at 70cm (15m from high tide line)

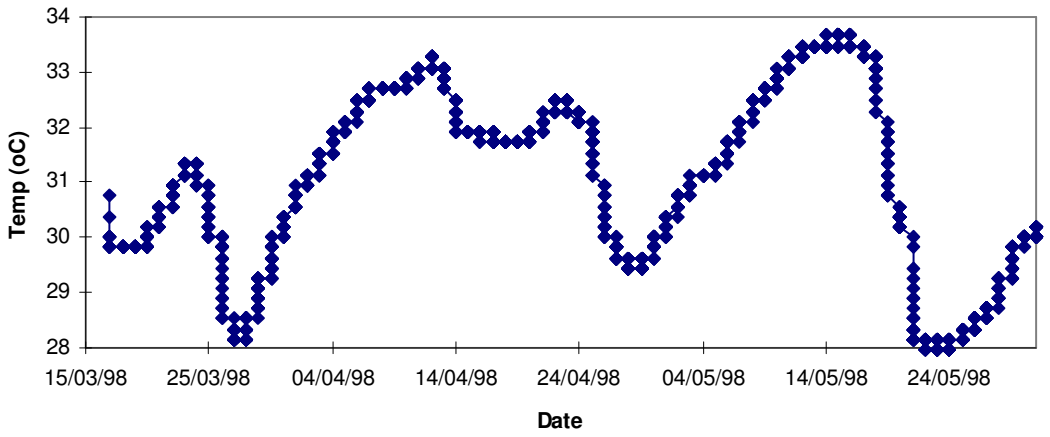
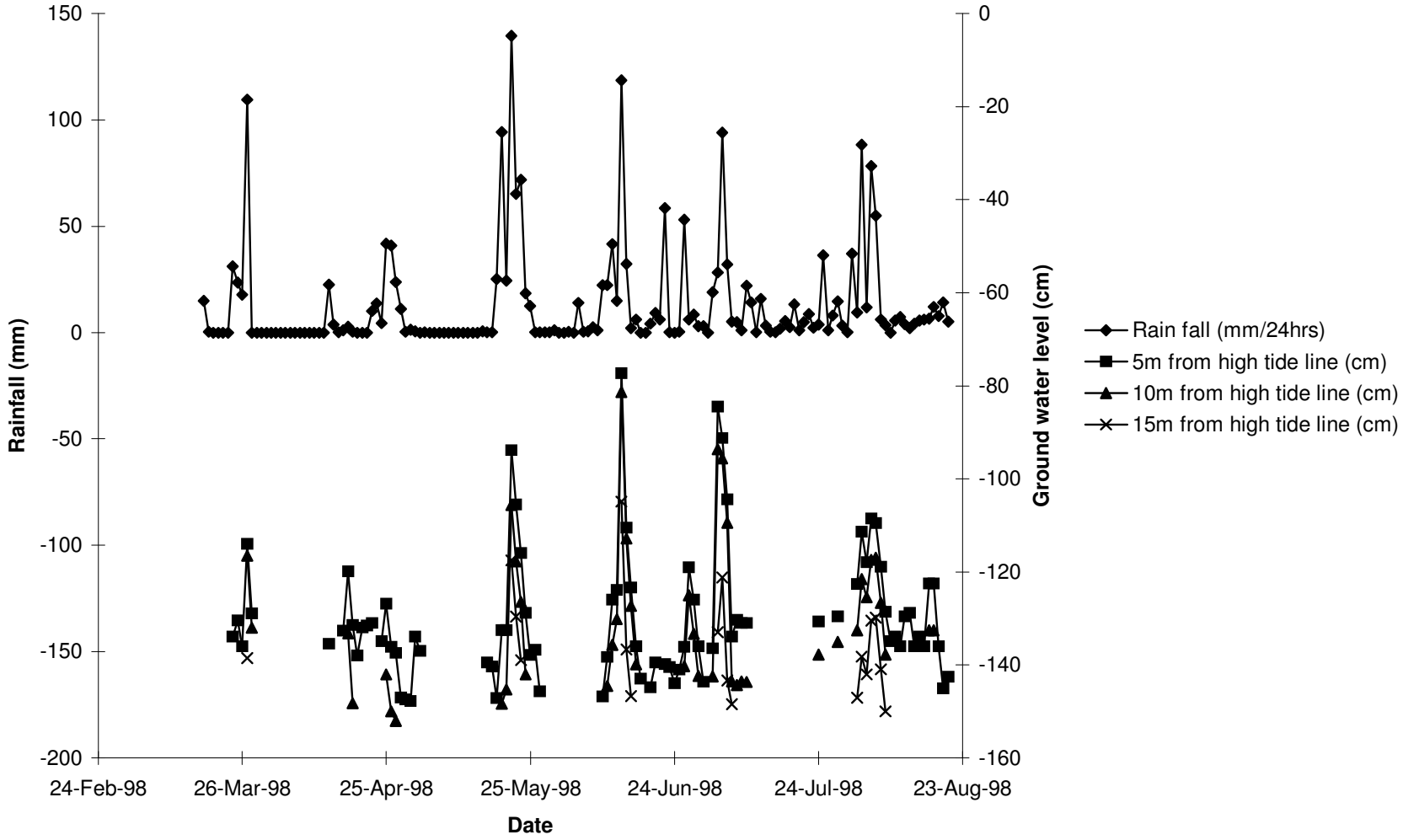


Figure 8. Ground Water Level.



Rainfall caused an increase in the ground water level in the beach (Figure 8). Ground water changes were observed in the PVC pipes at 5 m and 10 m distance from the high tide level at relatively low levels of rain (>1mm/24hrs) (Figure 8). Only when it was raining heavily (>100mm/24hrs) did the ground water level increase sufficiently to be noted in the PVC pipe at 15m distance from the high tide level (Figure 8). Ground water levels were higher than 90cm twice during the study period (13 June and 3 July) and may have drowned nests close to the high tide line.

Table 6. Precipitation and air temperature.

Month	Precipitation Total (mm/month)	Precipitation (mm/24 hrs)	Minimum Temperature (^{o}C)	Temperature at 9 AM (^{o}C)	Maximum Temperature (^{o}C)
March*	N/A	14.1	24.7	25.9	28.1
April	178.3	5.9	26.1	27.4	29.4
May	455.4	14.7	26.6	27.5	29.3
June	430.6	14.4	25.9	26.7	28.6
July	384.5	12.4	25	26.1	28.2

* Data from 18 March onwards

3.7 Collection of Human Impact Data

The number of visitors to Tortuguero National Park i.e. the number of persons paying the park entrance fee for 1995-1997, is shown in Table 7. There appears to have been an increase in the number of visitors to the park from 1996 to 1997, in particular with regards to the number of Costa Rican visitors to the park.

Table 7. Visitors to Tortuguero National Park 1995-1997.

	1995			1996			1997		
Month	No of CR visitors	No of foreign visitors	Total	No of CR visitors	No of foreign visitors	Total	No of CR visitors	No of foreign visitors	Total
January	121	145	266	125	734	859	93	701	794
February	61	569	630	32	724	756	149	766	915
March	68	1162	1230	62	981	1043	95	1089	1184
April	172	1023	1195	130	608	738	124	677	801
May	7	390	397	60	337	397	110	515	625
June	18	294	312	189	504	693	136	448	584
July	106	918	1024	152	832	984	346	1230	1576
August	77	1352	1429	127	1000	1127	195	1252	1447
September	67	549	616	142	603	745	314	834	1148
October	116	183	299	141	344	485	180	689	869
November	90	982	1072	48	490	538	213	1360	1573
December	107	687	794	79	609	688	319	1196	1515
Total	**1010**	**8254**	**9264**	**1287**	**7766**	**9053**	**2274**	**10757**	**13031**

The number of visitors to the CCC Natural History and Visitors Centre was monitored from January 1997 to July 1998 (Table 8). The main tourist seasons in Tortuguero are generally referred to as being July-August and November-March (Tortuguero tourguides pers. com.). However, from the data presented in Table 8 it appears that July-August and January-April are the months with most visitors to Tortuguero.

Table 8. Visitors to the CCC Natural History and Visitors Centre, January 1997-July 1998.

Month	1997 Total	Per Day	1998 Total	Per Day
January	2695	87	2086	67
February	2805	100	2024	72
March	2657	86	1812	58
April	1553	52	1953	65
May	909	29	852	27
June	1194	40	1432	48
July	2526	81	2555	82
August	2498	81		
September	1259	42		
October	1358	44		
November	1468	49		
December*	1401	54		
TOTAL	**22323**	**62**	**12714**	**60**

*No record for 11-15 December

The number of visitors to the CCC Natural History and Visitors Centre was considerably greater than the number of paying visitors to Tortuguero National Park for each month in 1997, with the exception of November.

The capacity of the lodges and cabinas in Tortuguero vastly exceeds the number of tourists visiting the area (Table 9). The tourist lodges are situated away from the village and generally have greater room and bed capacity than the cabinas in the village.

Table 9. Room and bed capacity of the lodges and cabinas in the Tortuguero area.

Lodge/Hotel	Rooms	Beds	Cabinas	Rooms	Beds
Mawamba	38	96	Ms Junie	12	35
Pachira	36	72	Sabina	35	80
Tortuga	24	80	Tortuga	5	15
Caribbean Magic	16	37	Pancana	6	16
Ilan-Ilan	24	60	Aracari	6	18
El Manati	8	21	Pisulin	4	12
Laguna	26	72	CCC	5	28
Jungle	50	110			
Caribe	7	20	**TOTAL**	**302**	**772**

3.8 Dead Turtles

Only one sea turtle, a green, was encountered dead on the beach. It had been dead for several days and all flippers and the head were missing. The cause of death was not possible to determine but there was no evidence of sharkbites. The carcass was washed up by mile 15 4/8.

3.9 Environmental Education Activities

School children and teachers of the Tortuguero school participated in the nightly work of CCC every night between 17-23 April, 28 April-1 May and 5 May.

CCC staff and the RAs were present at an environmental eduction event for the village school and high school at the ACTo station in Tortuguero (Cuatro Esquinas) on 28 April.

The RC together with two RAs visited the Mondonguillo/Pacuare reserve, south of Tortuguero National Park, on 23 and 30 March. The purpose of both visits was to provide groups of 18 staff from the Costa Rican Coast Guard with lectures on sea turtle biology and conservation. Both occasions proved valuable to empower and educate the Coast Guard staff with regards to sea turtle conservation. Also, contacts were made between CCC and Coast Guard staff, which may prove useful in future efforts to curb illegal harvest of sea turtles and their eggs in Tortuguero National Park.

4. DISCUSSION

4.1 Preparations

Renovating mileposts and verifying the distance between mile posts are time consuming activities. However, it makes the RAs more familiar with the beach and the extensive walking required during work activities. The one or two additional markers in front of each mile marker made finding the mile markers considerably easier and it is suggested that this practise is continued in future leatherback and green programs.

Although only one leatherback was encountered during the preparatory camping trip, the trip gave the RAs an opportunity to get to know each other better and also to become familiar with the demanding nature of the nightly tagging work.

4.2 Track Surveys

There appears to be substantial observer variation in determining the freshness of leatherback tracks (Figures 2 and 3). Leatherback tracks are larger than tracks from other species of sea turtle and hence remain visible on the beach for extended periods of time. This is particularly the case during periods of little precipitation such as April (Table 6). Considerable experience is required to accurately conduct track surveys. Therefore, the results of the most experienced track surveyor, Thomas Alonso Rankin, should be considered more accurate (Figure 2a and 2b).

However, the spatial distribution of tracks should not be affected by observer variation. The track surveys of Sebastian Troëng should, therefore, be used to determine spatial distribution as those surveys extended from Boca del Río Tortuguero to Boca del Río Parismina (Figure 3a and b).

The percentage of poached nests should be considered a minimum estimate as the track surveys were conducted early the morning after the nests were deposited (Table 1). The track surveyors regularly encountered poachers on the beach, in particular between mile 5 and Laguna Jalova (Appendix 3). From observations and anecdotal information it can be concluded that the poachers visited this section of beach at least every two or three days, harvesting all sea turtle eggs laid since their last visit. Hence, it is possible that close to 100% of the leatherback nests were illegally harvested. Clearly, increased enforcement of national park legislation is needed along this section of beach.

4.3 Tagging of Nesting Sea Turtles

The total number of sea turtles tagged during nightly work would no doubt increase if more effort was put into the nightly work. The catastrophic decline of leatherback populations in the Pacific (Eckert and Sarti 1997, Liew 1997, Limpus 1997, Spotila *et al.* 1996) has resulted in the Tortuguero population being globally more important and hence efforts to monitor and protect the Tortuguero population should be increased. At least a doubling of the effort i.e. eight RAs should be considered for future leatherback seasons.

The Monel tag retention by the leatherbacks that nest at Tortuguero appears to be satisfactorly considering no leatherbacks lacking tags and displaying old tag holes or notches were encountered. However, other researchers have noted a very high tag loss for Monel tags applied to leatherbacks (P. Dutton pers.comm) and it is therefore suggested that Monel tags are used together with passive integrated transponder (PIT) tags in future leatherback seasons. The relatively low number of females nesting in Tortuguero means that the cost of purchasing PIT tags would be modest in comparison to other program costs.

The encounters with leatherbacks that were previously tagged on other Central American beaches clearly show that there exists a need for regional cooperation in leatherback monitoring and conservation. The first steps have been taken already, and involve CCC, Asociacíon ANAI, the Endangered Wildlife Trust, Panamanian and Honduran organizations. It is anticipated that a joint report, or other publication, addressing leatherback nesting activity and theats to the Central-American Caribbean populations will be produced in the near future. All initiatives increasing inter-organizational coordination and cooperation should be encouraged.

The number of encounters/team hour is not presented in order to suggest hours for the nightly monitoring (Figure 4). Instead it is presented to show that no conclusions, with regards to what hours would yield most turtles, can be made from the data presented in Figure 4. Effects of the tidal cycle, start and end points of the monitored beach sections, and date may influence the number of turtles encountered on the beach at any given moment in time.

The results presented in Figure 5 reflect the duration of the nesting stages. Many leatherbacks were encountered during the most time-consuming stage of nesting i.e. when disguising the nest site (Figure 5). If nightly beach patrol effort was increased, more leatherbacks would be encountered during the early stages of nesting and more egg counts and nest marking could be carried out.

4.4 Biometric Data Collection

The usefulness of diagnosing the caudal projection of leatherbacks as being complete or incomplete can be questioned. In 50% of cases the caudal projection was diagnosed differently during successive observations. Observer variation may be large or the definition of what constituted a complete or incomplete caudal projection was not properly explained to the RAs at the beginning of the season. Also, individuals with incomplete caudal projection did not significantly differ in size from individuals with complete caudal projection (independent t-test $p>0.05$). Unless females get their caudal projections damaged after they reach a certain size or age, or after they have started actively reproducing, the irregular shape does not significantly affect carapace length. Considering the small sample size of individuals

with incomplete caudal projection, it is suggested that the practice is continued for another leatherback season and that the usefulness of the diagnosis is evaluated at the end of the 1999 nesting season.

The precision of CCLmin was significantly higher than the precision of the CCL measurements (Table 4, paired t-test $p<0.05$). Hence, it is suggested that the CCLmin measurement be used as a standard carapace measurement for leatherbacks in Tortuguero and other beaches where individuals from the same population nest.

4.5 Determination of Nest Survivorship and Hatching Success

A total of 25% of the marked nests could not be located in order to determine hatching success. The flagging tape to mark one of the lost nests was tied around two sticks that may have been moved during the incubation period. The other losts nests may have been incorrectly marked or illegally harvested by persons that concealed the poaching event. The first conclusion seems more likely, based upon personal observations.

The flagging tape used to mark nests should be placed high in the vegetation to ensure that loss of marked nests is minimal. Marking three points in the vegetation behind the nest is suggested to improve the localization of marked nests.

Mean hatching success for the marked nests that were located was only 20.3%, with four nests accounting for 96.7% of hatchlings (Table 5b). The most likely cause of the low hatching success of the remaining nests is high ground water levels that drowned the eggs. The overall emerging success for the marked leatherback nests was only 12.5%, if it is assumed that the poached and excavated nests had the same mean number of eggs.

The two nests that were located from hatchling tracks had higher hatching success than the marked nests (Table 5b). The hatching success for leatherback nests in Tortuguero would be grossly overestimated if only nests located from hatchling tracks were excavated.

4.6 Physical Data Collection

Rainfall is clearly a physical factor which has profound effects on physical, chemical and biological parameters. It is, therefore, suggested that rainfall is monitored by program staff during the nesting seasons and by permanent station staff out of nesting seasons.

Rainfall can reduce the air temperature by more than $6^{o}C$ (Figure 7). However, minimum temperature may also be affected by other factors. The minimum temperature fell 6 May and 29 May, despite absence of rain and without a decrease in maximum and 9:00 AM temperatures. The low minimum temperatures for those two days may have been caused by minimal cloud cover at night resulting in rapid heat loss.

High ground water levels have the potential to drown sea turtle nests. There are concerns that changes in land use, which involve the clearing of vegetation further up in the water catchment area, may cause ground water levels in the beach to rise rapidly following rainfall. Changes in ground water levels in response to rainfall were observed as far as 15m from the high tide line during periods of heavy rain (>100mm/24hrs)(Figure 8). The ground water rose high enough to interfere with leatherback nests and it is likely that some nests were

completely drowned (Table 5b). It is, therefore, important to continue ground water monitoring. This information also provides baseline data with which to compare future ground water levels, especially if further clearing of vegetation occurs in the water catchment area.

Lids with locks should be considered for the PVC pipes as it would stop the pipes from being filled with sand by passing children.

4.7 Collection of Human Impact Data

There was an increase in the number of visitors paying the Tortuguero National Park fee from 1995 to 1997 (Table 7). This is likely to reflect a real increase in the number of visitors to the area. To date, no determination has been made as to the carrying capacity of the park in terms of supporting tourism. Studies should be encouraged, in particular if the number of visitors to the area continues to increase.

Both the number of visitors to the CCC Natural History and Visitors Centre and the number of paying visitors to Tortuguero National Park should be considered minimum estimates of the real number of visitors to the area as not all visitors go to CCC or pay the park fee.

The number of visitors to the CCC Natural History and Visitors Centre considerably exceeds the number of paying vistors to Tortuguero National Park (Table 7 and 8). It is unlikely that this reflects the real situation. A more plausible explanation is that not all tourists that enter Tortuguero National Park pay the park fee. The number of visitors to the CCC Natural History and Vistors Centre may, therefore, provide a better index of the number of visitors to the area. The number of paying visitors to Tortuguero National Park may be more severely affected by seasonal and non-seasonal park staff shortages. In other words, the data on paying visitors to Tortuguero National Park may partly reflect the effort put into making the tourists pay the park fee.

The capacity of the tourist lodges and cabinas greatly exceed the number of visitors to the area (Table 7, 8 and 9). Occupancy rates are far from 100%, in particular during the low seasons of May-June and September-October.

4.8 Dead Turtles

The carcass of a green turtle was washed up by mile 15 4/8, close to where fishermen were observed setting nets four days earlier (Appendix 3). Although there is no direct evidence supporting that the turtle was accidentally caught in the fishing nets, such a cause of death can not be ruled out.

4.9 Environmental Education Activities

The cooperative efforts between the Tortuguero school and the CCC were appreciated both by the school children, their teachers and CCC staff. Further cooperation in coming years is anticipated and will contribute to raising conservation awareness in the local community as well as improving relations between the local community and the CCC. However, environmental education does not address low salaries, drug abuse or lack of work which are major contributing factors to the illegal harvest of turtles and eggs that occur in the area.

The request for lectures on sea turtle biology and conservation from the Costa Rican coastguard is a positive sign that interdepartmental cooperation for sea turtle conservation is increasing. It is also further proof of the unparallelled level of conservation awareness Costa Rica has managed to raise in its citizens. Further cooperation during the green turtle program is anticipated and should be encouraged.

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6. RECOMMENDATIONS

6.1 Preparations

Two or three posts should be placed at each mile marker position to make the mile markers easier to find on dark nights.

6.2 Track Surveys

The RC should conduct regular track surveys between Boca del Río Tortuguero and Boca del Río Parismina. The track surveys provide CCC with important data on nesting activity and harvest trends as well as making the RC aware of human activities occuring on the beach.

6.3 Tagging of Nesting Sea Turtles

At least eight research assistants are needed to increase the beach coverage during the nightly tagging work.

6.4 Biometric Data Collection

For leatherbacks, the measurement with highest precision, i.e. CCLmin, should be used.

6.5 Determination of Nest Survivorship and Hatching Success

Nests should be marked with flagging tape high in the vegetation, preferably inconspicuously. Flagging tape should not be attached to sticks or other items that can be moved by passers-by. The success of localizing marked nests for excavation may increase if each nest is marked at three points in the vegetation.

6.6 Physical Data Collection

It is necessary to put lids on the PVC pipes that are used for monitoring the ground water level, to prevent them filling up with sand.

6.7 Collection of Human Impact Data

The results from this year's census of the capacity of the lodges and cabinas should be disseminated to the managers and owners of the lodges and cabinas when the census is repeated next year.

6.8 Dead Turtles

Dead turtles should be recorded when they are encountered in conjunction with other monitoring activities. No extra effort is required to locate or count dead turtles during the Leatherback Program.

6.9 Environmental Education Activities

Environmental education activities involving the village school and the RAs provide both parties with valuable experience and should be part of future leatherback and green turtle programs.

Any initiatives increasing inter-organizational and inter-departmental cooperation with regards to sea turtle conservation should be strongly encouraged.

APPENDIX 1. Sea Turtle Encounters During the 1998 Leatherback Program.

	Leatherbacks			Green		Loggerhead	Hawksbill
Date	Newly tagged	Previously tagged	Renesters	Newly tagged	Renesters	Newly Tagged	Newly tagged
17 March	1						
20 March	1						
21 March				1			
22 March	1						
27 March		2					
29 March	1						
31 March	1						
4 April	1						
5 April	1						
6 April		1					
7 April	2						
8 April	1						
11 April		1					
14 April				1			
16 April	1	1					1
18 April	2						
19 April	1						
21 April			1				
22 April	2	2	2				
24 April	1		1	1			
27 April		1	1				
29 April	1	2			1		
30 April		1	1				
1 May	1						
2 May		1					
3 May		1					
4 May		1					
6 May				1		1	
9 May			1				
10 May				1			
11 May	2	2	1				
12 May	1						
13 May		1					
14 May	2	2		3			
15 May	2			1		1	
TOTAL	**26**	**19**	**8**	**9**	**1**	**2**	**1**

APPENDIX 2. Biometric Data for Leatherbacks.

ID No	Species	Date	CCLmin (cm)	CCL (cm)	Eggs	Yolkless eggs	Caudal projection
D6395	Leatherback	29/04/98	146.1	148.6			INCOMPLETE
D6728	Leatherback	22/04/98	153.4	156.7			COMPLETE
D7847	Leatherback	16/04/98	155.5	158.3			INCOMPLETE
D7847	Leatherback	23/05/98	151.9	153.6	78	44	COMPLETE?
D8487	Leatherback	14/05/98	156.4	158.2	76	9	COMPLETE
D8513	Leatherback	27/04/98	162.3	165.4	73	48	COMPLETE
D10452	Leatherback	02/05/98	146.4	148.5	85	33	COMPLETE
54241	Leatherback	13/05/98	154.8	156.4	102	24	COMPLETE
57762	Leatherback	11/05/98	151.3	152.2			INCOMPLETE
60466	Leatherback	27/03/98	139.5	140.5	55	43	COMPLETE
61937	Leatherback	30/04/98	152.2	155.1			COMPLETE
65106	Leatherback	11/04/98	148.0	150.2	74	18	COMPLETE
65128	Leatherback	11/05/98	159.7	161.5			COMPLETE
65130	Leatherback	22/04/98	159.9	161.0			COMPLETE
65203	Leatherback	03/05/98	159.9	162.6			COMPLETE
65210	Leatherback	06/04/98	158.4	160.4			COMPLETE ?
65210	Leatherback	24/04/98	146.6	148.1	106	7	INCOMPLETE
76001	Leatherback	17/03/98	142.2	145.1			COMPLETE
76001	Leatherback	21/04/98	148.9	151.5			COMPLETE
76003	Leatherback	29/03/98	150.2	152.8			COMPLETE
76007	Leatherback	04/04/98	150.1	152.7			COMPLETE ?
76007	Leatherback	22/04/98	152.1	154.1			INCOMPLETE
76009	Leatherback	05/04/98	154.4	156.8			INCOMPLETE
76011	Leatherback	07/04/98	145.7	147.5			COMPLETE
76013	Leatherback	07/04/98	146.9	148.8	128	12	COMPLETE
76015	Leatherback	08/04/98	157.7	159.8			COMPLETE
76019	Leatherback	22/04/98	155.5	159.7	87	9	INCOMPLETE
76025	Leatherback	01/05/98	147.4	150.3			INCOMPLETE
76026	Leatherback	19/03/98	155.1	158.3			COMPLETE
76028	Leatherback	22/03/98	151.3	154.3	97	5	COMPLETE
76030	Leatherback	16/04/98	154.5	157.1			COMPLETE
76033	Leatherback	18/04/98	155.8	158.1	35	6	COMPLETE
76035	Leatherback	18/04/98	150.3	151.4			COMPLETE
76037	Leatherback	19/04/98	154.0	156.5			COMPLETE
76039	Leatherback	24/04/98	168.7	172.1			COMPLETE
76042	Leatherback	29/04/98	145.3	146.5			COMPLETE
76044	Leatherback	12/05/98	143.2	145.5	80	48	INCOMPLETE
76048	Leatherback	14/05/98	135.4	136.9			COMPLETE
76051	Leatherback	22/04/98	146.8	147.2	86	40	COMPLETE
76054	Leatherback	11/05/98	147.3	149.0	89	24	COMPLETE
76056	Leatherback	11/05/98	156.0	157.0	67	52	COMPLETE
76059	Leatherback	14/05/98	159.5	162.2			COMPLETE
76061	Leatherback	15/05/98	161.8	165.5			COMPLETE
76066	Leatherback	15/05/98	160.5	162.6	51	39	INCOMPLETE
77470	Leatherback	14/05/98	151.9	152.9	71	49	COMPLETE
79038	Leatherback	29/04/98	171.8	173.1	104	27	COMPLETE
79038	Leatherback	09/05/98	153.3	155.3	82	14	COMPLETE
79043	Leatherback	04/05/98	149.2	150.5	90	38	COMPLETE

APPENDIX 3. Notes and Anecdotal Information on Illegal Harvest.

Date	Observation
19/03/98	Encountered six poachers on the beach by Mile 11 6/8+ one more poacher in a boat close to the shore. They took at least four leatherback nests + one green turtle nest. The incidence was reported to ACTo in Jalova and Tortuguero 20/3/98.
20/03/98	Nest marked 17/3/98 by mile 2 2/8 poached.
01/04/98	Encountered same poachers as 19/3/98 by Mile 11. They took at least 16 leatherback nests + one green turtle nest.
06/04/98	One fresh leatherback nest poached and four old leatherback nests poached.
06/04/98	Fishing boat 300-400m off the beach at Mile 14 4/8, fishermen setting nets in a 90^{o} angle to the beach.
07/04/98	Child walking down the beach with a metal bar to look for eggs by Mile 4 3/8.
14/04/98	Three old leatherback nests and three fresh leatherback nests poached.
14/04/98	Fishing boat setting nets 300m offshore by Mile 15 4/8.
19/04/98	Seven old leatherback nests and eight fresh leatherback nests poached. One old hawksbill nest poached.
19/04/98	Three poachers by old leatherback track by mile 13 4/8. Boat waiting outside surfzone.
28/04/98	Nine old leatherback nests poached, one fresh leatherback nest poached and one old hawksbill nest poached.
29/04/98	Two poachers encountered at Laguna Jalova (northern side). The next morning their footprints were observed on the beach as the poachers were following the tagging team. Four leatherback nests were poached between Laguna Jalova and mile 15 by the same persons.
04/05/98	Eleven old leatherback nests and eight fresh leatherback nests poached. One fresh green nest and one green turtle poached.
09/05/98	Four boats with poachers from Limon observed off the beach.
11/05/98	Four fresh leatherback nests poached.
11/05/98	Boat (with four poachers) going north by mile 20 4/8.
11/05/98	Boat and three poachers on the beach by mile 2 1/8. They left as two policemen approached. At least three fresh leatherback nests were poached.

Most of the illegal harvest that was observed during the leatherback nesting season was conducted by a few fishermen from Limón. The major market for the leatherback eggs is Limón.

APPENDIX 4. Dead Turtles.

Date	Mile	Species	Sex	Length (cm)	Comments
16-Apr-98	15 4/8	Green	?	95.4	Missing all appendages. Too decomposed to determine sex or cause of death.