REPORT ON

THE 1998 GREEN TURTLE PROGRAM

AT TORTUGUERO, COSTA RICA

Submitted to
Caribbean Conservation Corporation
and
the Ministry of Environment and Energy of Costa Rica.
25 January 1999

by

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ACKNOWLEDGMENTS

The 1998 Green Turtle Program was conducted under a research permit from the Ministry of Environment and Energy of Costa Rica, detailed in resolution Nº 145-98-OFAU.

The research assistants Richard Zanre (UK), Carrie Singer (USA), Tim Pinion (USA), Jairo Castro (Costa Rica), Emma Harrison (UK), David Ayala (Mexico), Lina Maria Hinestroza (Colombia), Alejandro Polo (Spain), Agustín Quijada (Venezuela), Alexander Castillo (Costa Rica), and Pilar Ho (Costa Rica) spent many late nights and early mornings on the Tortuguero beach in order to collect all the data that are presented in this report. They were supported by the work of 61 green turtle program participants whose help and financial assistance are gratefully acknowledged.

Tortuguero Conservation Area (ACTo) staff assisted the green turtle program whenever they could and provided data on turtle walks and the number of visitors. The hard work of the ACTo park guards under the professional and dedicated supervision of Sr. Eduardo Chamorro was the main reason for the 1998 season being a safe time for nesting turtles. Many apologies to Amancio and his friends for not informing them about the "dynamite" dataloggers.

Stanley Velasquez and his colleagues of the environmental commando of the Costa Rican Coast Guard made the most of a difficult situation and helped with protecting the Tortuguero rookery and adjacent marine areas.

Freddy Piedra Pochet, station manager at the John H. Phipps Biological Field Station did an excellent job organizing support for the monitoring activities. His warm personality and friendly manners made everyone feel happy and at home. Luis, the station groundskeeper and William, the boat driver worked long hours to assist the 1998 green turtle program. Adelina and Zelmira fed the starving hordes with Caribbean delicacies. José Antonio and Edgardo made sure the station was safe at night.

The birdbanders Daniel van den Broek, Rob Emerson, Andy Day and the visitors center administrators Mario Zamora and Grethel Zamora assisted in turtle work and contributed to the field station fun.

Thomas Alonso Rankin González conducted track surveys and gave useful advice on many aspects of the green turtle program. The villagers of Tortuguero provided support and good times for all CCC staff. A special thanks to the teachers of the school and the students of T.A.A.F.F. for their help with patrolling the beach. Tony and Rubier were particularly keen to participate in the nightly tagging efforts. The tour guides from Tortuguero, and the tourist lodges, are thanked for seeking mutually beneficial solutions to problematic situations that arose during the green turtle program. We hope that our cooperation and friendship can continue and expand in future nesting seasons.

Sr. Enrique Obando of the Tortuguero Development Association kindly provided data on the money raised from the turtle walks. The lodge managers and cabinas owners in Tortuguero also provided information when requested.

Sr. Ronaldo “Don Ming” Coward, the proprietor of El Delphin in Cieneguita is thanked for allowing us to collect data from the green turtles awaiting slaughter. The Rankin brothers, Roberto and Danny, gave us the fishermen’s point of view with regards to the green turtle fishery. Willis Rankin gave us a lift from Limón to Matina.

Sr. Miguel Madrigal, technical advisor to the Minister of Environment and Energy, worked hard to drum up support for increased turtle protection in Limón. He is thanked for allowing us to participate in meetings and provide feedback on action plans.

Roxana Silman and Liliana Vargas of the CCC San Jose office made the 1998 green turtle program possible with their limitless energy and unconditional support. The staff of the CCC office in Gainesville - David Godfrey, Cindy Taft, Dan Evans, Eugenio Bermudez, Pat McCloskey, Cristina Escobar, Kim Allen, Rebecca Fry, and Sue Ellen Smith are thanked for providing help whenever needed and for bringing much appreciated gifts to the program staff.

1. INTRODUCTION

Green turtles (*Chelonia mydas*) have been studied every nesting season in Tortuguero since 1954, and under the direction of Caribbean Conservation Corporation (CCC) since 1959. The protocol for CCC's green turtle monitoring program was revised in preparation for the 1998 nesting season. The new protocol 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*". The monitoring protocol was developed by the staff and Scientific Advisory Committee of the CCC to be consistent with international standards for sea turtle monitoring. In comparison with previous years, the revised protocol includes additional areas of study such as monitoring of physical data and hatching success, and decreases the effort put into the tagging of nesting female turtles. The objectives of this report are to summarize and discuss the results of the 1998 green turtle monitoring program. Recommendations for future green turtle programs are given in the final section of the report.

2. METHODS

2.1 Preparations

The Research Assistants (RAs) arrived in Tortuguero 13-15 June 1998. During the first week they were given lectures on sea turtle biology, the monitoring protocol, station rules and other information relating to the green turtle program. Practical training in tagging and data collection were provided along the northern five miles of beach as well as further into the national park, between miles 12 and 15.

The mile markers along the northern five miles were repaired and painted during the first days of the green turtle program. The same mile marker positions were used as during the 1998 leatherback program (Troëng et al. 1998).

2.2 Track Surveys

Track surveys were conducted approximately weekly during the entire green turtle program. Track surveys were always conducted by Sr. T.A. Rankin and nesting activity was recorded from Tortuguero river mouth (mile -3/8) to Jalova lagoon. The surveys begun at dawn (5:00-5:30 AM) at Tortuguero village and finished at 9:30-10:00 AM by Jalova lagoon. The beach section between Tortuguero river mouth and village was surveyed in the afternoon the same day by the same person. Only tracks from the previous night were recorded and for each track were recorded: species, mile section, false crawl or nest, and if the turtle was depredated or not. Dead turtles were considered depredated by jaguars if they were surrounded by jaguar tracks or showed characteristic jaguar injuries.

2.3 Tagging of Nesting Sea Turtles

Tagging teams were patrolling the beach every night between 13 June-25 October (except 14 June and 24 October). The number of teams varied from one to four, depending on the number of research assistants and program participants resident at the field station. The

beach was divided into two sections: mile -3/8 to the field station (at mile 2 5/8) and the field station to the mile 5 marker. Each section was patrolled by separate teams and by different teams at 8-12 PM and 12-4 AM, when the number of station residents allowed.

Every encountered turtle that had finished nesting was checked for old tags. Turtles without old tags were tagged in each front flipper, axillary, proximal to the first scale. Species, mile section, tagger, nest zone (open, border, vegetation, or did not lay) and special characteristics or injuries were noted for each tagged turtle.

Tags used during the 1998 Green Turtle Program include Inconel #681 tags, no. 80019-80023, 80040-80043, 80046-83000 and Monel #49 tags, no. 76072-76073. (Inconel #681 tags, no. 80001-80018, 80024-80039, 80044-80045 were used during the 1998 leatherback program).

2.4.1 Green turtles

A sample of green turtles without old tags were tagged using Inconel #681 tags. One green turtle was tagged with Monel#49 tags no. 76072-76073.

Probability of tag loss was calculated for green turtles tagged with two Inconel #681 tags and subsequently encountered with one or two tags. The probability of tag loss is $1-K_i=1-((2r_{di})/(r_{si}+2r_{di}))$ where K_i is the probability of retaining a tag during the interval i, r_{di} is the number of turtles encountered carrying two tags at interval i and r_{si} is the number of turtles encountered carrying one tag at interval i (Wetherall 1982). Probability of tag loss was estimated for first-to-last encounter.

2.4.2 Hawksbills

Hawksbills were tagged with Inconel #681 tags. Tissue samples were collected from the hawksbills by prepunching the tagging site with a leather hole punch. The samples were kept in ethanol in the field station fridge until a CITES permit was obtained and the samples could be sent to Dr. Anna Bass at the University of Florida, for analysis. The tagging team always remained with the hawksbill until it had returned to the sea and thoroughly deleted the tracks afterwards.

2.4.3 Leatherbacks

Leatherbacks were tagged in the rear flippers using Monel #49 tags.

2.4 Biometric Data Collection

2.4.1 Green turtles

Biometric data were collected from a subsample of nesting green turtles. An attempt was made to count 1-2 clutches of eggs per night as the eggs were being laid. The person counting the eggs was wearing a plastic glove so as not to contaminate the nest. Eggs were counted using an egg counter.

All tagged turtles were measured after they had finished nesting, if time allowed. Curved carapace length minimum (CCLmin), from where the skin meets the carapace by the nuchal

notch to the posterior notch between the supracaudals, along the midline, was determined to the closest millimeter using a fiberglass measuring tape. Straight carapace length maximum (SCLmax), from the anteriormost edge of the carapace to the posterior tip of the supracaudals, was determined, to the closest millimeter, using a set of calipers. Both CCLmin and SCLmax were taken three times by the same person, whose name was recorded in the field book, in order to determine the precision of the measurements. Precision is defined as the difference in cm between the longest and the shortest of the three measurements.

A sample of 30 green turtles awaiting slaughter were measured and weighed during a 20 August visit to El Delphin. El Delphin is a seafood processing plant in Limón and the only site where green turtles can be legally slaughtered in Costa Rica. Weight (kg), CCLmin, curved carapace width, tail length from the plastron to the tip of the tail and tail length from the end of the carapace to the end of the tail were recorded for each turtle.

2.4.2 Hawksbills

All hawksbills encountered during nightly tagging work were measured. The clutch was counted, if the hawksbill had not already started laying at the time of encounter.

2.4.3 Leatherbacks

CCLmin (from where the skin meets the carapace by the notch of the neck to the posterior end of the caudal projection, next to the central ridge) was measured using two 150cm fiberglass measuring tapes that had been stapled together.

2.5 Fibropapilloma Assessment

2.5.1 Green turtles

The green turtles for which clutches were counted, were also examined for fibropapillomas. All soft body parts, including the cloacal region were examined, using a flashlight with red filter. The absence or presence of fibropapillomas, location of fibropapillomas and persons examining the turtle were recorded.

2.6 Determination of Nest Survivorship and Hatching Success

A sample of green turtle, hawksbill and leatherback nests were marked when the turtles were laying the eggs. The nests were marked with two pieces of flagging tape in the vegetation behind the nest. From 31 July onwards, three pieces of flagging tape were used, to make up for pieces of flagging tape that were lost as a result of camouflaging turtles, feeding insects or persons removing the tapes.

The distance from the nest to the vegetation and to the latest high tide line were recorded when the nest was being marked.

Marked nests were inspected daily. Inspection of a nest ceased if it was depredated, dug-up or excavated after hatching. If hatching was observed, the date was noted and the nest was excavated a couple of days later. If no hatchlings were observed the nest was excavated after approximately 65 days. Nests would not be excavated if the excavator encountered a

large number of hatchlings in the nest. If a few hatchlings were encountered, a new shallow hole was dug for them so that they could reach the sand surface and emerge the following night. Nests that could not immediately be found were located by probing for soft sand using a wooden stick (after hatching and emerging had taken place). This technique greatly aided in finding many of the marked nests for excavation.

Date laid, date excavated, date hatched (if available), mile section, excavator, nest code, distance from sand surface to top egg, distance from sand surface to bottom of egg chamber, empty shells, live hatchlings, dead hatchlings, unhatched eggs with no embryo, unhatched eggs with embryo, unhatched eggs with full embryo, pipped eggs, depredated eggs, destroyed eggs and yolkless eggs were recorded for each excavated nest.

In case a nest could not be found, an attempt was made to determine the fate of the nest. The nest was considered poached if an empty egg chamber was encountered. The nest was assumed dug-up by another turtle if broken eggshells and a new bodypit were encountered where the nest was supposed to be located.

2.7 Physical Data Collection

2.7.1 Rainfall

Rainfall over the past 24hrs was recorded daily at 9 AM at John H. Phipps Biological Field Station.

2.7.2 Air temperature

Air temperature (current, minimum and maximum over past 24 hours) was recorded daily at 9 AM at John H. Phipps Biological Field Station.

2.7.3 Sand temperature

Sand temperature was measured using dataloggers located at 70cm depth at 5, 10 and 15m distance from the high tide line (as of 15 March) by the field station. Dataloggers were also placed at 70cm depth at 4, 8 and 12m distance from the high tide line (as of 21 June) in front of the ranger station by mile 11 6/8 and at 5, 13 and 20m distance from the high tide line in front of the mile 3 7/8 marker (as of 22 June).

2.7.4 Ground water level

The level of the ground water was measured daily at 9am, starting 18 March. The water level was determined from the water level in three PVC pipes (8.5cm x 160cm) dug down 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). The ground water level was also measured daily in front of the mile 3 7/8 marker at 5, 10 and 15m distance from the high tide line (as of 22 June).

2.8 Collection of Human Impact Data

2.8.1 Visitors to Tortuguero

The number of visitors to the CCC Natural History and Visitors Center was estimated from the number of paying tourists that entered the center. The number of tourists visiting

Tortuguero National Park was estimated from the number of visitors that paid the entrance fee at the park office in Tortuguero.

2.8.2 Capacity of hotels and cabinas

The cabina owners and hotel managers provided information on the room and bed capacity of their respective establishments.

2.8.3 Turtle walks

The number of tourists going on turtle walks was estimated from the permits that were issued to tour guides by Tortuguero Conservation Area (ACTo). The Tortuguero Development Association recorded the money raised from tour guide fees, to be used for community projects.

2.8.4 Artificial lights

Lights along the northern 5 2/8 miles of beach were monitored monthly from June to September 1998. Light surveys were carried out when there was no moon visible. The mile section, light source and location (beach side or lagoon side) were recorded for each artificial light.

2.8.5 Hatchling orientation

Hatchling orientation was determined for a subsample of nests from which a large number of hatchlings had emerged the previous night. The observer, mile section, distance from the nest to the sea (m), the approximate number of tracks, the angular range of the tracks 10 m from the nest (^{o}), the angular range minus outlier at 10 m distance from the nest (^{o}) and the modal direction at 10 m from the nest (^{o}) were determined for each hatchling orientation, using a compass.

2.9 Environmental Education Activities

Regular environmental education activities were aimed at the Tortuguero school children and the school children's ecological group T.A.A.F.F. Talks and slide shows about sea turtle biology, conservation and environmental economics were given opportunistically to groups of educator and decision makers staying at or passing by the field station.

3. RESULTS

3.1 Track Surveys

3.1.1 Green turtles

Green turtle nesting was observed from mid-March to November with the main nesting season extending from mid-June to late-October (Figure 1). Peak nesting occurred in late July-early August with more than 2,300 green turtle nests being deposited from the Tortuguero river mouth to Jalova lagoon, in a single night.

The heaviest nesting at Tortuguero beach was at mile 9 and the lowest nesting was at mile 2, north of Tortuguero village (Figure 2). Low levels of green turtle nesting were observed outside of Tortuguero beach, from Barra del Colorado in the north to Gandoca-Manzanillo in the south (pers. obs., D. Chacón pers. comm., S. Rodriguez pers. comm.).

Large scale illegal harvest of green turtles was observed only twice during the 1998 Green Turtle Program, both instances occurring in late August (Figure 3). A total of 12 poached green turtles and 66 poached nests were recorded during other monitoring activities.

Natural depredation of green turtles by jaguars was observed throughout the nesting season, with up to six green turtles killed per night (Figure 4). The jaguar(s) ate only the neck muscles of the turtles and left the remainder to be consumed by vultures and other scavengers. The jaguar(s) ate the flippers of a turtle only on one occasion. The turtles were killed and left in the open in most cases, although jaguar-killed turtles were also encountered in the vegetation behind the beach.

3.1.2 Hawksbills

Results from the track surveys indicate that hawksbills nest in very low numbers (0-4 nests per night), from April to October with peak nesting in July-October (Figure 5).

A partly erased hawksbill track, encountered 5 October during a nest survey, suggests that a hawksbill was poached at mile 2 7/8, the previous night.

3.1.3 Leatherbacks

Leatherbacks nested at Tortuguero from early March to early July, with peak nesting in April-May (Figure 6).

3.2 Tagging of Nesting Sea Turtles

3.2.1 Green turtles

A total of 1,225 green turtles were newly tagged, 286 green turtles with tags from previous years or other projects were encountered and 430 renesters were observed (Appendix 1). One of the green turtles bore Tortuguero tags from the 1997 nesting season, the others had tags from other years or projects.

Three female green turtles with tags from other projects were encountered. Two of the females had been captured and tagged by Drs. Meylan at Zapatilla Cays in Bocas del Toro Province, Panama. The first, encountered 12 September at Tortuguero, was captured whilst mating 14 July 1998. The second, encountered 13 September at Tortuguero, was tagged 11 January 1994 (A. Meylan pers. comm.). The third female, encountered 9 September at Tortuguero, was originally captured in feeding habitat close to Isla Mujeres, Quintana Roo, Mexico and tagged 9 July 1994 by Sr. Germán Andrade of Centro Regional de Investigación Pesquera de Puerto Morelos (R. Marquez pers. comm.).

A total of 44 % of monitored green turtles nested in the open zone (n=779), 38 % nested in the border zone (n=663) and 18% nested in the vegetation (n=310).

Old tag holes or notches were observed in 10 % (n=123 of 1,224) of newly tagged female green turtles that were checked for evidence of old tags.

The probability of within-season tag loss from first-to-last encounter was 0.019±0.012 (Table 1). The number of turtles encountered again with 1998 tags was not large enough to determine if the probability of tag loss varied significantly with person applying the tags.

Table 1. Probability of within-season tag loss from first-to-last encounter.

Tagger	**r_{di}**	**r_{si}**	**1-K_i±95% CL**
RA1	41	0	0±0
RA2	32	0	0±0
RA3	27	0	0±0
RA4	23	0	0±0
RA5	9	0	0±0
RA6	3	0	0±0
RA7	2	0	0±0
RA8	35	1	0.014±0.028
RA9	22	1	0.022±0.044
RA10	42	2	0.023±0.033
RA11	22	3	0.064±0.074
RA12	20	3	0.070±0.080
Mixed taggers	3	1	0.143±0.283
TOTAL	**281**	**11**	**0.019±0.012**

RA=Research Assistant, r_{di}=number of green turtles encountered with two tags, r_{si}=number of green turtles encountered with one tag, 1-K_i=probability of tag loss, 95%CL=95% confidence limits

Two male green turtles were encountered on the beach and subsequently tagged. The first male was washed up during mating, 16 June, and tagged before he could return to the sea. The second male was encountered 17 July, in the process of digging an egg chamber. At the time of encounter the egg chamber was approximately two-thirds complete (estimation). The male continued digging with longer and longer periods of rest in between the digging motions. After 45 minutes he started to cover the egg chamber for three minutes and then progressed to camouflage the nest site for 28 minutes. The male had large claws on the front flippers and a soft plastron. The tail measured: 45 cm from the plastron to the tip of the tail, 35 cm from the edge of the carapace to the tail tip and 35 cm from the plastron to the cloaca. Blood and tissue samples were collected from the male and kept in lysis buffer and ethanol respectively.

3.2.2 Hawksbills

A total of eight individual hawksbills were encountered (Appendix 1). All hawksbills were tagged except for one female that came ashore to nest, in front of Mawamba Lodge (mile 2 2/8), 7 October at 8:30 AM. Although the hawksbill tracks in front of Mawamba Lodge, were obliterated and the nest was not marked, there was evidence of digging in the area the following day, suggesting that the nest was poached.

No hawksbills showed evidence of old tags. One female was encountered twice, the others were encountered once. Tissue samples were collected from five females.

A total of 43 % of monitored hawksbills nested in the open zone (n=3), 29 % nested in the border zone (n=2) and 29% nested in the vegetation (n=2).

3.2.3 Leatherbacks

Only three leatherbacks were encountered (Appendix 1). Two of them were previously tagged and the third was a renester that was encountered during the 1998 leatherback program.

All monitored leatherbacks that laid eggs, nested in the open zone of the beach (n=2).

3.3 Biometric Data Collection

3.3.1 Green turtles

The clutch size and carapace length of female and male green turtles encountered at Tortuguero beach during the 1998 nesting season are shown in Table 2. Included in Table 2 are the carapace measurements from green turtles depredated by jaguars and the sample of 30 green turtles at the slaughterhouse in Limón.

Table 2. Carapace length and clutch size of green turtles.

Sample	n	× CCLmin ± ST.D. (cm)	n	× SCLmax ± ST.D. (cm)	n	× Clutch size ± ST.D. (eggs)
Females - Tortuguero beach	1,392	103.6±5.4	1,154	97.7±5.1	192	108.6±20.9
Males - Tortuguero beach	2	97.1±0.4	2	91.9±1.0	N/A	N/A
Females – Depredated by jaguar	8	102.8±3.6	N/A	N/A	N/A	N/A
Male - Depredated by jaguar	1	93.9	N/A	N/A	N/A	N/A
Slaughterhouse - Limón	30	101.3±5.3	N/A	N/A	N/A	N/A

All green turtles measured in Limón were larger than the smallest green turtle female encountered at Tortuguero beach.

The tail of the male green turtle was longer than the tail of any of the green turtles in the Limón sample (Table 3).

Table 3. Width, weight and tail length of green turtles.

Sample	n	× Plastron to tail-tip (range in cm)	× Width±ST.D. (cm)	× Weight±ST.D. (kg)
Slaughterhouse - Limón	30	15 - 32	91.6±5.2	112.5±18.1
Male – Tortuguero	1	45	N/A	N/A

Precision of the carapace measurement was higher for the research assistants than for the participants (Table 4a).

Table 4. Precision of carapace measurements for green turtles:
a) during the same encounter

	CCLmin			SCLmax		
Observer	**n**	**×±ST.D.**	**Range**	**n**	**×±ST.D.**	**Range**
Research Assistants	830	0.3±0.2	0 - 2.2	870	0.3±0.3	0 - 3.0
Participants	787	0.4±0.3	0 - 4.2	454	0.4±0.4	0 - 2.7
TOTAL	**1,617**	0.4±0.3	**0 - 4.2**	**1,324**	0.3±0.3	**0 - 3.0**

b) during more than one encounter

	CCLmin			SCLmax		
Encounters	**n**	**×±ST.D.**	**Range**	**n**	**×±ST.D.**	**Range**
2	162	1.1±0.8	0.1 - 5.0	120	1.1±0.7	0.1 - 4.7
3	24	1.5±0.5	0.7 - 2.5	12	1.5±0.5	0.9 - 2.4
4	1	1.3	N/A	1	2.3	N/A

The precision of the carapace measurements was considerably lower if the turtle was measured during more than one encounter than if it was only measured at one encounter (Table 4a and 4b).

3.3.2 Hawksbills

CCLmin was collected from seven of the eight female hawksbills that were encountered, with a mean of 84.4 cm (Table 5). Precision of the carapace measurements during the same encounter was high for hawksbills (Table 6). Only one hawksbill was encountered and measured twice.

Table 5. Carapace length and clutch size of hawksbills.

Sample	n	× CCLmin ± ST.D. (cm)	n	× SCLmax ± ST.D. (cm)	n	× Clutch size ± ST.D. (eggs)
Females - Tortuguero	7	84.4±3.8	3	82.8±2.0	2	156.5±29.0

Table 6. Precision of carapace measurements for hawksbills.

	CCLmin (cm)			SCLmax (cm)		
Encounters	**n**	**×±ST.D.**	**Range**	**n**	**×±ST.D.**	**Range**
1	7	0.2±0.3	0 - 0.8	3	0.3±0.1	0.2 - 0.4
2	1	0.6	N/A	N/A	N/A	N/A

3.3.3 Leatherbacks

Two leatherbacks were measured and only one leatherback clutch counted (Table 7).

Table 7. Carapace length and clutch size of leatherback turtles.

Sample	n	× CCLmin ± ST.D. (cm)	n	× Clutch size (eggs+yolkless eggs)
Females - Tortuguero	2	149.4±6.6	1	76 + 10

3.4 Fibropapilloma Assessment

3.4.1 Green turtles

A total of 195 green turtles were examined for fibropapillomas. Only four of these turtles had obvious fibropapilloma tumors - one had a tumor in the soft body tissue by the neck, two had them on the right front flipper and one had a tumor on the left front flipper. The largest of the tumours measured 5 cm in diameter. None of the affected turtles showed evidence of old tags.

3.5 Determination of Nest Survivorship and Hatching Success

During nightly tagging patrols and morning nest surveys, various predators were observed eating green turtle eggs and hatchlings from non-marked nests. Tayras (*Eira barbara*) and raccoons (*Procyon lotor*) were observed excavating green turtle nests and eating the eggs. Coatis (*Nasua narica*) and domestic dogs (*Canis familiaris*) were seen excavating nests, depredating eggs and hatchlings. A tour guide reported that he saw a cat eating an egg from a nest that had been dug up by a nesting turtle (T.A. Rankin pers. comm.).

Black vultures (*Coragyps atratus*) and turkey vultures (*Cathartes aura*) depredated eggs and hatchlings from nests that had been opened by other predators or nesting turtles. They also depredated inactive hatchlings, waiting at the sand surface, during the day. Yellow-crowned night-herons (*Nyctanassa violacea*) depredated hatchlings at night and a whimbrel (*Numenius phaeopus*) was observed eating a hatchling during the day.

Ghost crabs (*Ocypode quadrata*) dug into nests and depredated eggs as well as hatchlings on their way to the sea. Fly larvae (*Megaselia scalaris*), commonly known as maggots, were found depredating eggs, pipped hatchlings and hatchlings in the nest. Ants were observed depredating or killing: eggs, pipped hatchlings, hatchlings in the nest and hatchlings in the vicinity of the nest.

3.5.1 Green turtles

The eggs in 74.0% of the marked nests were allowed to hatch and the hatchlings allowed to emerge without disturbance. Nesting turtles dug up 8.7% of the marked nests. Poachers harvested 6.7% of the marked nests, dogs depredated 1.0% and coatis depredated 1.5% of the marked nests (Table 8).

The spatial distribution of marked nests or flagging tapes that were tampered with are shown in Figure 7. Disturbed nests and flagging tapes were located in the vicinity of the Tortuguero village (mile 2 5/8 to mile 3 6/8), between Mawamba and Laguna lodges (mile 1 4/8 to mile 2 3/8) and by the airport (mile 6/8 to mile 1 2/8).

Table 8. Fate, hatching and emerging success of marked green turtle nests.

Fate	n	% of total	Hatching success (%)	Emerging success (%)
Undisturbed				
1. Undisturbed.	145	74.0	77.6	74.5
Disturbed				
2. Hatched + hatchlings dug up by tour guides.	3	1.5	88.1	?
3.Two nests together.	4	2.0	69.4*	68.6*
4. Partly dug up by nesting turtles.	9	4.6	55.2*	54.7*
5a. Dug up by nesting turtles.	11	5.6	0	0
5b. Eggshells + new bodypit encountered.	6	3.1	0	0
6a. Poached.	7	3.6	0	0
6b. Empty egg chamber encountered.	6	3.1	0	0
7. Depredated (coatis).	3	1.5	0	0
8. Depredated (dogs).	1	0.5	0	0
9. Partly depredated (dogs) + dug up by turtle.	1	0.5	0	0
TOTAL	196	100		
(10. Flagging tapes removed	5)			
(11. Dug up by turtle after hatching.	1		?	?)
(12. Undetermined.	2)			
(13. Reburied.	1		0	0)

*Assuming an original nest size of ×=111.8

Nests located in the vegetation zone (n=46) were left undisturbed in 65 % of cases, 68% of nests in the border zone (n=80) were undisturbed and 80% of nests in the open zone (n=76) were undisturbed.

The mean distance from the sand surface to the top egg in the clutch was 56.7 cm (range 18-104 cm) and the mean distance from the sand surface to the bottom of the egg chamber was 73.2 cm (range 31-124 cm).

The mean incubation period for the marked nests for which emerging was observed (n= 68) was 53.7 days (range 48-65 days).

Table 9. Results of nest excavations.

Fate	Empty shells	Pipped eggs	Live hatchlings	Dead hatchlings	Unhatch. embryo	Unhatch. full embryo	Unhatch. no embryo	Depred.	Destr.	Total eggs	□ eggs/nest
1	12578	441	332	163	267	1391	1068	461	5	16211	111.8
2	310	11	4	1	1	16	11	3	0	352	117.3
3	621	12	2	5	15	38	89	25	2	802	200.5
4	555	26	2	3	27	26	92	22	5	753	83.7
ALL	**14065**	**490**	**341**	**172**	**314**	**1471**	**1357**	**532**	**20**	**18249**	**N/A**

Fate 1=Undisturbed, 2=Hatched + hatchlings dug up by tour guides, 3=Two nests together, 4=Partly dug up by nesting turtles

A total of 18,249 eggs were excavated and their fate determined (Table 9). If it is assumed that disturbed nests originally contained the same number of eggs as the undisturbed nests

(x=111.8), the overall hatching success (disturbed + undisturbed nests) was 62.8 % and the overall hatchling emerging success was 60.0 %.

Unhatched albinos, twins and triplets made up 0.07 % of the green turtle eggs (Table 10).

Table 10. Incidence of albinism, twins and triplets.

	n	**% of total eggs**
Albinos	8	0.044
Twins	4	0.022
Triplet	1	0.005
TOTAL	**13**	**0.07**

3.5.2 Hawksbills

One of the marked hawksbill nests was dug up by a nesting turtle and two of the nests were undisturbed (Table 11). The mean emerging success of the hatched nests was low (54.5 %) as a majority of the hatchlings in one of the nests died close to the sand surface, presumably due to high sand temperature during the day.

Table 11. Results of hawksbill nest excavations.

Fate	Nests (n)	Shells	Pipped	Live hatchl.	Dead hatchl.	Unhatch. embryo	Unhatch. full embryo	Unhatched no embryo	Depred.	Total eggs	Hatching success	Emerging success
1	2	289	19	5	81	1	7	23	6	354	89.5 %	54.5 %
5b	1									?	0 %	0 %

Fate 1=Undisturbed, 5b=New bodypit encountered (dug up by nesting turtle)

3.5.3 Leatherbacks

Both marked leatherback nests hatched, with a mean emerging success of 51.5 % (Table 12).

Table 12. Results of leatherback nest excavations.

Fate	Nests (n)	Shells	Pipped	Live hatchl.	Dead hatchl.	Unhatch. embryo	Unhatch. full embryo	Unhatched no embryo	Depred.	Total eggs	Hatching success	Emerging success
1	2	85	2	2	1	26	6	38	0	157	55.4 %	51.0 %

Fate 1=Undisturbed

3.6 Physical Data Collection

3.6.1 Rainfall

The daily rainfall for 1 June-6 November is shown in Figure 8. Rainfall was greatest in June with 430.6 mm (Table 13). The only month with less than 200 mm of rain was September (80.9 mm).

Table 13. Rainfall, June-October 1998.

Month	Total rainfall (mm/month)	× rainfall (mm/24hrs)
June	430.6	14.4
July	384.8	12.4
August	375.2	12.1
September	80.9	2.7
October	225.5	7.3

3.6.2 Air temperature

Air temperature varied little with July being the coolest and September the warmest of the months (Table 14).

Table 14. Air temperature, June-October 1998.

Month	× minimum temp. (°C) *	× temp. at 9 AM (°C) **	× maximum temp. (°C) *
June	25.9	26.7	28.6
July	25.0	26.1	28.2
August	25.3	26.3	28.3
September	26.0	27.5	30.2
October	25.4	26.4	28.3

*No data for 28 August, **No data for 28 August, 10 October, 23 October, 26 October

3.6.3 Sand temperature

Nesting turtles and changes in beach morphology affected the depth of the temperature data loggers (Table 15). Mean monthly temperature at 70 cm depth varied from 25.9 ºC (5 Aug-8 Aug) in the vegetation zone at mile 11 6/8 to 34.3 ºC (30 Sept-2 Oct) in the open zone at the field station. Shading by vegetation and greater depth appear to have lowered the mean temperature. One data logger at mile 11 6/8 failed after being dug up by a nesting turtle and left exposed on the beach. A second data logger, located in front of the field station, failed for no apparent reason.

Table 15. Mean monthly sand temperatures.

	Field station (*1 June-)			Mile 3 7/8 (*22 June-)			Mile 11 6/8 (*21 June-)		
Distance to high tide line (m)	**5**	**10**	**15**	**5**	**13[a]**	**20[b]**	**4[c]**	**8**	**12[d]**
Zone	Open	Open	Open	Open	Open	Bord.	Bord.	Bord.	Veg.
Depth (cm)	*70*	*70*	*70*	*70*	*70*	*70*	*70*	*70*	*70*
June*, × temp (ºC)	30.6	30.5	30.5	29.0	28.7	26.9	28.5	FAIL	26.6
July, × temp (ºC)	30.6	30.3	30.5	28.9	29.0	27.1	28.7	FAIL	26.6
August, × temp (ºC)	30.4	30.2	30.4	28.8	(29.3)	27.0	-	FAIL	26.3
Retrieval depth (cm)	*70*	*70*	*70*	*90*	*35*	*70*	*0*	*0*	*0*
Depth (cm)	*70*	*70*	*70*	*70*	*30*	*70*	*70*	*N/A*	*70*
September, × temp (ºC)	33.3	FAIL	33.3	30.6	(32.9)	(29.4)	30.8	N/A	29.2
October, × temp (ºC)	31.8	FAIL	31.7	29.5	(30.2)	(28.9)	30.1	N/A	28.5
Retrieval depth (cm)	*69*	*70*	*67*	*83*	*10*	*36*	*68*	*N/A*	*65*

[a]13 Aug and onwards located at shallow depth, moved by nesting turtle
[b]7 Sept and onwards located at shallow depth, moved by nesting turtle
[c]3-30 August excluded due to removal by nesting turtle
[d]30 August-4 September excluded due to removal by nesting turtle and park guards

Examples of sand temperature profiles are shown in Figure 9. Periods of high sand temperature coincide with periods of little rain (Figure 8).

3.6.4 Ground water level

The ground water level was generally lower than could be observed in the PVC pipes but occasionally increased to levels higher than a meter. The maximum water level was higher in the pipes that were placed by mile 3 7/8 than in the pipes in front of the field station (Table 16). The pipe closest to the sea at mile 3 7/8 was below the high tide line from 3 August onwards due to erosion of that section of beach.

Table 16. Maximum ground water level (cm), June-October 1998.

	Maximum water level (cm) - Field Station			Maximum water level (cm) - Mile 3 7/8		
Month	**Pipe 1**	**Pipe 2**	**Pipe 3**	**Pipe 1**	**Pipe 2**	**Pipe 3**
June	77.3	81.4	104.9	64.2	74.1	98.1
July	84.5	93.7	121.2	38.5	48	73.2
August	108.6	117	129.8	sand	97	111
September	no water	no water	no water	sand	no water	no water
October	131.6	125.8	no water	sand	99.1*	127.4

*No data for 26-27 October

3.7 Collection of Human Impact Data

3.7.1 Visitors to Tortuguero

The results of monitoring the number of visitors to the CCC Natural History and Visitors Center, January 1997-October 1998 are shown in Table 17.

Table 17. Visitors to the CCC Natural History and Visitors Center, January 1997-October 1998.

	1997		1998	
Month	**Total**	**× Per Day**	**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	2809	91
September	1259	42	1565	52
October	1358	44	1006	32
November	1468	49		
December*	1401	54		
TOTAL	**22323**	**62**	**18094**	**60**

*No record for 11-15 December 1997

The number of foreign visitors to Tortuguero National Park remained more or less the same from 1996 to 1998 but Costa Rican visitors paying the park fee more than doubled during the same time period (Table 18).

Table 18. Visitors to Tortuguero National Park, January 1996-October 1998.

	1996			1997			1998		
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	125	734	859	93	701	794	114	748	862
February	32	724	756	149	766	915	943	688	1631
March	62	981	1043	95	1089	1184	154	742	896
April	130	608	738	124	677	801	248	594	842
May	60	337	397	110	515	625	122	375	497
June	189	504	693	136	448	584	93	439	532
July	152	832	984	346	1230	1576	289	981	1270
August	127	1000	1127	195	1252	1447	347	1636	1983
September	142	603	745	314	834	1148	172	864	1036
October	141	344	485	180	689	869	196	617	813
November	48	490	538	213	1360	1573			
December	79	609	688	319	1196	1515			
Total	**1287**	**7766**	**9053**	**2274**	**10757**	**13031**	**2678**	**7684**	**10362**

3.7.2 Capacity of hotels and cabinas

The total capacity of the hotels and the cabinas in the Tortuguero area amounted to 302 rooms or 772 beds (Table 19). The majority of this capacity is shared by the hotels/lodges that are located away from the Tortuguero village.

Table 19. Room and bed capacity of the hotels and cabinas in the Tortuguero area.

Hotels/Lodges	**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	*Total - Cabinas*	*73*	*204*
Caribe	7	20			
Total - Hotels	*229*	*568*	**TOTAL**	**302**	**772**

3.7.3 Turtle walks

A total of 16,972 tourists paid to go on turtle walks between 25 June and 31 October (Table 20). Local tour guides charged tourists a minimum of US$5 per person for a nightly turtle walk. The tourist lodges charged up to US$25 per person for the same tour. Hence, the total income from the turtle walks amounted to a minimum of US$84,860.

For each tourist going on a turtle walk, the guide or lodge, paid c150 (=approx. US$0.56) to the Tortuguero Development Association. The fee was taken from the money that the tourists paid for the walk. A total of c2,489,400 (=approx.US$9,220) was raised from this fee during the 1998 green turtle season, for the purpose of building a small sports court for the village children. The turtle walk fee has been in place since 1994. Previous projects include making improvement to the water system, constructing a playground, building a house for the teachers and renovating the police station (E. Obando pers. comm.).

Table 20. Tourists paying to go on turtle walks, June-October 1998 (data from ACTo).

Month	Park (mile 3 3/8 to 5)	Public beach (mile -3/8 to 3 3/8)	Total	Tour guide nights
June*	53	407	460	73
July	1059	3913	4972	649
August	1431	4679	6110	729
September	654	2685	3339	484
October	383	1708	2091	309
TOTAL	**3580**	**13392**	**16972**	**2244**

*Permits only issued for 25-30 June

3.7.4 Artificial lights

Artificial lights that were visible from the beach were located from mile 3 3/8 and northwards (to mile -3/8 by the Tortuguero river mouth). The strongest lights were the streetlights located in the village, some of which could be seen from mile 4 6/8 (Table 21).

Table 21. Artificial lights visible from the beach, Tortuguero river mouth to Mile 5.

Mile	Light source	Beach side	Lagoon side	June	July	Aug	Sept
- 3/8	Tortuga Lodge + House		X	X	X	X	X
5/8	Tortuga Lodge		X	X			X
6/8	Tortuga Lodge		X	X	X	X	
1	Manati Lodge		X	X	X		
1 1/8	Ilan-Ilan Lodge		X	X	X	X	X
1 2/8	Ilan-Ilan Lodge		X	X	X	X	
1 3/8	Manati + Laguna Lodge	X	X	X	X		X
1 4/8	Laguna Lodge	X		X	X	X	X
2 2/8	Mawamba Lodge	X		X	X	X	X
2 3/8	Mawamba Lodge	X		X	X	X	X
2 4/8	CCC	X		X	X	X	X
2 5/8	CCC	X		X	X	X	X
2 6/8	Houses	X		X	X	X	X
2 7/8	Houses + Street Lights	X		X	X	X	X
3	Houses + Street Lights	X		X	X	X	X
3 1/8	Houses + Street Lights	X		X	X	X	X
3 2/8	Houses + Street Lights	X		X	X	X	X
3 3/8	House	X				X	
0 to 5	Red light on mast (m2 6/8)	X		X	X	X	X
1/8-6/8, 1 1/8-4 6/8	Street lights (m2 7/8-3 2/8)	X		X	X	X	X

3.7.5 Hatchling orientation

The mean angular range of the hatchling tracks for 41 undisturbed nests was 56º ± 21º.

Table 22. Hatchling orientation.

Nests	n	× hatchling tracks ± ST.D.	× angular range ± ST.D.	× angular range minus outlier/s ± ST.D.	circlers ± ST.D.
Undisturbed	41	73±23	56º±21º	46º±16º	0.3±0.6

One hatchling disorientation event was recorded at mile 3 2/8 where a total of 50 hatchlings became disoriented by the lights from a nearby house and from the village street lights. Approximately 16 of the hatchlings appeared to have reached the sea.

3.8 Environmental Education Activities

The Tortuguero school children and the some of the students at the Tortuguero high school participated in nightly beach patrols on a regular basis throughout the nesting season. Participation was highest during the first part of the Green Turtle Program.

Environmental education activities were also carried out opportunistically. Slide shows and talks about sea turtle biology, conservation and environmental economics were given at the tour guide training course at the beginning of the nesting season, for park and coast guards, for groups of school children from Puerto Viejo, Cocles and Manzanillo, for groups of educators from Costa Rica and United States, for journalists, for officials of MINAE, and for members of the Costa Rican legislative assembly.

4. DISCUSSION

4.1 Track Surveys

4.1.1 Green turtles

Green turtle nesting activity was high in 1998 (Figure 1). Fishermen, local people and sea turtle conservationists on the Caribbean coast considered 1998 a record year for green turtles (pers. obs., D. Chacón pers. comm., S. Rodríguez pers. comm.). However, a thorough analysis of the track survey data for 1998 and a comparison with previous years track surveys are needed to determine if 1998 was indeed a record year (Bjorndal et al. in press).

Nesting intensity was lowest north of the village, in mile 2 (Figure 2). It is likely that the streetlights and the lights from houses in the village deterred green turtles from nesting in front of, or close to the village.

The onset of the illegal harvest in Tortuguero National Park was again in late August (Figure 3). This is a time when mating green turtles become rare in the waters off Matina, close to Limón. Turtle boats from Limón therefore travel further north, to Tortuguero National Park, in pursuit of prey (Appendix 2). The start of the illegal harvest also coincided with the start of the dry season, when wave action decreases and boats can approach the nesting beach at night. The main reason for limiting the illegal harvest, to only two events, was the admirable commitment by Tortuguero Conservation Area (ACTo) staff in patrolling the beach at night. In August, park guards started to regularly patrol the distant section of beach where illegal harvest of nesting turtles was rampant during the 1997 nesting season (Troëng 1997). The ACTo efforts were supported by CCC through the donation of a large field tent that allowed park guards to set up camp in the middle of the remote beach section. CCC also contributed to the beach protection by paying the salary for a Tortugueran to work as a park guard for the duration of the nesting season.

Two alternative theories can explain the considerable predation of nesting green turtles by jaguars (Figure 4). Firstly, the jaguar population may have increased in recent years as a result of protective measures and enforcement of national park legislation in Tortuguero National Park. A second, and less promising theory, is that deforestation for agriculture and cattle ranching, inland from Tortuguero, has been forcing jaguars toward the coast where more intact forest and suitable jaguar habitat remain. Further studies of the area's jaguar population are needed in order to determine which of the two explanations, if only one, is correct.

4.1.2 Hawksbills

Hawksbills nested in low numbers throughout both the leatherback and green turtle nesting seasons (Figure 5). The low numbers and lack of a concentrated nesting season make it difficult to specifically target hawksbills for conservation and research purposes.

4.1.3 Leatherbacks

Leatherback nesting overlapped little with green turtle nesting (Figure 6). The current division of the CCC activities into a leatherback program and a green turtle program appears adequate. It is also apparent that for most of the year (March-October) sea turtles are nesting at Tortuguero beach.

4.2 Tagging of Nesting Sea Turtles

4.2.1 Green turtles

More than 1,225 newly tagged green turtles could easily have been tagged as the nesting density was high for much of the program. However, this would have entailed extra costs for tags. The monitoring objectives with regards to tagging were fulfilled and it is therefore suggested that the sample size of 1,000 newly tagged green turtles remain the same in future programs.

The three tag returns from Panama and Mexico emphasize the importance of maintaining beach patrols to check turtles for tags even if the sample of new turtles have been tagged. Many of the green turtles tagged at projects throughout the Caribbean belong to the Tortuguero rookery, as this population is the largest in the region (Carr et al. 1978). Valuable data on migration and movements of green turtles in the western Caribbean, and beyond, would be lost if the beach patrol effort is minimized.

Data on the zone in which green turtles nested may be skewed as program staff may have been choosing to tag turtles nesting in the open zone, for ease of tagging. It may be better to collect the zone data at track surveys than during nightly tagging. One could speculate that green turtles nest more frequently in the open zone during rainy nights (pers. obs.). A study is needed to evaluate this hypothesis.

The many newly tagged green turtles that had evidence of old tags (10%) indicate that tag loss is high. Therefore it is encouraging to note the low within-season tag loss (Table 1). Inconel #681 tags have a locking mechanism that is easier to check than the Monel #49 tags and this may be the major reason for the low within-season tag loss. Also, the experience and dedication of the RAs may have contributed to the high tag retention.

The male green turtle that was encountered digging an egg chamber may have been a unique occurrence and it therefore seems inappropriate to speculate about the reasons for its abnormal behavior. If similar events occur in the future, they should be reported and described in detail so that an explanation to the phenomena can be found. An investment in the equipment necessary to obtain blood serum samples for hormone analysis, should be considered. (Hormones may be involved in inducing nesting behavior.)

4.2.2 Hawksbills

It is discouraging that all hawksbills that were encountered lacked previous tags or evidence of old tags. One explanation could be that there is high adult mortality as a result of human depredation so that few or no hawksbills survive to return during more than one nesting season.

Tissue samples were only collected from five hawksbills. This is not enough to get a complete profile of the genetic composition of the hawksbill population that nest at Tortuguero (A. Bass pers. comm.). However, if the genetic sampling is continued for more years, a sufficient sample may be obtained in the future.

4.2.3 Leatherbacks

The tagging of leatherbacks at Tortuguero in 1998 is described in more detail in Troëng et al. (1998).

4.3 Biometric Data Collection

4.3.1 Green turtles

The turtles measured at the slaughterhouse in Limón did not show any secondary sexual characteristics typical of sexually mature male turtles (i.e. soft plastron, large claws on front flippers, large tail). The turtles in Limón were also larger than the smallest female encountered at the beach in Tortuguero. We were not able to confirm that the turtles in Limón were all sexually mature females by inspection of the gonads, as we were not present at the time of slaughter. However, all indications suggest that the majority of the turtles caught in the Costa Rican green turtle fishery are reproductively active females. This is unfortunate as these are the individuals that contribute most to the maintenance of the population.

The precision of the carapace measurements was lower for turtles measured by program participants than for RAs. Training and practice are clearly needed to measure a turtle. There is a trade-off between the financial and environmental education gains of many short-term participants, and data quality.

The measurements of green turtles that were encountered and measured more than once were considerably less precise than if the turtle was only measured at one occasion. It is probably safe to assume that the accuracy of the measurements are much less than the precision of the measurements from one encounter.

4.3.2 Hawksbills

The largest hawksbill (CCLmin=91.3 cm) was larger than the smallest nesting green turtle (CCLmin= 89.2 cm). Too few hawksbills were measured to determine if the precision of the hawksbill measurements were higher than for the green turtles. It is possible that precision is related to carapace length, i.e. that absolute precision is higher for hawksbills as they have a shorter mean carapace length than green turtles.

4.3.3 Leatherbacks

Leatherback biometrics at Tortuguero in 1998 are described in more detail in Troëng et al. (1998).

4.4 Fibropapilloma Assessment

4.4.1 Green turtles

Only 2% of female green turtles were affected with fibropapillomas. It is suggested that a biopsy punch be used to collect samples from fibropapillomas or other suspect growths. These samples could be used to confirm that the observed growths are indeed fibropapillomas and not other tumorous tissue.

4.5 Determination of Nest Survivorship and Hatching Success

The frequent encounters with egg and hatchling predators and the ample evidence of their feeding provide many good opportunities for detailed studies. For example; studies into the biology and population dynamics of the area's coatis, raccoons and tayras could be conducted. A quantitative study of the relationship between the ever-present black vultures and the green turtles would also be interesting. CCC should facilitate and encourage any serious attempts at setting up studies into the biology of egg and hatchling predators.

4.5.1 Green turtles

As many as 8.7% of green turtle nests were dug up by nesting turtles. This is probably not a common occurrence but rather an effect of the very high density of nests during the 1998 nesting season. Monitoring of nests in future years will reveal if this assumption is correct.

Three beach sections where poaching and tampering with the flagging tapes took place, could be identified (Figure 7). The problem of poaching could be addressed by increasing patrols by park guards or other interested parties along the affected stretches of beach during the morning and day.

The system of marking nests should be revised as several flagging tapes were lost, making it difficult to find the nests for excavation. Placing a marker in the nest at laying should be considered, so that the nest can be verified as being correct at excavation.

It is possible that the clutch size for excavated nests was overestimated as the broken-up shell from one egg could be counted as two eggs. To determine if this is the case, it is suggested that egg counts are made from the same nests that are marked in future seasons. A correct egg count would also help to verify that the right nest has been excavated.

A specific study is suggested to determine if the fate and hatching success vary with beach zone (open, border, vegetation).

The depth of the egg chamber (from sand surface to top egg and to bottom of egg chamber) varied substantially as a result of beach erosion, accretion and the activity of nesting turtles. Some nests were obviously uncovered by camouflaging or bodypitting turtles, whilst other nests were increasingly covered by the same actions. Again, the results of the 1998 nesting season may be atypical due to the very heavy nesting activity.

The incubation period varied between 48-65 days. Shading by vegetation may have increased the incubation period of the eggs. The length of the incubation may not be directly related to rainfall (mm/24hrs) but rather days with rain or overcast during incubation. Nests incubated during the warmer month of September had shorter incubation periods.

The incidence of albinism, twins and triplets were monitored (Table 10). These categories represent a small percentage (0.07%) of green turtle eggs but changes in the frequency of abnormal embryos and hatchlings may be an indication of other environmental changes. It is therefore suggested that also deformed "normal" hatchlings and embryos are noted in future monitoring of hatching success.

4.5.2 Hawksbills

The sample of marked hawksbill nests is too small to draw any conclusions. It is discouraging to see so few hatchlings emerging from the three marked hawksbill nests.

4.5.3 Leatherbacks

Nest survivorship and hatching success for leatherbacks at Tortuguero in 1998 are described in more detail in Troëng et al. (1998).

4.6 Physical Data Collection

Rainfall, air temperature and ground water level will be monitored by the field station birdbanders between the 1998 green turtle program and the 1999 leatherback program.

4.6.1 Rainfall

Rainfall was abundant during the first part of the nesting season from June until mid-August. Late August to early October was very dry (Figure 8). During the same time the sea was very calm and the usually intimidating breakers were nothing but ripples on the surface.

4.6.2 Air temperature

The month with least rainfall, September, was also the month with the highest mean temperature (Table 14). Rainfall per se (mm/24hrs) may not determine air temperature but rather it is the number of days with rain or overcast that control mean monthly temperatures.

4.6.3 Sand temperature

Nesting turtles moved the data loggers several times. Beach erosion and accretion also changed the depth of the data loggers. The movement of the data loggers resulted in the temperature data from the loggers being difficult to compare. The placement of the loggers at three different sites of which two were located at considerable distance from the field station made it impractical to frequently adjust the depth of the data loggers. It is therefore suggested that all data loggers are placed in front of the field station with three data loggers in each zone (open, border, vegetation) at 30 cm, 50 cm and 70 cm depth.

Sand and air temperature showed the same pattern with September being the warmest month (Table 15).

4.6.4 Ground water level

The ground water pipes were also affected by beach erosion and accretion. The changes in beach morphology resulted in changes in the elevation of some of the pipes during the season. The pipes in front of the field station were frequently filled with sand which meant

that they had to be dug up and emptied. The changes in elevation of the pipes obviously affected the distance between the top of the pipe and the ground water level. The data in Table 16 should therefore be treated as a rough estimation of the ground water level. Also, due to differences in beach morphology, the ground water data may be very site specific to the place where the pipes are located.

There was no indication that high ground water levels caused widespread mortality of green turtle eggs during the period of monitoring.

4.7 Collection of Human Impact Data

4.7.1 Visitors to Tortuguero

CCC's Natural History and Visitors Center captures the attention of many of the tourists that come to Tortuguero (Table 17). The number of visitors to the Center exceeds the number of persons paying the National Park fee (Table 18). However, the real number of visitors to Tortuguero probably exceeds the number of those who visit the CCC Natural History and Visitors Center or pay the park fee.

ACTo plans to set up entrance posts by Jalova lagoon and by the Tortuguero airstrip and to have them operational by 1 January 1999. All visitors that enter at the two sites will have to pay the park fee and the accumulated funds will be kept by ACTo for use in Tortuguero Conservation Area.

4.7.2 Capacity of hotels and cabinas

The capacity of the hotels and the cabinas generally greatly exceeds the demand for tourist lodging (Table 19). However, more cabinas are being constructed and several of the hotels in the area are expanding their room capacity by constructing additional buildings.

4.7.3 Turtle walks

The income generated from the turtle walks is providing a great incentive in favor of sea turtle conservation (Table 20). The tourists that come to Tortuguero to see the nesting turtles spend much more money on transport, food, lodging and souvenirs than they spend on the turtle walk. Hence, the total financial benefits of the turtle walks is much greater than the minimum US$84,860 generated by the tour guides. The sustainable use of the nesting turtles through tourism is proving to be a major argument in favor of conservation. Some of the benefits of the turtle walks, such as the funds raised for the community projects are direct and very apparent to local people.

A study determining how much money the average tourist spends during his/her Tortuguero visit would show the economic importance of the sustainable use of sea turtles. Such a study would be a powerful tool in raising local and national support for sea turtle conservation.

4.7.4 Artificial lights

The artificial lights that are visible from the nesting beach are all located north of Mile 3 3/8 although the strongest lights are visible further south (Table 21). The possibilities of

shading the strongest lights or replacing them with sodium lights should be investigated and encouraged.

4.7.5 Hatchling orientation

The sample of nests for which hatchling orientation was determined (n=41) did not reach the desired size (n=75) (Table 22). Hatchling tracks were only visible some mornings due to rain and strong wind that erased the little tracks. When the hatchling tracks were visible, tracks from more than one nest were often overlapping, making it difficult to determine hatchling orientation for individual nests.

The hatchling disorientation event was caused by some of the strong lights in front of the village. Although only one disorientation event was recorded, many persons reported seeing disoriented hatchlings crawling around in the village in places such as by the school and on the football field. Again, the strong lights in front of the village were the probable causes of these disorientations.

4.8 Environmental Education Activities

The interest in sea turtle biology and conservation seems to be increasing in several sections of Costa Rican society. The response from government agencies such as MINAE and the Coast Guard as well as the Costa Rican media during the 1998 green turtle program were particularly encouraging. With regards to environmental education, MINAE has been organizing a multi-institutional commission that will develop a strategy for environmental education in the zone. Several of the Costa Rican ministries and universities are involved as well as representatives from CCC and other NGOs active in the area.

Goals for future green turtle programs should include increased local participation in conservation activities and an effort should be made to get more Costa Rican and Latin American Research Assistants. Support should be provided to any efforts to increase environmental education in the area.

5. REFERENCES

Bjorndal, K.A., Wetherall, J.A., Bolten, A.B. and J.A. Mortimer. In press. Twenty-six years of green turtle nesting at Tortuguero, Costa Rica: An encouraging trend. *Conservation Biology*.

Carr, A., Carr, M.H. & A.B. Meylan. 1978. The ecology and migrations of sea turtles, 7. The west Caribbean green turtle colony. *Bull. Amer. Mus. Nat. Hist.*, 162, 1-46.

Troëng, S. 1997. Report on the 1997 Green Turtle Program at Tortuguero, Costa Rica. Unpublished report to Caribbean Conservation Corporation. 28+xiii pp.

Troëng, S., Castillo, A., Duque, V., Klement, J., Ordoñez, C. & T.A. Rankin. 1998. Report on the 1998 Leatherback Program at Tortuguero, Costa Rica. Unpublished report to Caribbean Conservation Corporation and Ministry of Environment and Energy of Costa Rica. 30 pp.

Wetherall, J.A. 1982. Analysis of double-tagging experiments. *Fish. Bull.*, 80, 687-701.

6. RECOMMENDATIONS

6.1 Track Surveys

⇒ The results of the track surveys should be regularly disseminated to ACTo throughout the nesting season so that appropriate action can be taken with regards to illegal harvest of eggs and turtles.

6.2 Tagging of Nesting Sea Turtles

⇒ A study should be conducted to see if green turtles nest more frequently in the open beach zone during rainy nights.

⇒ Inconel #681 tags should be used to tag green turtles and hawksbills.

⇒ An investment in equipment necessary to obtain blood serum samples from sea turtles for hormone analysis, should be considered.

⇒ Tissue or blood samples for genetic analysis should be collected from as many hawksbills as possible.

6.3 Biometric Data Collection

⇒ It should be noted that more short-term volunteers participating in the program result in less precise (and less accurate?) data.

6.4 Fibropapilloma Assessment

⇒ Samples of tumor-like growths should be collected, using biopsy punches, for analysis of the affected tissue.

6.5 Determination of Nest Survivorship and Hatching Success

⇒ Morning and day patrols, by interested parties, of beach sections where poaching is occurring should be considered.

⇒ Flagging tapes for nest marking should be attached to at least three positions so that a nest can be found even if one piece of tape is lost.

⇒ Placing a marker in the nest at laying should be considered.

⇒ Egg counts should be conducted during egg laying for marked nests.
⇒ A specific study should be conducted to determine if nest survivorship and hatching success vary with beach zone.
⇒ Deformed hatchlings and embryos should be monitored as part of the nest excavations.

6.6 Physical Data Collection

⇒ Physical data collection should continue year around at the field station.
⇒ Sand temperature data loggers should be placed in front of the field station with data loggers in each zone (open, border, vegetation) at 30 cm, 50 cm and 70 cm depth.
⇒ If exact ground water data is a priority, then a new system for ground water monitoring will have to be developed.

6.7 Collection of Human Impact Data

⇒ A study determining how much money the average tourist spend during his/her Tortuguero visit would show the economic importance of the sustainable use of sea turtles in the area.
⇒ The possibilities of shading the strongest artificial lights that are visible from the beach or replacing them with sodium lights should be investigated and encouraged.

6.8 Environmental Education Activities

⇒ Goals for environmental education should include increased local participation in conservation activities and an effort should be made to get more Costa Rican and Latin American Research Assistants.
⇒ Any efforts to increase environmental education in the area should be supported.

6.9 Other Recommendations

⇒ Studies into the area's jaguar population should be encouraged.
⇒ Studies into the biology and population dynamics of egg and hatchling predators should be encouraged.

Figura 1. Distribución de actividad de desove durante la temporada de anidación determinada por conteo de huellas desde la Boca del Río Tortuguero (milla -3/8) a la Laguna de Jalova (milla 18).

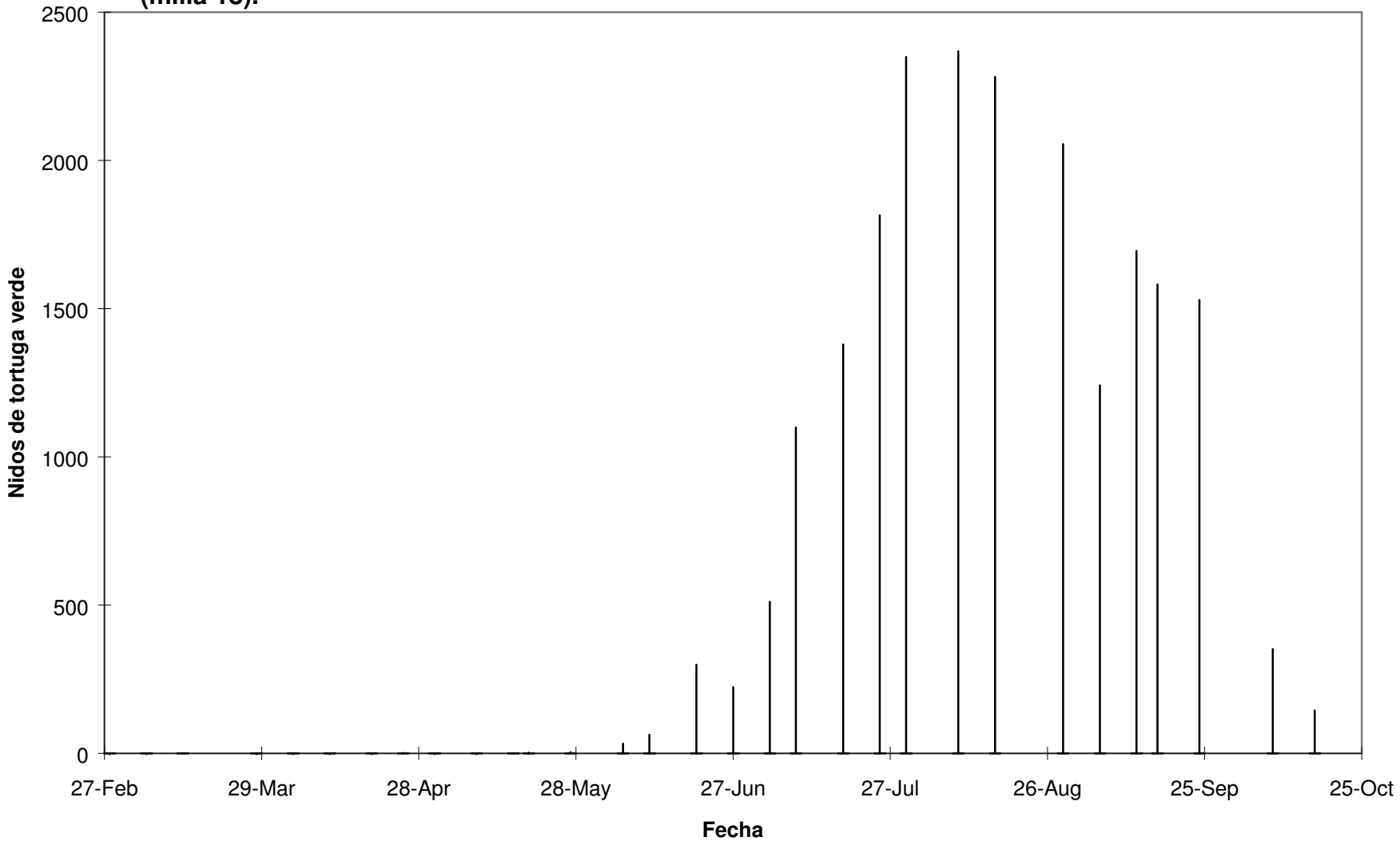


Figura 2. Distribución espacial de actividad de desove de tortuga verde, determinada por conteo de huellas desde la Boca del Río Tortuguero (milla -3/8) a la Laguna de Jalova (milla 18).

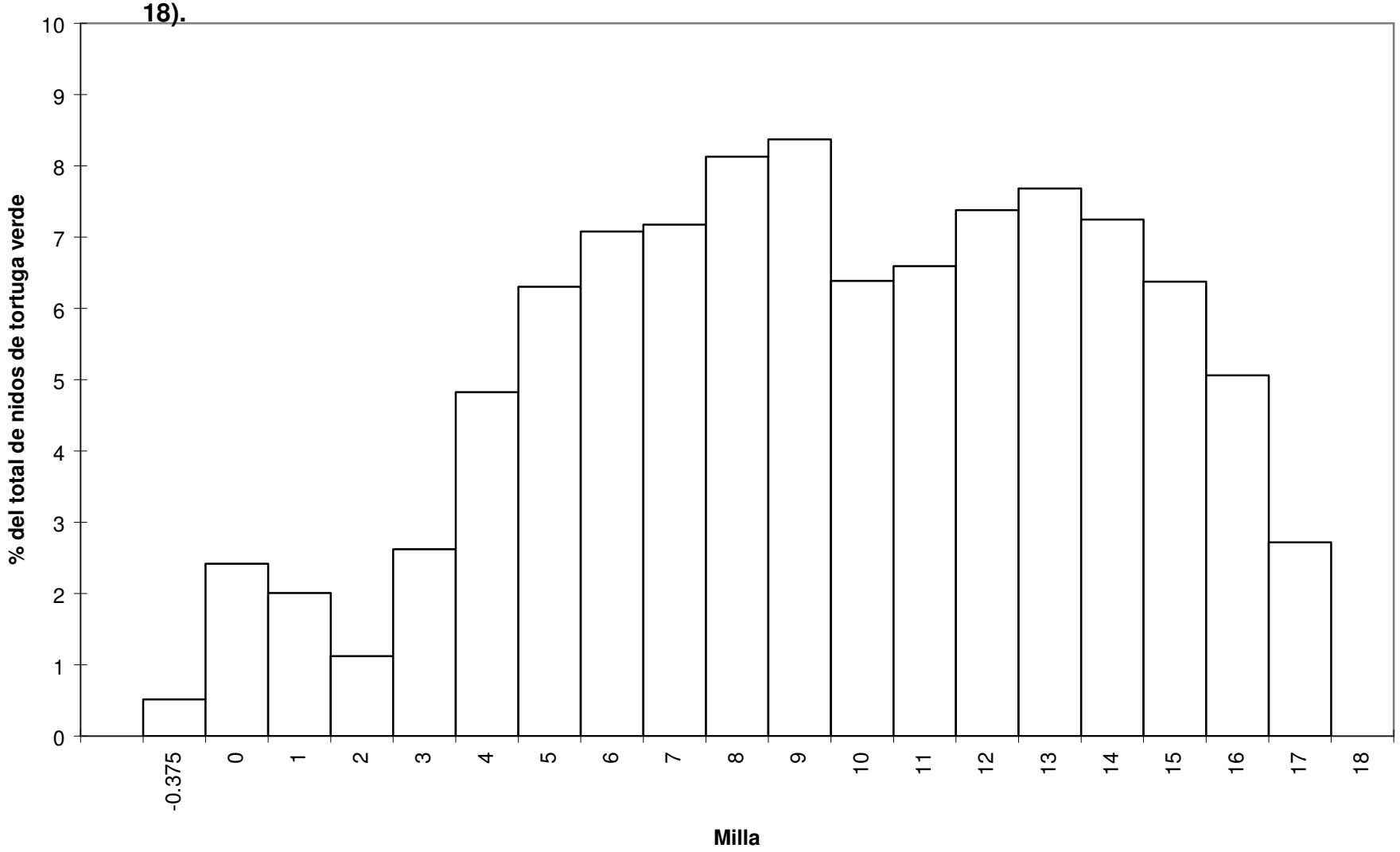


Figura 3. Cosecha ilegal de tortugas verdes, determinada por conteo de huellas desde la Boca del Río Tortuguero (milla -3/8) a la Laguna de Jalova (milla 18).

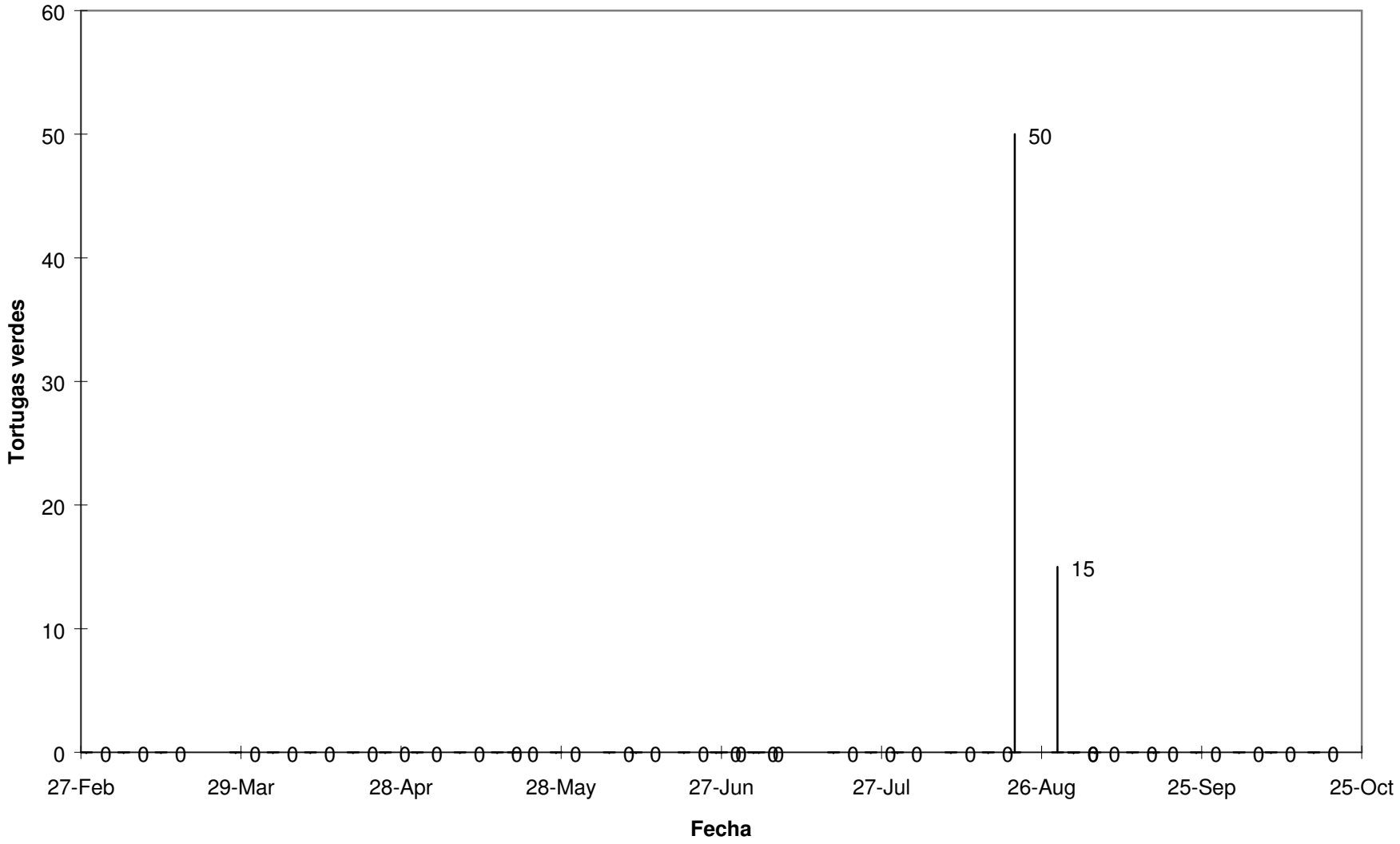


Figura 4. Tortugas verdes recién cazadas por jaguares, determinada por conteo de huellas desde la Boca del Río Tortuguero (milla -3/8) a la Laguna de Jalova (milla 18).

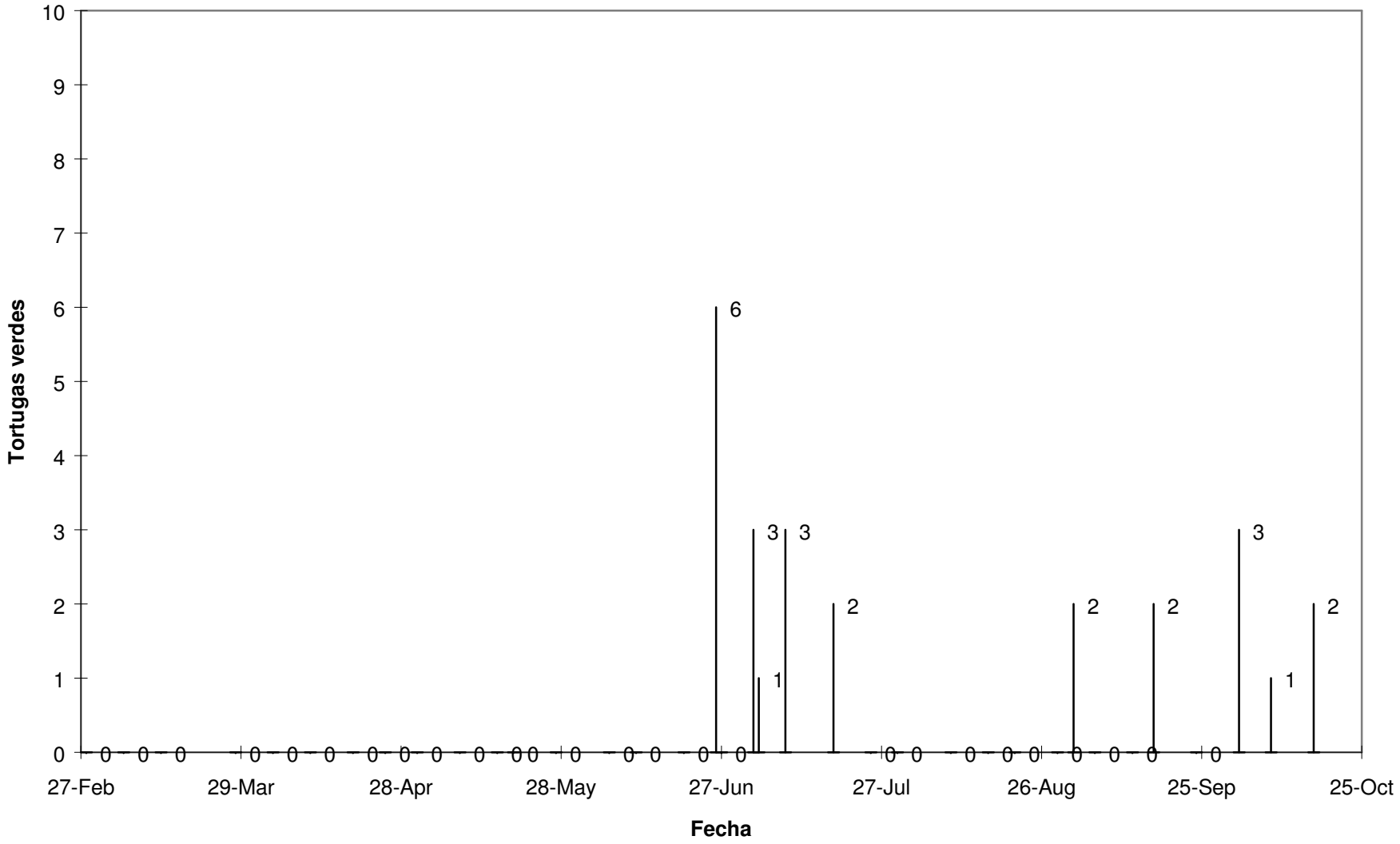


Figura 5. Distribución de actividad de desove de tortuga carey durante la temporada, determinada por conteo de huellas desde la Boca del Río Tortuguero (milla -3/8) a la Laguna de Jalova (milla 18).

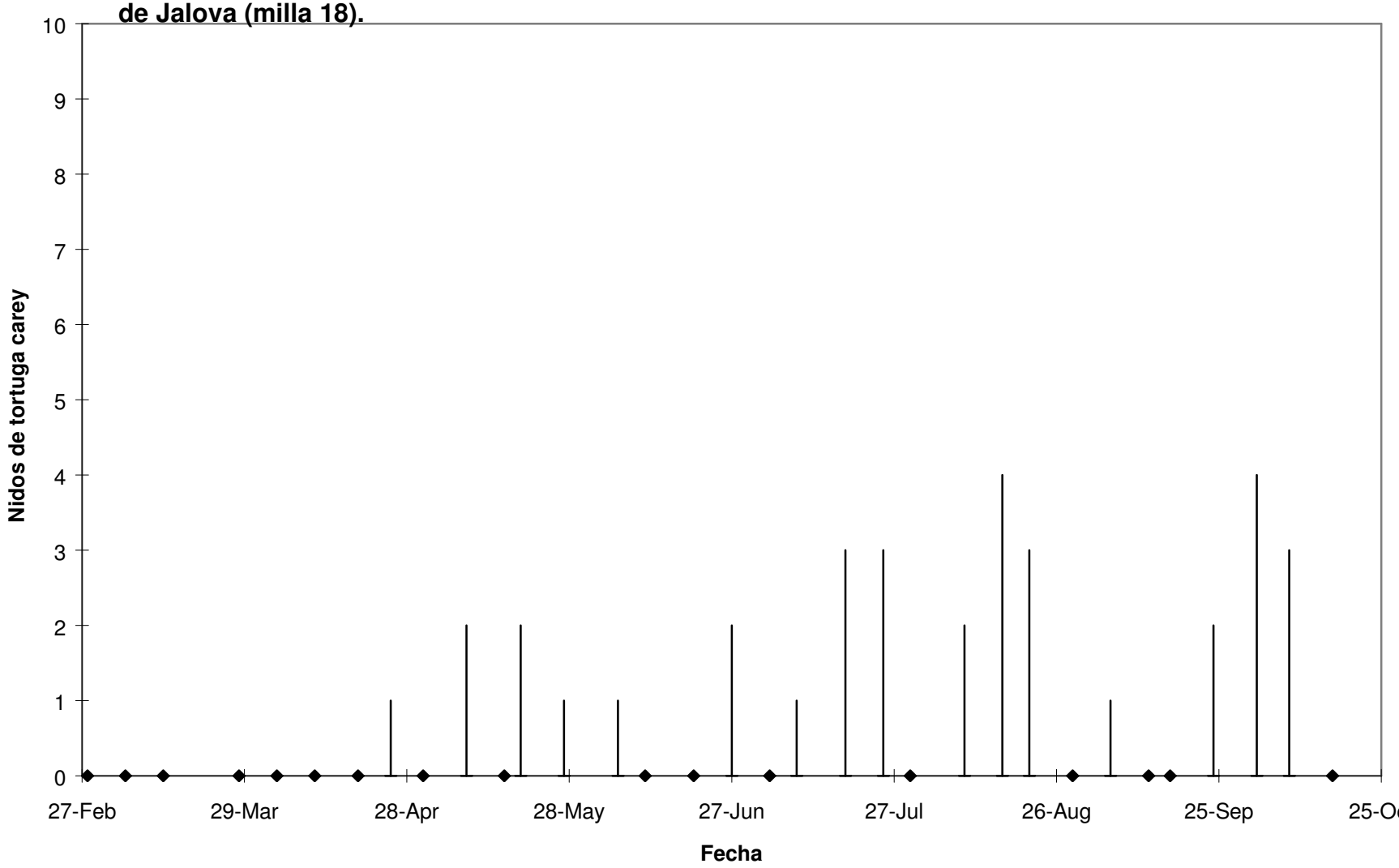


Figura 6. Distribución de actividad de desove de tortuga baula durante la temporada, determinada por conteo de huellas de la Boca del Río Tortuguero (milla -3/8) a la Laguna de Jalova (milla 18).

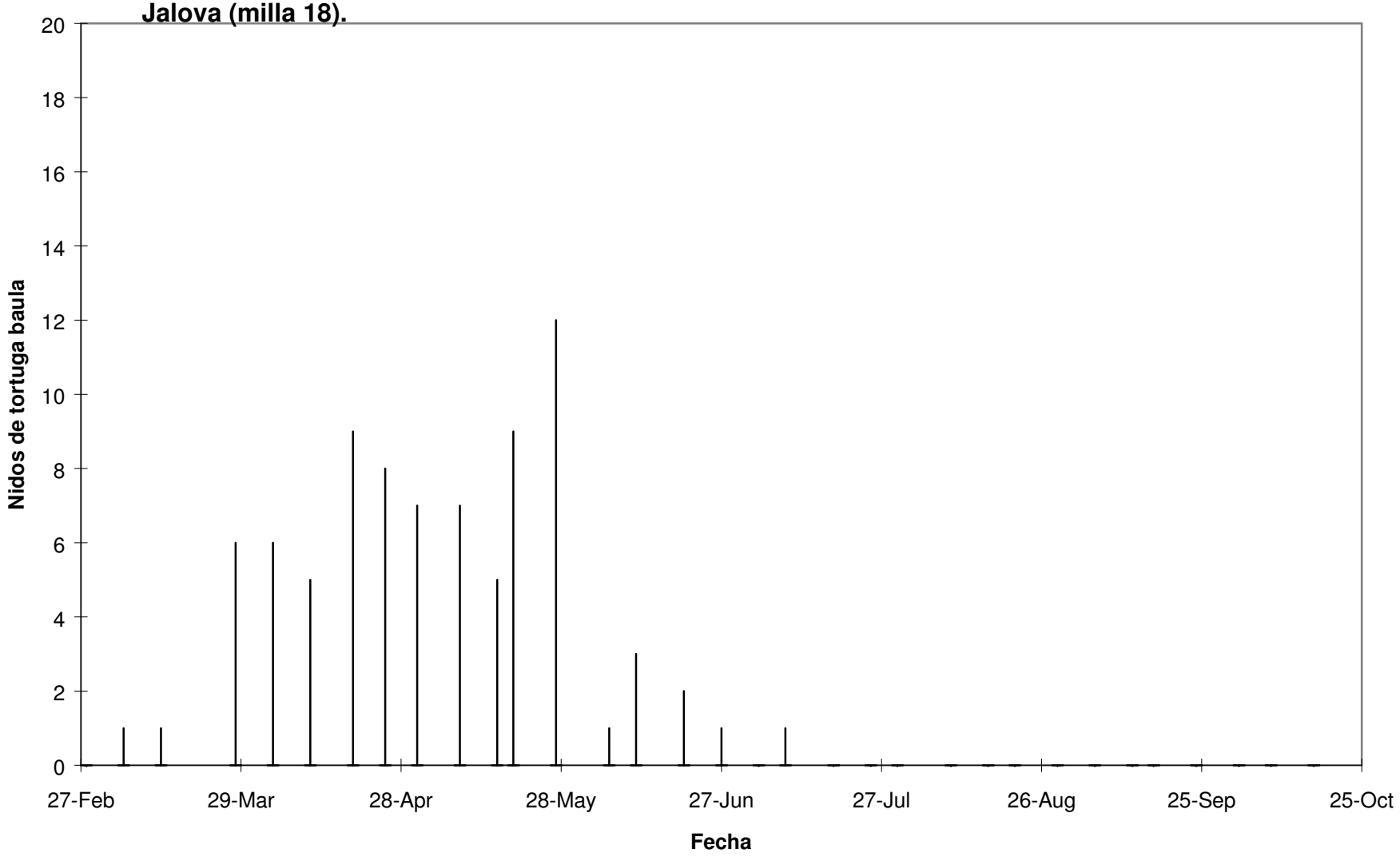


Figura 7. Nidos perturbados o alterados.

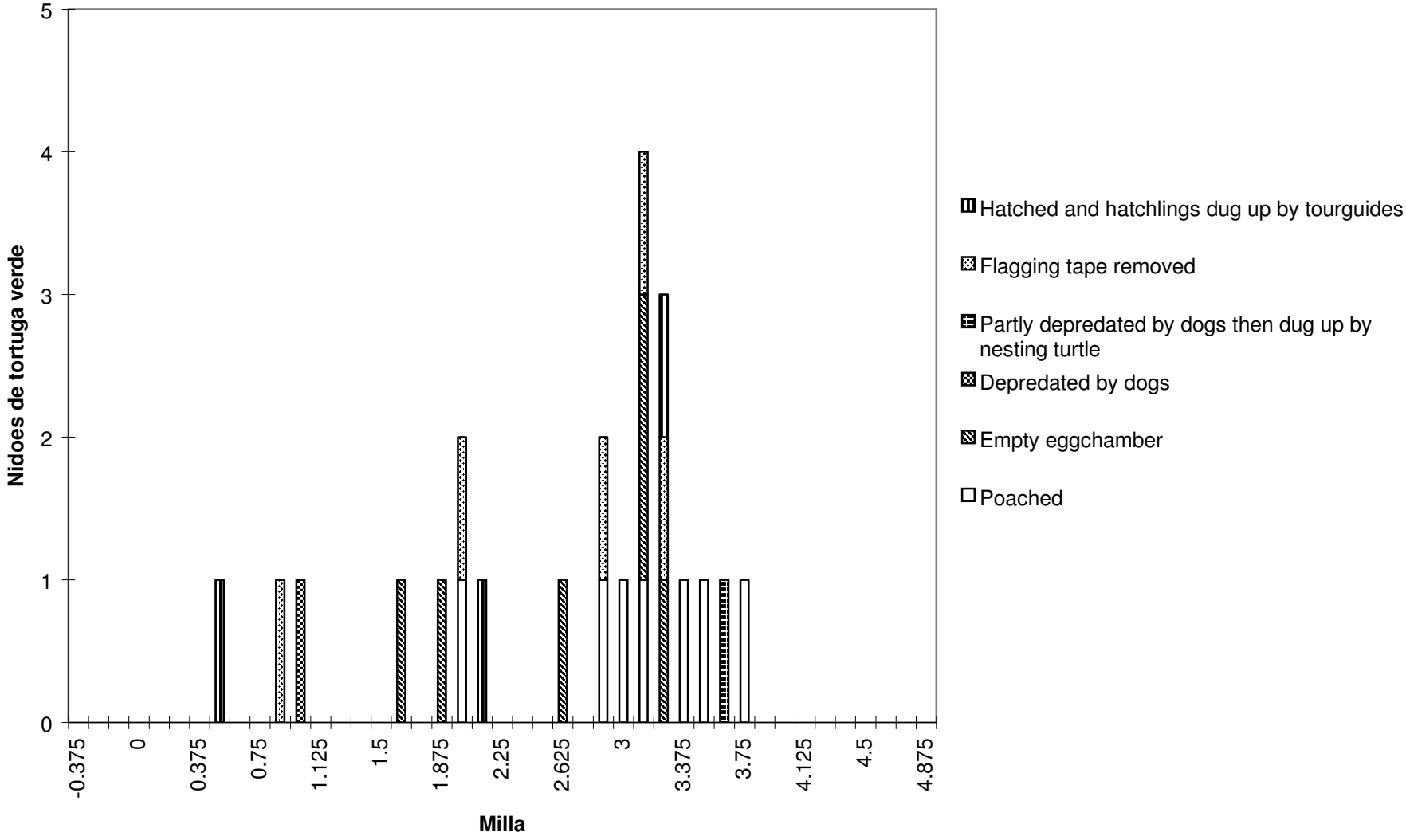


Figura 8. Lluvia.

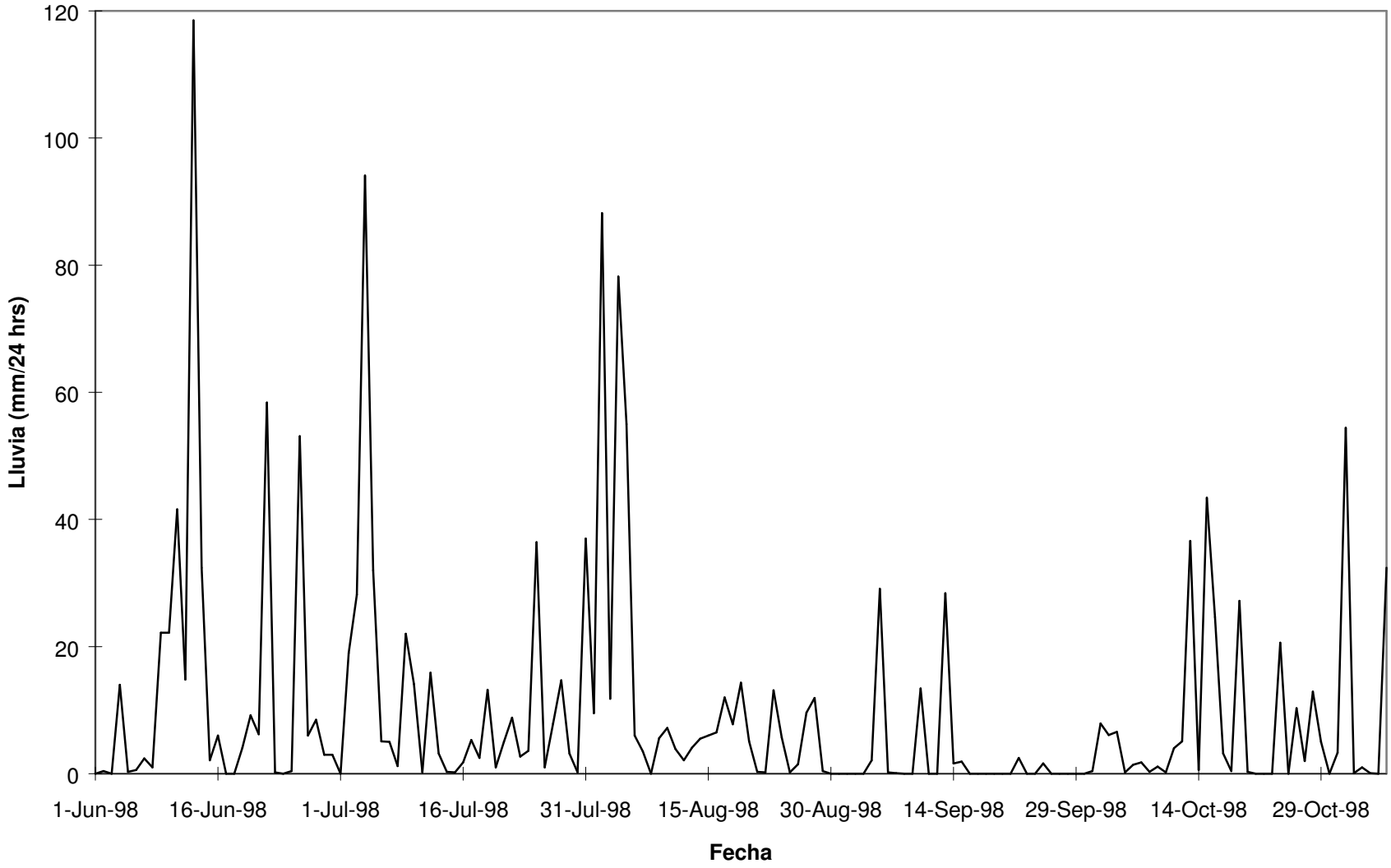


Figura 9. Temperatura a 70 cm de profundidad.

Figura 9a. Temperatura a 70 cm de profundidad: Estación Biologica, zona abierta, 5 m de alta mar.

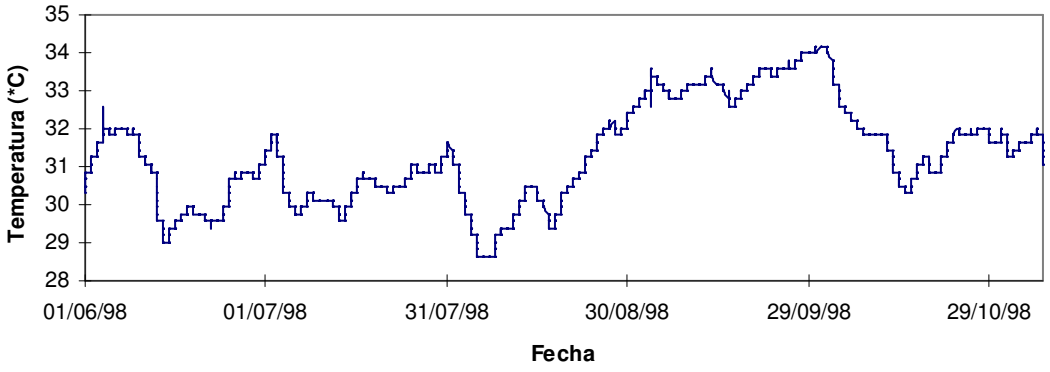


Figura 9b. Temperatura de 70 cm de profundidad: Milla 3 7/8, zona borde, 20 m de alta mar.

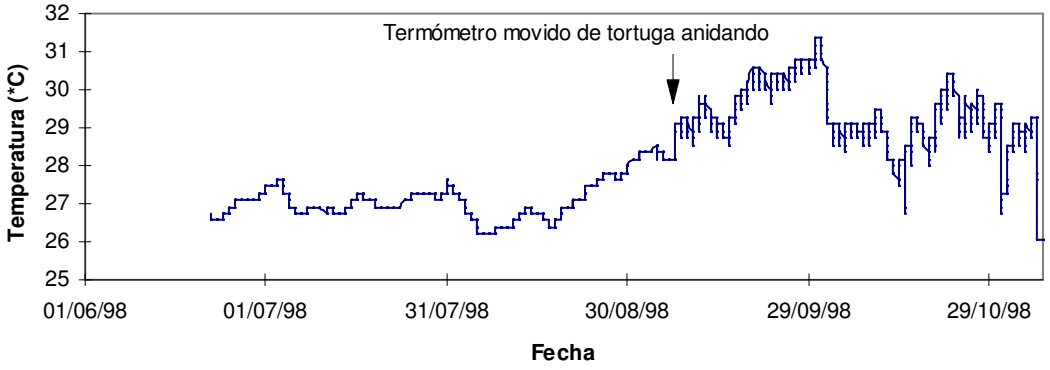
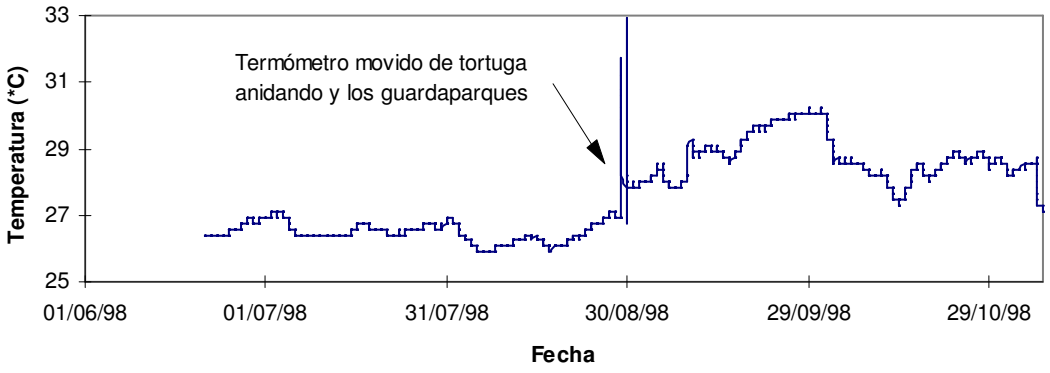


Figura 9c. Temperatura de 70 cm de profundiad: Milla 11 6/8, zona de vegetación, 12 m de alta mar.



APPENDIX 1. Sea Turtle Encounters.

	GREEN TURTLES				LEATHERBACKS				HAWKSBILLS			
Date	Newly tagged	Tagged previous years	Renester	Total	Newly tagged	Tagged previous years	Renester	Total	Newly tagged	Tagged previous years	Renester	Total
13-Jun	3			3		1		1				0
14-Jun					NO TAGGING TEAMS ON BEACH							
15-Jun	4			7				1				0
16-Jun	14			21				1				0
17-Jun	3			24				1				0
18-Jun	5			29		1	1	3				0
19-Jun	4			33				3				0
20-Jun	11	1		45				3				0
21-Jun	7			52				3				0
22-Jun	11	1		64				3				0
23-Jun	5	3	1	73				3				0
24-Jun	4	1		78				3				0
25-Jun	5	1		84				3				0
26-Jun	7			91				3				0
27-Jun	12	1	1	105				3				0
28-Jun	14	1	1	121				3				0
29-Jun	8	2	1	132				3				0
30-Jun	10			142				3				0
1-Jul	16	3	2	163				3				0
2-Jul	16	1	3	183				3				0
3-Jul	19	4	2	208				3				0
4-Jul	19	2	1	230				3				0
5-Jul	22	7	2	261				3				0
6-Jul	22	1	2	286				3				0
7-Jul	21	6	3	316				3	1			1
8-Jul	29	1	3	349				3				1
9-Jul	32	2	1	384				3				1
10-Jul	27	3	5	419				3				1
11-Jul	22	1	4	446				3				1
12-Jul	27	2	3	478				3				1
13-Jul	21	2	5	506				3				1
14-Jul	18	3		527				3				1
15-Jul	16	2	2	547				3				1
16-Jul	25	2	7	581				3				1
17-Jul	14	1	3	599				3				1
18-Jul	12	1	8	620				3				1
19-Jul	21	5	2	648				3				1
20-Jul	11	4	4	667				3				1
21-Jul	19	3	5	694				3				1
22-Jul	18	2	6	720				3				1
23-Jul	13	2	7	742				3				1
24-Jul	14	4	3	763				3				1
25-Jul	17	3	3	786				3				1
26-Jul	14	3	3	806				3				1
27-Jul	12	8	4	830				3				1
28-Jul	30	6		866				3				1

29-Jul	8	4	4	882		3		1
30-Jul	11	4	2	899		3		1
31-Jul	18	5	5	927		3		1
1-Aug	8	3	2	940		3		1
2-Aug	16	7	6	969		3		1
3-Aug	18	5	9	1001		3		1
4-Aug	38	4	4	1047		3	1	2
5-Aug	27	3	6	1083		3		2
6-Aug	34	3	9	1129		3		2
7-Aug	21	2	11	1163		3		2
8-Aug	11	6	8	1188		3		2
9-Aug	16	2	9	1215		3	1	3
10-Aug	15	4	6	1240		3		3
11-Aug	15	5	6	1266		3		3
12-Aug	13	8	3	1290		3		3
13-Aug	14	5	2	1311		3		3
14-Aug	7	2	2	1322		3		3
15-Aug	11	2	4	1339		3		3
16-Aug	15	1	5	1360		3	1	4
17-Aug	11	5	5	1381		3		4
18-Aug	12		7	1400		3		4
19-Aug	12	4	5	1421		3		4
20-Aug	11	6	5	1443		3		4
21-Aug	11	4	3	1461		3		4
22-Aug	7	1	8	1477		3		4
23-Aug	11	2	3	1493		3		4
24-Aug	10	2	2	1507		3		4
25-Aug	7	1	2	1517		3		4
26-Aug	5	5	6	1533		3		4
27-Aug	9	3	9	1554		3		4
28-Aug	9	1	5	1569		3		4
29-Aug	2	3	6	1580		3	1	5
30-Aug	6	5	5	1596		3		5
31-Aug	3	4	14	1617		3		5
1-Sep	3	3	9	1632		3		5
2-Sep	9		4	1645		3		5
3-Sep	3	5	7	1660		3		5
4-Sep	6		4	1670		3		5
5-Sep	3	4	5	1682		3		5
6-Sep	4	2	9	1697		3		5
7-Sep	6	2	2	1707		3		5
8-Sep	5	2	6	1720		3		5
9-Sep	6	4	5	1735		3		5
10-Sep	6	3	6	1750		3		5
11-Sep	3	4	6	1763		3		5
12-Sep	6	4	10	1783		3		5
13-Sep	4	4	2	1793		3		5
14-Sep	5	1	4	1803		3		5
15-Sep	4	2	2	1811		3		5
16-Sep	1	4	5	1821		3		5
17-Sep	2		2	1825		3		5
18-Sep	2	1	5	1833		3		5

19-Sep	1	2	2	1838				3				5
20-Sep	3	3	5	1849				3				5
21-Sep	2		1	1852				3				5
22-Sep	2	1	5	1860				3				5
23-Sep	1		2	1863				3				5
24-Sep	1	1	5	1870				3				5
25-Sep		6	4	1880				3				5
26-Sep		2	1	1883				3				5
27-Sep	1		1	1885				3				5
28-Sep	2			1887				3				5
29-Sep	1			1888				3				5
30-Sep	1	1	3	1893				3				5
1-Oct	2	2	6	1903				3				5
2-Oct			1	1904				3				5
3-Oct	1	1		1906				3	2			7
4-Oct	1		2	1909				3				7
5-Oct	1	2	2	1914				3				7
6-Oct				1914				3				7
7-Oct	1		1	1916				3	1*			8
8-Oct		1	1	1918				3				8
9-Oct	2		1	1921				3				8
10-Oct	1		3	1925				3			1	9
11-Oct			2	1927				3				9
12-Oct		1		1928				3				9
13-Oct	1	1	1	1931				3				9
14-Oct			1	1932				3				9
15-Oct				1932				3				9
16-Oct				1932				3				9
17-Oct				1932				3				9
18-Oct		1	1	1934				3				9
19-Oct	1			1935				3				9
20-Oct			1	1936				3				9
21-Oct	1			1937				3				9
22-Oct	1			1938				3				9
23-Oct				1938				3				9
24-Oct					NO TAGGING TEAMS ON BEACH							
25-Oct	3			1941				3				9
Subtotal	1225	286	430	1941	0	2	1	3	8	0	1	9
TOTAL				**1941**				**3**				**9**

*This female was observed nesting at 8:30 AM and was not tagged.

APPENDIX 2. Notes and Anecdotal Information on the Costa Rican Green Turtle Fishery.

Extent

The harvest of green turtles in Costa Rica greatly exceeds the allowed quota of 1,800 green turtles per year, according to fishermen, local people, sea turtle conservationists and representatives of local and regional government institutions in Limón. Green turtle meat is also frozen, against regulations, to be sold after the legal fishing season (June-August) ends. Green turtle meat is sold in the markets and restaurants in Limón and San José. Eggs are being sold openly in the markets and by people walking around restaurants offering to sell eggs.

Catch locations

The harvest of green turtles predominantly takes place around Matina before and during the first part of the nesting season (until August) although some fishermen travel to Tortuguero to harpoon turtles (pers. obs.). After mid-August when mating turtles become rarer around Matina, the fishery moves further north, to Tortuguero. Illegal harvest is occurring along the whole Caribbean coast of Costa Rica and is not limited to Tortuguero National Park.

Slaughter and landing sites

The only site with a permit to slaughter green turtles is El Delphin sea food processing plant in Cieneguita, Limón. Government representatives estimate the number of illegal slaughterhouses to a minimum of nine although some officials suggest at least 30 illegal slaughterhouses or locations in the Limón area. During a visit to Limón in August, carapaces from illegally slaughtered green turtles were encountered at Barra Los Cocos, Cieneguita, Barra Dos Cangrejos, Playa Bonita, and Portete which are all sites in and around Limón. Government officials informed us that Playa Matina, Moin, Portete, Piuta and Cieneguita are the main landing sites for the green turtle fishery.

Harvesters

Although local people catch sea turtles for subsistence along the Caribbean coast, a majority of the fishery is for commercial purposes. Fishermen from Limón catch most green turtles but there are there are also individuals from Tortuguero and inland from Tortuguero (Cariari and Guápiles) involved in illegal trade. The illegal road to Tortuguero provides a route inland for the trade. A majority of the profits from the sea turtle fishery benefit a small group of businessmen that trade in seafood and other items. These persons also control several of the boats and fishermen involved in the sea turtle fishery. Poor fishermen in Limón that are entirely dependent on fishing may be as few as 30 people (government officials pers. comm.). These fishermen generally do not have the resources, in terms of boats and equipment, to fish for green turtles during the better part of the green turtle fishing season, as the sea tends to be very rough in June until mid-August.

Prices

A fisherman catching a green turtle out of season can bring in as much as c25,000 per turtle. However, during peak season, a green turtle female may bring in as little as c5,000 or a male as little as c2,500, to the fisherman that caught the turtle (government officials, fishermen pers. comm.).