REPORT ON THE 2011 GREEN TURTLE PROGRAM AT TORTUGUERO, COSTA RICA

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Sea Turtle Conservancy (Formerly Caribbean Conservation Corporation)
and the Ministry of Environment, Energy and Telecommunications of Costa Rica
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Acknowledgments

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Executive Summary

Monitoring and Research Activities Conducted

1 During 2011, a total of 51 track surveys were conducted along the entire 18 miles of beach between Tortuguero river mouth and Jalova lagoon.

2 Green turtle nesting was observed between June and October, 2011; with the first nest recorded on 15 February.

3 Peak nesting was recorded on 6 August; 1,622 green turtle nests were counted in a single night.

4 An estimated 78,852 green turtle nests were laid during 2011. This equates to a population of 13,142 – 28,161 nesting females.

5 A total of 20.9% of all green turtle nests recorded during track surveys were deposited between Tortuguero river mouth (mile –3/8) and mile 5, and between mile 15 and the Jalova lagoon.

6 Jaguars killed a minimum of 57 green turtles in 2011; on 11 June and 3 September six turtles were killed in a single night. One leatherback was also reported as killed by jaguars.

7 Hawksbill nesting density was very low throughout the season, with 10 nests recorded from May – November.

8 During daily track surveys conducted by RAs between 12 June and 1 November a total of 12,420 green turtle nests and 11,000 green turtle false crawls were recorded between the Tortuguero river mouth and the mile 5 marker. Surveys between mile 15 and the Jalova lagoon recorded 6,618 nests and 7,396 false crawls.

9 Four leatherback and 45 hawksbill nests were recorded.

10 181 green turtle nests were recorded as poached during daily track surveys.

11 Thirty-two adult green turtles were poached from the beach.

12 Illegal poaching activity was observed on 51.1% of surveys.

13 Fifteen green turtle nests were depredated by dogs in the northern five miles of beach.

14 A total of 109 green turtle nests were destroyed by other nesting females.

15 Eight dead green turtles were found on the beach; seven were killed by jaguars and one was stranded dead.

16 Two green turtles were found alive following poaching attempts; both were released to the sea.

17 2,290.2 team hours of night patrols were conducted from 6 June – 30 October; 1,749.8 hours in Tortuguero and 540.4 hours in Jalova.

18 A total of 1,000 green turtles were newly tagged, 430 green turtles had tags, and 328 females were encountered more than once during night patrols.

19 Ninety-eight of the previously tagged turtles had been originally been tagged in Tortuguero more than 10 years ago, and three more than 20 years ago.

20 The longest nesting history for a turtle observed in 2011 was a turtle that was originally tagged in 1980, 31 years ago; this is a new record for the program.

21 Twenty-five green turtles were encountered in 2011 with tags from other projects; three were tagged at Pacuare Nature Reserve, five at Mondonguillo, 11 at Caño Palma and seven at Parismina.

22 Three turtles were encountered with tags from locations outside of Costa Rica; one from Panama, one from Nicaragua and one from Mexico.

23 Newly tagged green turtles had evidence of old tag holes or notches in at least one front flipper in 14.7% of cases.

24 Tagging efficiency for night patrols at Tortuguero varied from 0 – 100.0%, with a mean of 14.5%, for nights preceding track surveys; in Jalova the mean was 8.0%.

25 Green turtles encountered during night patrols nested in the open zone in 23.7% of cases, 61.4% were located in the border zone and 14.4% in the vegetation zone. Only 0.6% of turtles were encountered during a false crawl emergence.

26 Fourteen newly tagged and one previously tagged hawksbill turtles were encountered during the 2011 Green Turtle Program. One hawksbills tagged during the 2011 Leatherback Program was also encountered.

27 One leatherback turtle was encountered during the 2011 Green Turtle Program; on 28 July.

28 Overall carapace length for green turtles was 105.5cm (CCLmin) and 99.8cm (SCLmax).

29 Mean clutch size for green turtles was 114.0 eggs; with a range of 52 – 178 eggs.

30 Precision of CCLmin and SCLmax measurements of green turtles was very similar within a single encounter; 0.4cm and 0.3cm, respectively. For turtles seen more than once, SCLmax measurements were more precise.

31 Mean carapace length for hawksbill turtles was 87.3cm (CCLmin) and 82.5cm (SCLmax).

32 Mean clutch size for hawksbill females was 164 eggs.

33 Carapace length for the one leatherback observed was 164.1cm (CCLmin).

34 Clutch size for one leatherback nest was 76 yolked and 12 yolkless eggs.

35 Of 189 green turtles carefully examined for the presence of fibropapilloma tumors, only one was recorded with tumors. Thirteen other turtles were observed with tumors.

36 A total of 220 green turtle nests were marked and the fate was determined for 154 nests.

37 Overall mean hatching success was estimated at 77.2% and overall mean emerging success at 76.1%.

38 Comparison between egg counts at excavation and the moment of oviposition showed a mean difference of 5.6 less eggs counted at the time of the excavation.

39 Mean depth for undisturbed green turtle nests at excavation was 59.0cm (n = 127) from the sand surface to the top egg and 75.2cm (n = 127) to the bottom of the egg chamber.

40 A total of three albino, seven twin and 18 deformed embryos were observed in unhatched eggs, accounting for 0.19% of eggs.

41 Thirteen hawksbill nests were monitored and the fate was determined for 11 nests.

42 Mean hatching and emerging success of hawksbill nests (n = 11) was 70.9% and 69.0%, respectively.

43 Mean depth to top egg for hawksbill nests was 41.8cm and to the bottom of the egg chamber was 50.0cm.

44 Rainfall was monitored from January – December 2011; September was the driest month (82.7mm) and November was the wettest month (1,254.5mm).

45 Sand temperature in the border zone ranged from 22.9 – 33.9ºC, and in the open zone from 23.9 – 33.6 ºC. Information from the datalogger in the vegetation zone could not be downloaded at the end of the program.

46 A total of 23,529 persons visited the STC Natural History and Visitors Center in 2011; an average of 64 people per day.

47 Tourist visitation to Tortuguero National Park (TNP) increased in 2011, to 117,817 paying visitors. Entrance fees to TNP generated a total of ¢394,911,518 (~ US$789,823).

48 A total of 32,199 tourists were issued permits to go on guided turtle tours during the official green turtle season (July - October) in 2011; an average of 262 tourists per night.

49 Despite shading of public lights by ICE, there were still a considerable number of artificial lights visible on the beach, especially in front of the village of Tortuguero. The Costa Rican Energy Institute (ICE) was involved in helping to reduce impacts of problematic street lights in the village close to the beach; they put shades over the bulbs to redirect the light.

50 Two green turtles were fitted with satellite transmitters to monitor their migration movements; one was tracked to Mexico and the other to Nicaragua.

51 The FRC and RAs conducted environmental education activities at the Tortuguero school and at a school in Limon; they taught students about sea turtles, their threats and how they could help conserve them.

52 The seventh veterinary clinic was held in November, 2011; 117 animals were treated, of which 35 were spayed/neutered. To data, 395 animals have been treated since the first clinic in 2008.

Conclusions

1 Monitoring activities at the southern end of Tortuguero beach were continued, thanks to the collaboration with GVI.

2 Nesting in 2011 was much lower than levels seen in previous years, though this was to be expected, according to the nesting trend observed over the last three decades, where a very high nesting year is typically followed by a very low year.

3 Illegal take of females and eggs was higher in 2011 than in 2010; the poaching hotspot close to the Tortuguero river mouth showed high levels of poaching again in 2011.

4 Biometric data show that the size of nesting females within the Tortuguero green turtle population remains constant each year.

5 Tourist visitation to STC Visitor Centre decreased for another successive year in 2011; however, visitation to Tortuguero National Park showed a slight increase.

6 There was considerable support from ICE to help reduce the problem of artificial light pollution on the beach, by shading public lights and using different bulbs and fixtures.

7 The lack of a dedicated Education and Outreach Coordinator meant that there was a very limited number of environmental education and outreach activities conducted in the communities of Tortuguero and San Francisco.

Recommendations

1 The collaboration of STC with GVI should continue in the future, to increase monitoring activities at the southern end of the nesting beach.

2 Adequate training of RAs in all aspects of the monitoring protocol is essential to ensure that they are tagging and collecting data effectively and accurately; increased practical sessions should be scheduled during the orientation period, with on-going supervision throughout the program. They should also be taught how to manage groups of volunteers around the turtle, and how to interact with tour groups, guides and turtle spotters.

3 Regular updates of program results should be made available to TNP staff and tour guides throughout the season; including interesting turtle encounters and nesting distributions.

4 A more effective long-term solution to the control of dog populations should be sought; MINAET should take an more active role in helping to reduce the influx of animals into the area.

5 Collection of physical data should continue on a daily basis throughout the year, to monitor changes in environmental conditions in Tortuguero and provide a baseline for possible studies into the effects of climate change on sea turtles and their habitats.

6 A carrying capacity study should be conducted to determine maximum limits related to turtle tours on the beach at night to observe nesting; including the total number of people permitted per night, the total number of people permitted per section of the beach, total number of people permitted to view one turtle, and a minimum distance established between turtles being observed by tourists, to prevent crowding.

7 A re-vegetation program should be initiated to plant native vegetation between the beach and buildings in the village, to try to reduce the problem of artificial light on the beach that can negatively affect hatchlings and nesting turtles.

8 The program of tracking turtles using satellite telemetry should be continued in the future; it is not only a way of understanding the migration routes of turtles that nest at Tortuguero, to determine possible threats they may face during migration and at their feeding grounds, but it is also a great opportunity to engage local residents and visitors, and explain to them the work that STC is doing, and about sea turtle conservation in general.

1. Introduction

Dr. Archie Carr began studies of green turtles (*Chelonia mydas*) in Tortuguero in 1954 (Carr et al. 1978). Since 1959, the Sea Turtle Conservancy (Formerly Caribbean Conservation Corporation), STC, has implemented the annual Green Turtle Program. Prior to the 1998 nesting season, STC staff and the Scientific Advisory Committee revised the Green Turtle Program monitoring protocol. The new protocol defines that the Green Turtle Program is conducted in order to fulfill STC's scientific mission in Tortuguero:

'STC 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 2011Green T urtle Program represents the fourteenth consecutive year of implementing the revised monitoring protocol.

The objectives of this report are to summarize and discuss the results of the 2011 Green Turtle Program and provide recommendations for future sea turtle programs, conservation efforts and research activities in Tortuguero.

2. Methods

2.1 Preparations

Prior to the start of monitoring activities at Tortuguero in 2011, STC signed an agreement with GVI to detail the continuation of the collaboration between the two organizations with regard to data collection for the long-term STC program at Tortuguero. The agreement detailed how GVI staff and volunteers would be trained by STC and assist in monitoring activities close to the Jalova lagoon.

At the start of the 2011 Green Turtle Program the RAs completed an extensive two-week orientation and training program; they received lectures about sea turtle biology and conservation, and the Green Turtle Program monitoring protocol was explained in detail and conducted training patrols at night. They also learned about the history of the National Park, environmental laws relating to sea turtles, and the historical development of Tortuguero.

In addition to the practical and theoretical training the RAs checked the position and condition of the beach markers in the northern five miles of beach (from the river mouth to the mile five marker); any missing markers were replaced and all markers were repainted white, with the mile numbers in black.

2.2 Track Surveys

2.2.1 Weekly track surveys

Track surveys were carried out approximately weekly during the entire Green Turtle Program. The track surveyor conducted surveys between the Tortuguero river mouth (mile -3/8) and Jalova lagoon (mile 18). The surveys commenced at dawn (4:30-5:00am) at the Tortuguero river mouth, or at Tortuguero village, and finished between 9:30am-12:00pm at Jalova lagoon. If the survey started at the village, and the section between Tortuguero river mouth and the village had not been surveyed in the morning, the same person surveyed that beach section upon completing the other part of the survey.

Only tracks from the previous night were recorded and for each track the following information was recorded:

- Species
- Mile
- Nest or false crawl
- If the nest and/or turtle was poached
- If the turtle was depredated by jaguars

A nest was recorded as poached if there were signs of human disturbance, including footprints around the nest, poke holes from a stick, evidence of digging, an empty egg chamber or fresh broken egg shells close to the nest. A turtle was considered poached when there was no down track heading back to the sea and there was evidence that she had been flipped over and dragged off the beach (either through the vegetation or to a boat).

Dead turtles were considered depredated by jaguars (*Panthera onca*) when they were surrounded by jaguar tracks or showed characteristic jaguar injuries, such as extensive bites marks to the neck.

2.2.2 Daily track surveys

In addition to the weekly track surveys of the entire 18 miles of nesting beach the FRC and RAs conducted daily track surveys along the northern 5 2/8 miles of beach (from the Tortuguero river mouth to the mile 5 marker) from June – October and the southern three miles of beach (from mile 15 to the Jalova lagoon). These surveys commenced at 6.00am each morning.

Only tracks from the previous night were counted, and for each track the following information was recorded:

- Species
- Mile (using the 1/8 mile marker to the north of the track)
- Nest or false crawl

Once a nest had been recorded two lines were drawn through the track to ensure that it was not counted on future surveys.

2.2.3 Illegal take and nest predation

During track surveys researchers also recorded the level of illegal take of nests and nesting turtles, and nest depredation.

For each nest the following information was recorded:

- Species
- Mile (using the 1/8 mile marker to the north of the nest)
- If the nest and/or turtle was poached by humans
- If the nest was predated
- Identify the predator – if possible

2.3 Dead Turtles

Any dead turtles encountered during track surveys or other monitoring activities were examined and an attempt was made to determine the cause of death.

For each turtle the following information was recorded:

- Species

- Mile (using the 1/8 mile marker to the north of the turtle)
- Sex – if possible to determine
- If the turtle was killed by a jaguar
- Cause of death – if possible to determine
- Presence of flipper tags – numbers recorded if present
- Other pertinent observations

2.4 Tagging of Nesting Sea Turtles

Tagging teams patrolled the beach every night from June - October. The northern part of the beach was divided into two sections: Boca - from the river mouth to the field station (at mile 2 5/8) and Park - from the field station to the mile 5 marker. Separate teams patrolled each section during two shifts: 8pm - 12am and 12 - 4am, when the number of researchers and volunteer participants allowed. Trained GVI staff and volunteers conducted additional patrols in the southernmost three miles of beach, between mile 15 and the Jalova lagoon; typically one patrol per night was conducted unless sufficient personnel were available to have two patrols.

Female turtles encountered during the patrol were tagged after finishing oviposition or when returning to the sea. Leatherbacks (*Dermochelys coriacea*) were tagged in the rear flippers; green and hawksbill (*Eretmochelys imbricata*) turtles were tagged axillary, close to the first scale on the front flippers. All turtles were double-tagged to allow identification even if one tag was lost between nesting emergences. Tags were removed and replaced if the tag was badly located (too far from/too close to the edge of the flipper) in such a way that it could rip out or become infected and cause harm to the turtle, or if tag numbers were obscured or could not be read for any reason.

For each encounter the following information was recorded:
- Date
- Mile (using the 1/8 mile marker to the north of the turtle)
- Species
- Tag numbers of existing tags and/or evidence of old tag holes or notches

The location of the nest was classified into one of three groups:
- Open – open beach with no vegetation and no shading
- Border – nest partially shaded by vines or other sparse vegetation for some part of the day
- Vegetation – dense vegetation completely shading the nest throughout the day.

2.4.1 Green turtles

Inconel #681 tags were used to tag a minimum sample of 1,000 green turtles not carrying old tags. Every effort was made not to mix Inconel and Monel tags on the same individual. Thus, if a turtle was encountered carrying one Monel tag this was removed and two Inconel tags were applied. If it was not possible to remove the Monel tag for some reason, a second Monel tag was applied to the other flipper.

2.4.2 Hawksbill turtles

Hawksbill turtles were tagged with Inconel #681 tags. Due to the very low level of hawksbill nesting at Tortuguero, and the fact that they are listed as critically endangered, researchers always remained with the turtle until she returned to the sea and then they thoroughly erased the track afterwards, to minimize the possibility of the nest being taken by poachers.

2.4.3 Leatherback turtles

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

2.5 Biometric Data Collection

2.5.1 Green turtles

Biometric data were collected from a sample of nesting green turtles. An attempt was made to count one clutch of eggs per night in each of the two northern beach sections (Boca and Park) and at least one clutch per night in the southern beach section (Jalova). Eggs counts were conducted as the eggs were laid, by a person wearing a plastic glove so as not to contaminate the nest. Eggs were counted using an egg counter; any yolkless eggs were counted separately. All egg counts were conducted after midnight, when there were no tour groups present on the beach.

All tagged turtles were measured after they had finished nesting, if possible. 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 tape measure. Straight carapace length maximum (SCLmax), from the anteriormost edge of the carapace to the posterior tip of the longest supracaudal, was determined, to the closest millimeter, using a set of calipers. Both CCLmin and SCLmax measurements 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 centimeters between the longest and the shortest of the three measurements. Precision for females encountered more than once during the 2011 season is defined as the difference between the shortest and the longest of all measurements taken from the same turtle over the course of the season.

2.5.2 Hawksbill turtles

CCLmin and SCLmax measurements were taken for all hawksbills encountered during night patrols. As for green turtles, the same observer measured the turtle three times for each measurement, to allow the precision to be calculated. Whenever possible the clutch was counted, if the hawksbill had not already started to lay eggs when encountered.

2.5.3 Leatherback turtles

For 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 a 300cm fiberglass measuring tape. Each turtle was measured three times to determine an average CCLmin. No SCLmax measurements were taken as the calipers were not sufficiently large enough to measure a leatherback turtle.

2.6 Fibropapilloma Assessment

For a minimum sample of 100 green turtles, those for which clutches were counted, an examination for fibropapilloma was also conducted. All soft body parts, including the cloacal region, were inspected for tumors, using a flashlight with a red filter.

The following data were recorded for each assessment:

- The presence or absence of fibropapilloma tumors
- Location of fibropapilloma tumors observed
- Size of any tumors detected

- The name of the person examining the turtle

Any evidence of fibropapilloma tumors on turtles for which the clutch was not counted was also recorded during the season.

2.7 Determination of Nest Survivorship and Hatching Success

A sample of green turtle and hawksbill nests was marked during oviposition. These nests were located between Tortuguero river mouth (mile -3/8) and the mile 5 marker at the northern end of the beach, and between mile 15 and the Jalova lagoon at the southern end of the beach. The nests were marked using three pieces of flagging tape that were attached to vegetation behind the nest. While the turtle was laying eggs the distance from the centre of the egg chamber to each of these tapes was measured to the nearest centimeter, so that the location of the nest could be determined at the time of excavation using triangulation. Three marker tapes were used to compensate for the loss of any tapes as a result of camouflaging turtles, insects or persons removing the tapes intentionally; if one marker tape was lost it was still possible to locate the nest using the other two tapes. The distance to the most recent high tide line was also recorded at the time of oviposition.

In previous years nests have been excluded from the analysis of survivorship and hatching success because it was not possible to confirm that the excavated nest was in fact the original marked nest (high nesting density can result in other females laying eggs on top or very close to a marked nest). To assist in the positive identification of the marked nest during excavation a small piece of flagging tape with the nest code written on it was deposited in the egg chamber during oviposition. In addition, the morning after a nest was marked the measurements were checked to ensure that they crossed; any discrepancies were re-checked by the researchers responsible for marking the nest the previous night. In this way, erroneous measurements, or errors during the recording of data in the field books could be identified and corrected immediately.

All of the marked nests were inspected daily at 6:00am. Evidence of predation, poaching, beach erosion or disturbance by another nesting female were noted and resulted in termination of monitoring for that nest; if the evidence was inconclusive, monitoring continued as normal, but the date of the observed disturbance was recorded, so that any resulting anomalous excavation data could be accounted for. Also, it was recorded if the nest had been washed over or inundated by the tide during the previous 24 hours. If evidence of hatching was observed, the date was noted and the nest was excavated two days later. If no depression or hatchling tracks were recorded, the nest was excavated after 65 days (75 days for any leatherback nests).

After 65 days, or sooner if signs of emergence had been recorded, the nest was excavated, once the distances from the marker tapes had been re-measured to confirm that it was the original nest. Nests that had no obvious depressions were located by carefully probing for soft sand using a wooden stick (only after 65 days, when it was presumed that hatching and emergence had occurred), and this technique greatly aided in locating several of the marked nests for which hatching had not been observed. The excavation was discontinued if the researcher encountered a large number of hatchlings in the nest; in such cases the hatchlings were re-buried and the nest excavated at a later date. If a few hatchlings were encountered, they were placed in a shallow hole close to the nest site and covered with moist sand so that they could reach the sand surface and emerge the following night.

For each nest the following information was recorded during the excavation:

- Nest code
- Mile marker
- Name of persons conducting excavation

- Date laid, hatched (if available) and excavated
- Number of empty shells – only shells corresponding to more than 50% of the egg were counted
- Number of hatchlings – alive or dead
- Number of unhatched eggs - these were categorized as
  - Without embryo – no visible embryo observed
  - Embryo – an embryo at any stage of development was present
  - Full embryo – a fully developed embryo was present
- Number of pipped eggs – embryo had broken the shell but failed to hatch
- Number of predated eggs
- Number of deformed embryos – including albinism or multiple embryos in a single egg
- Number of yolkless eggs
- If the nest identification tape was found
- Any other pertinent information

In addition, the depth from the surface to the top of the egg chamber (to the first egg encountered), and the bottom of the egg chamber (after the last egg was removed) was measured to the nearest centimeter.

If a nest could not be found when excavated, an additional attempt was made the following morning by a different research team. If after two attempts the nest could not be found, researchers tried to determine the fate of the nest. Nests were considered poached if an empty egg chamber was encountered. Nests were assumed dug-up by another turtle if broken eggshells and/or the nest code tape from within the egg chamber, and a new body pit were encountered where the original nest was supposed to be located. Nests were considered depredated if a large number of opened eggshells were found in close proximity to the location of the marked nest, and there were signs of digging by animals, or tracks. An attempt was made to identify the predator if possible. If human footprints and digging was observed at the location of the nest, the nest was considered dug-up by tour guides or other persons to show the hatchlings to tourists. Nests for which the fate could not be determined with certainty or which were not excavated entirely were excluded from the subsequent analysis of nest survivorship and hatching success.

2.8 Physical Data Collection

Throughout the 2011 Green Turtle Program several environmental variables were monitored on a daily basis at the John H. Phipps Biological Station in Tortuguero.

- Rainfall was collected in a gauge that was emptied each day at 9.00am and recorded to the closest 0.1mm.
- Air temperature was recorded at 9.00am; the minimum and maximum values for the previous 24 hours, and the current temperature were noted.
- Sand temperature was measured using data loggers buried at 30, 50 and 70cm depth in the open, border and vegetation zones of the beach in front of the STC station. The data loggers were set to take a temperature reading every hour. The data were downloaded at the end of the 2010 Green Turtle Program.

2.9 Collection of Human Impact Data

2.9.1 Visitors to STC Visitors Centre

The number of visitors paying to enter the STC Natural History and Visitors Center was recorded each day during 2011 by the Visitor Center Administrator.

2.9.2 Visitors to Tortuguero National Park

Staff at the Tortuguero National Park headquarters at Cuatro Esquinas provided information on tourist visitation to the park during 2011.

2.9.3 Turtle tours

The number of tourists going on guided turtle tours during the 2011 Green Turtle Program was determined from the permits issued to tour guides by ACTo.

2.9.4 Artificial lights

To assess the level of impact of artificial lights on the Tortuguero nesting beach a light survey was conducted each month. Dates as close as possible to the new moon were selected when natural light levels on the beach were minimal. The beach was surveyed from the Tortuguero river mouth to the mile 5 marker, commencing at 8.00pm. For each survey the following data were recorded:

- Date
- Beach section – Boca or Park
- Name of observers
- Mile (using the 1/8 mile marker to the north of the light)
- Number of lights visible from the beach
- Light source (if possible to determine)
- Location of light source (beach side or river side)

To avoid duplicate recording of the same light source in more than one 1/8 mile section of beach, only those lights that could be seen while viewed perpendicular from the beach were recorded in each 1/8 mile.

2.9.5 Hatchling disorientation

Any evidence of hatchling disorientation was recorded, for marked or unmarked nests. Where possible the light source causing the disorientation was noted, in addition to the number of disorientated hatchlings encountered (dead or alive) and the number of hatchlings that reached the sea successfully.

2.10 Environmental Education and Outreach Activities

Presentations about sea turtle biology, conservation and the work of the STC in Tortuguero were given opportunistically to groups staying at or visiting the John H. Phipps Biological Station. In addition, the 2011 Green Turtle Program RAs, supervised by the FRC, implemented a series of environmental education activities at the Tortuguero school and high school, and also at the school in San Francisco village. When possible visits to other coastal communities were also made, to conduct education and outreach activities with students. Outreach activities for adult community members were also developed, to increase the interaction between STC staff and volunteers and local residents, and to raise awareness about environmental and conservation issues affecting the region.

In response to concerns in 2007 from STC, local guides and National Park staff about the level of dog predation of turtle nests and the increasing population of dogs in the village, a committee was organized comprising representatives from interested groups and individuals to coordinate a veterinarian spay/neuter clinic and educational program in 2008 with the aim of reducing the dog population and also providing advice to local residents on how to care for their pets. Two clinics were

held in 2008 and 2009; STC remained an active member of the organizing committee throughout 2011, helping to plan and run two further clinics.

2.11 Satellite Telemetry Project

Satellite transmitters were attached to turtles after they had finished nesting. When the turtle was returning to the sea she was put into a special holding box and transported to the STC Biological Field Station were she was retained overnight. The following morning trained STC staff (the Scientific Director and Dan Evans, satellite telemetry expert for STC) applied the transmitter to the carapace of the turtle using internationally accepted application techniques; either a fibre-glass resin method or an epoxy method. Members of the public had the opportunity to observe the transmitter application process, and were invited to a public release of the turtle on the beach, at around 9.00am, when the attachment medium was sufficiently fixed. Prior to the attachment of the transmitter the turtle was tagged and CCLmin and SCLmax carapace measurements were recorded.

Turtles released at Tortuguero were part of the STC on-line event "Tour de Turtles 2011"; this education event shows the migration routes of different turtles as they 'race' to be the turtle to travel the furthest distance during a fixed time period. Each turtle also raises awareness about a specific threat to sea turtles or their habitats, such as coastal development or marine pollution. The general public can follow the migration of the different turtles at a special website that is regularly updated (www.tourdeturtles.org)

3. Results

3.1 Preparations

The agreement between STC and GVI facilitated collaboration between the two organizations; GVI staff and volunteers assisted in the collection of data for the 2011 Green Turtle Program, and the additional personnel allowed beach patrols to be conducted in the section of beach close to Jalova which typically is only monitored at night during the Leatherback Program from March – June.

The RAs arrived in Tortuguero on 6 June, 2011. During the first two weeks of the 2011 Green Turtle Program the RAs received an intensive training program and general orientation. This included lectures about sea turtle biology, conservation, tourism in Tortuguero, and the history and structure of STC. There was also a detailed explanation of the Green Turtle Program monitoring protocol. In addition to theoretical instruction they also received practical training in flipper tagging, nest marking and other data collection procedures from the FRC. Training patrols were conducted on several nights along sections of beach close to the field station (between the Tortuguero river mouth and mile 5), during which the FRC demonstrated field techniques and supervised RAs tagging and measuring turtles, and recording data in the field books. To have a better understanding of Tortuguero National Park, Costa Rican environmental laws and the community, RAs spoke to park rangers and members of one of the founding families of Tortuguero to learn about the history and development of the area. To facilitate the environmental education program there were also visits to the school and high school in Tortuguero, and the school in San Francisco. RAs also visited the biological research station at Caño Palma to talk to investigators conducting sea turtle research north of the Tortuguero river mouth.

During the first week of the program the mile markers on the beach between the Tortuguero river mouth (mile -3/8) and the mile 5 marker were replaced and/or repainted as necessary, to ensure that there were three markers at each 1/8 of a mile. These markers were put in the same locations as those positioned at the start of the 2011 Leatherback Program.

3.2 Track Surveys

3.2.1 Weekly track surveys

Fifty-one weekly track surveys were conducted from 8 January to 25 December, 2011. The first green turtle nest was recorded on 15 February, 2011, with regular nesting observed from June – October (See Figure 1). Peak nesting was observed on 6 August, when 1.622 nests were recorded in a single night. Using the methodology of Troëng & Rankin (2005), it was estimated that 78,852 green turtle nests were laid along the entire 18 miles of beach during the 2011 nesting season (See Figure 2). This equates to a population of between 13,142 – 28,161 nesting females.

As observed in previous years, green turtle nesting density was found to be highest away from the river mouths that mark the end of the beach; the least stable area of nesting habitat (See Figure 3). Increased nesting was observed within Tortuguero National Park, between miles 5 – 13, with the highest density occurring in miles 9 and 10 (21.2% of nests were recorded within these two miles). Nests laid between the Tortuguero river mouth and the mile 5 marker, and between mile 15 and the Jalova lagoon, where nightly beach patrols were regularly conducted, accounted for 17.1% of all nests laid on the entire beach (See Figure 3).

Fifteen green turtle nests were recorded as poached during weekly track surveys; five on 10 July and 10 on 15 October. Twelve green turtles were reported as poached; one on 3 September, and 11 in just one night on 15 October. All of these turtles were taken within TNP, between miles 6 – 10.

Between 15 February (the first date that green turtle nesting activity was observed) and 25 December, a total of 57 green turtles were killed by jaguars the night before the survey. On 11 July and 3 September, six turtles were killed in a single night. In addition, the track surveyor reported one leatherback female killed by a jaguar on 24 April.

Levels of hawksbill nesting activity were higher than in previous years, though still at very low levels; 10 hawksbill nests were observed during 2011; between 7 May – 5 November.

A detailed discussion on the temporal and spatial distribution of leatherback nesting in 2011 can be found in the 2011 Leatherback Program Report.

Figure 1. Temporal distribution of green turtle nesting at Tortuguero in 2011, as determined from weekly track surveys

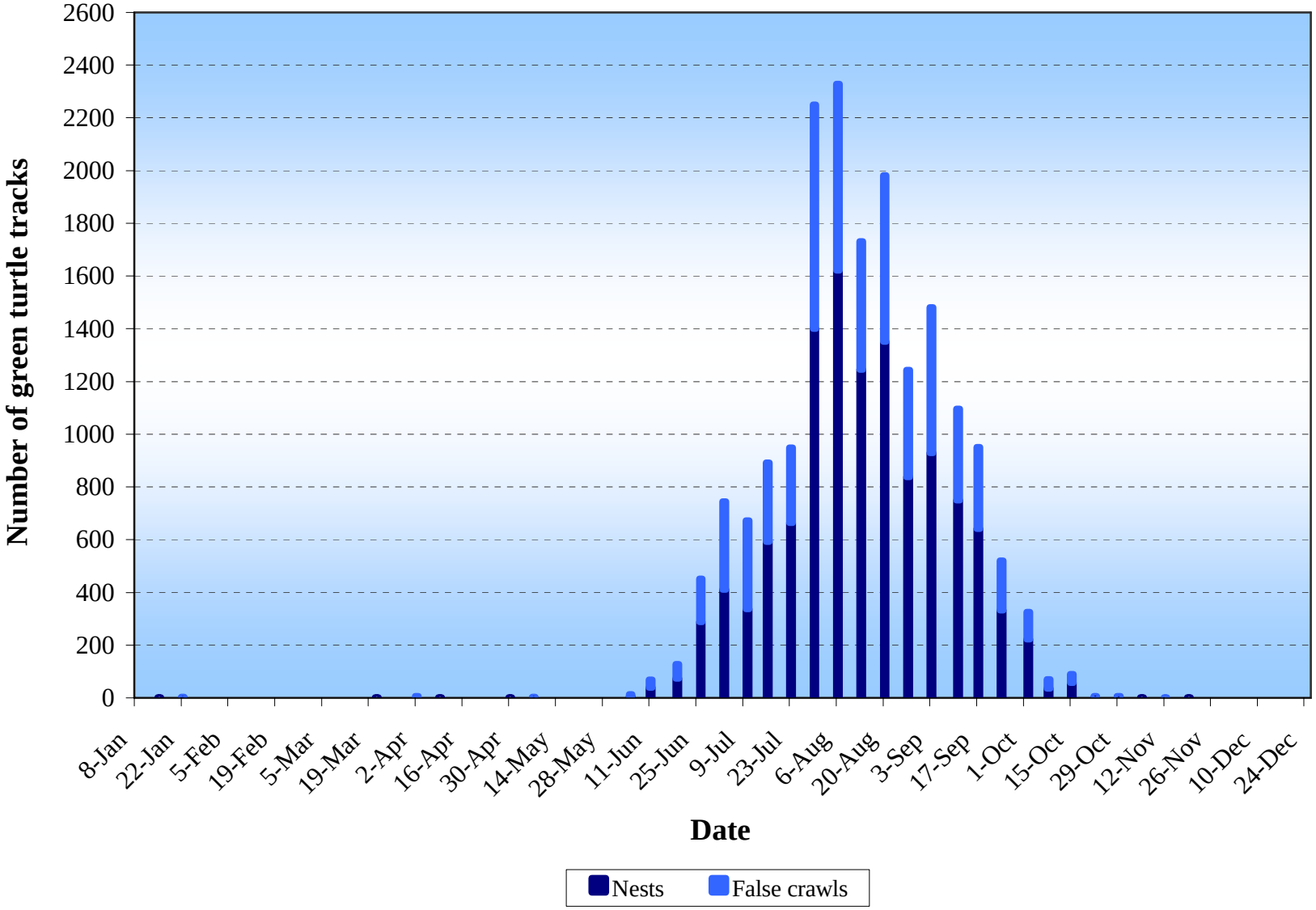


Figure 2. Green turtle nesting trend at Tortuguero, 1986 - 2011, as determined by weekly track surveys of the entire beach

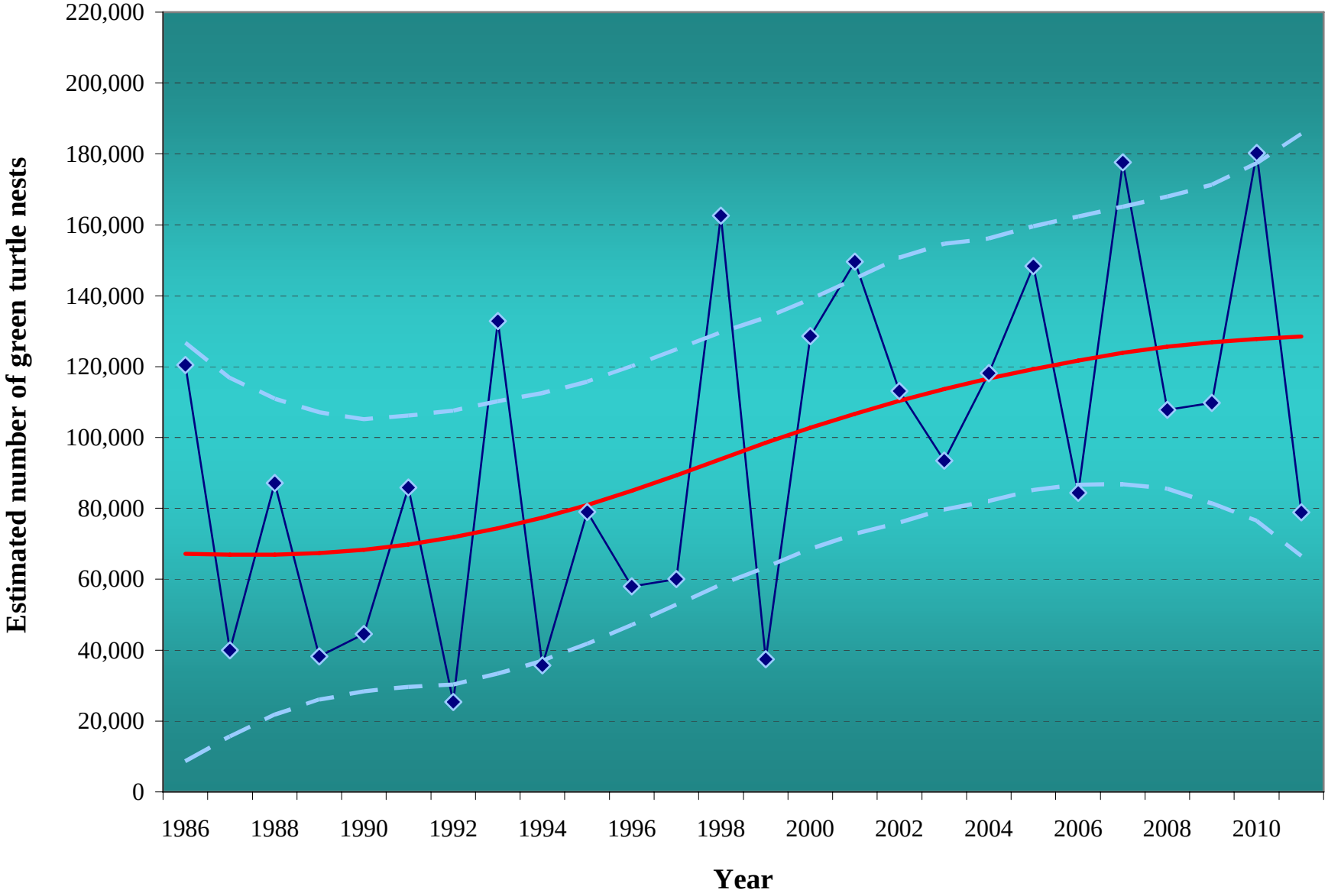
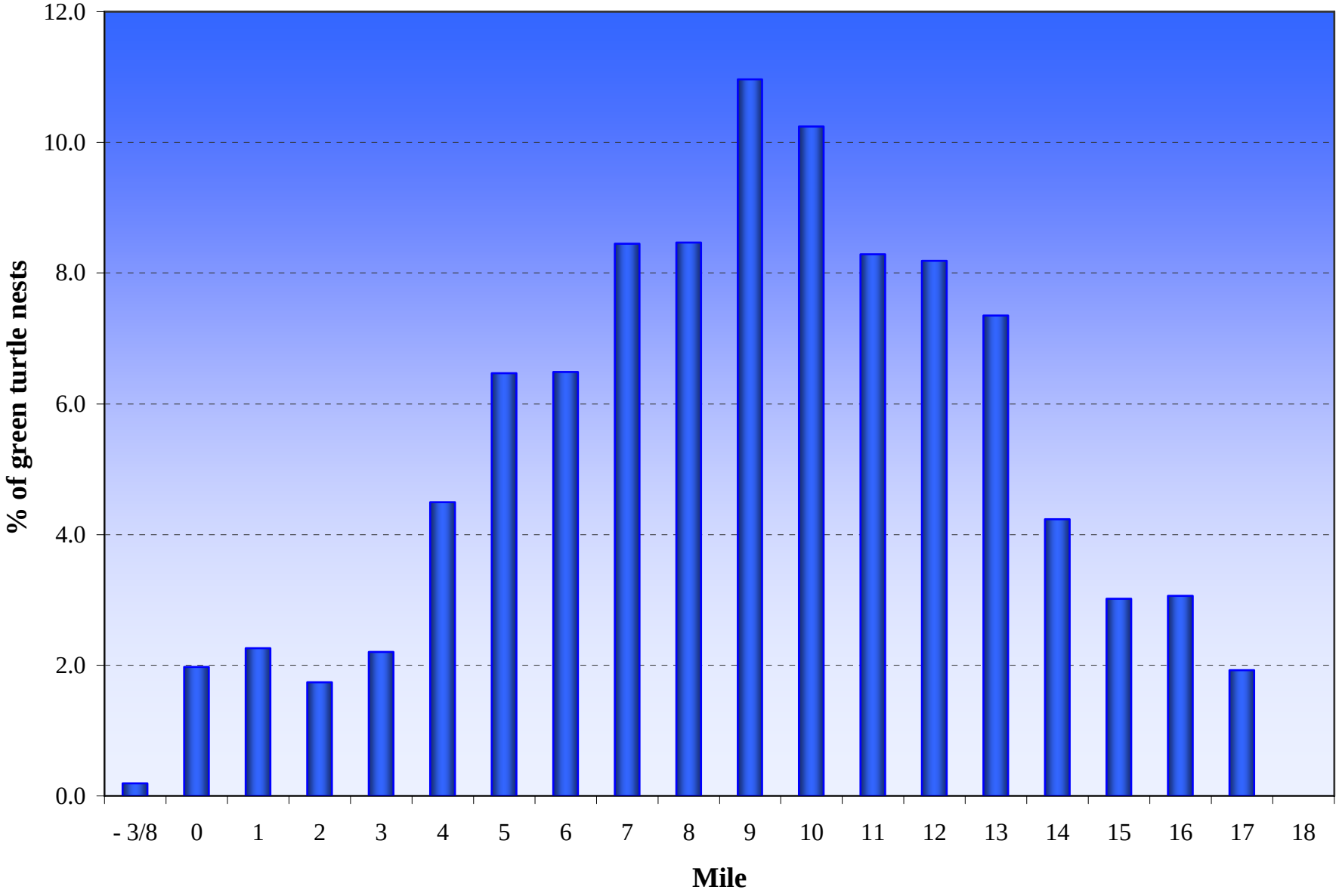


Figure 3. Spatial distribution of green turtle nesting at Tortuguero in 2011, as determined from weekly track surveys



3.2.2 Daily track surveys

Daily track surveys were conducted by the FRC and RAs between 12 June and 1 November (except 23 June, 13, 20 and 21 August, and 28 and 29 October). Partial surveys of the beach were conducted on 10 and 11 June, and 28 September. For several days in July and August, the RAs were unable to start track surveys at the river mouth, due to the condition of the beach; surveys on these days were initiated between mile 0 and mile 2/8. A total of 12,420 green turtle nests and 11,000 green turtle false crawls were recorded between the Tortuguero river mouth and the mile 5 marker (See Figure 4a and 4b); successful nesting was observed in 53.0% of green turtle emergences.

Figure 4a shows the spatial distribution of green turtle nests and false crawls for the northern 5 2/8 miles of beach. Nesting density per 1/8 mile was greater within the National Park (past 3 3/8), and the percentage of nests laid to the north of TNP (on the 'public' section of beach) was less than within the Park; 5,663 (45.6%) compared to 6,757 (54.4%), respectively. As in previous years, nesting density was lowest close to the river mouth (mile -2/8) and in front of Tortuguero village (miles 2 7/8 - 3 2/8).

The temporal distribution of nesting for the 2011 Green Turtle Program is shown in Figure 4b. Peak nesting activity was recorded on 25 August, when 297 green turtle nests were counted from the previous night. Nesting was considerably lower than in 2010, and there were only 12 nights between June and October when more than 200 nests were reported; 30 July, 4, 8, 11, 12, 23-25, 29-31 August and 8 September.

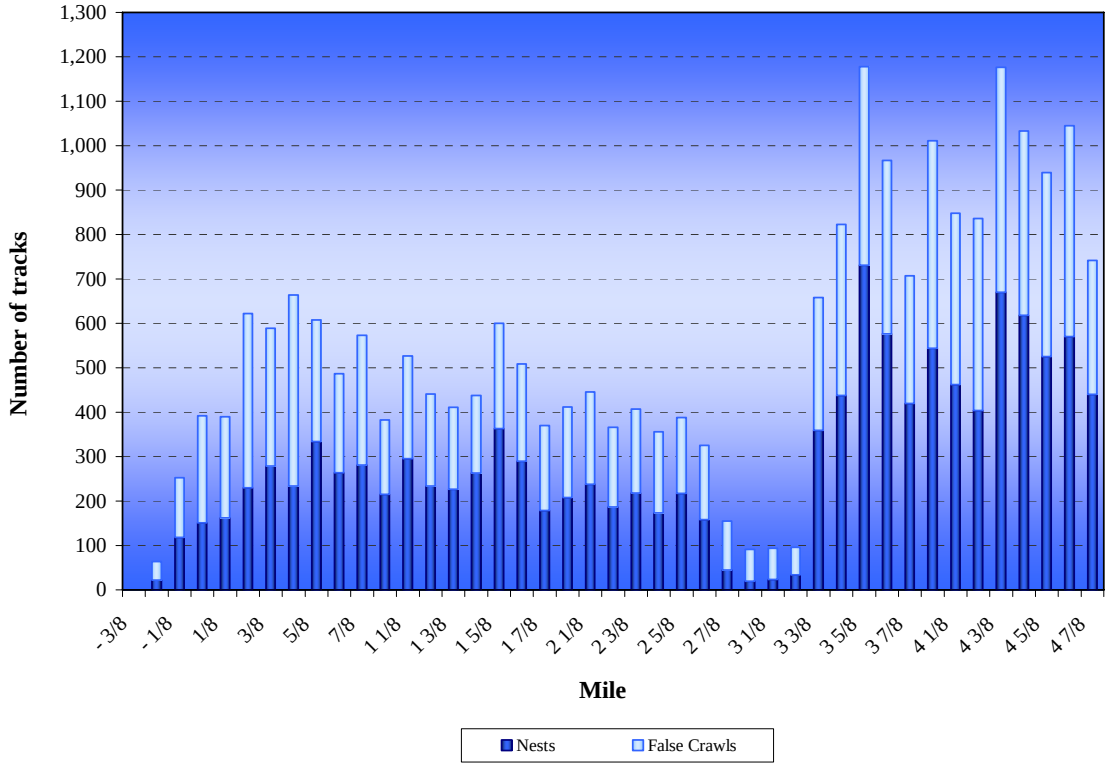
One leatherback nest was recorded at the beginning of the 2011 Green Turtle Program; on 13 June. Hawksbill nesting activity was observed from June to October, with a total of 26 nests and 29 false crawls recorded during track surveys. Nesting was reported throughout the 2011 Green Turtle Program; the first nest was seen on 16June, the last on 22 October. There were also several track surveys in which two hawksbill nests were recorded.

Daily track surveys were conducted by the GVI staff and volunteers between 6 June and 31 October (except 18-23 September); partial surveys were conducted on 27 June, 1 July, and 10 and 13 September. A total of 6,618 green turtle nests and 7,396 green turtle false crawls were recorded between mile 15 and the Jalova lagoon (See Figure 5a and 5b); successful nesting was observed in 47.2% of green turtle emergences at the southern end of the beach.

In addition, from 16 June – 31 October, four leatherback nests and three false crawls were recorded during track surveys close to Jalova; the last nest was registered on 28 July. Hawksbill nesting was observed from June – September; a total of 19 nests and 25 false crawls were registered. Two loggerhead (*Caretta caretta*) nests and two false crawls were also reported during track surveys close to Jalova; however, the individual was not encountered, so there was no verification of the species identification. It is possible that the tracks were hawksbill, not loggerhead, as the two species have very similar tracks.

Figure 4. Results of daily track surveys of the northern 5 2/8 miles of beach in 2011

a) Spatial distribution



b) Temporal distribution

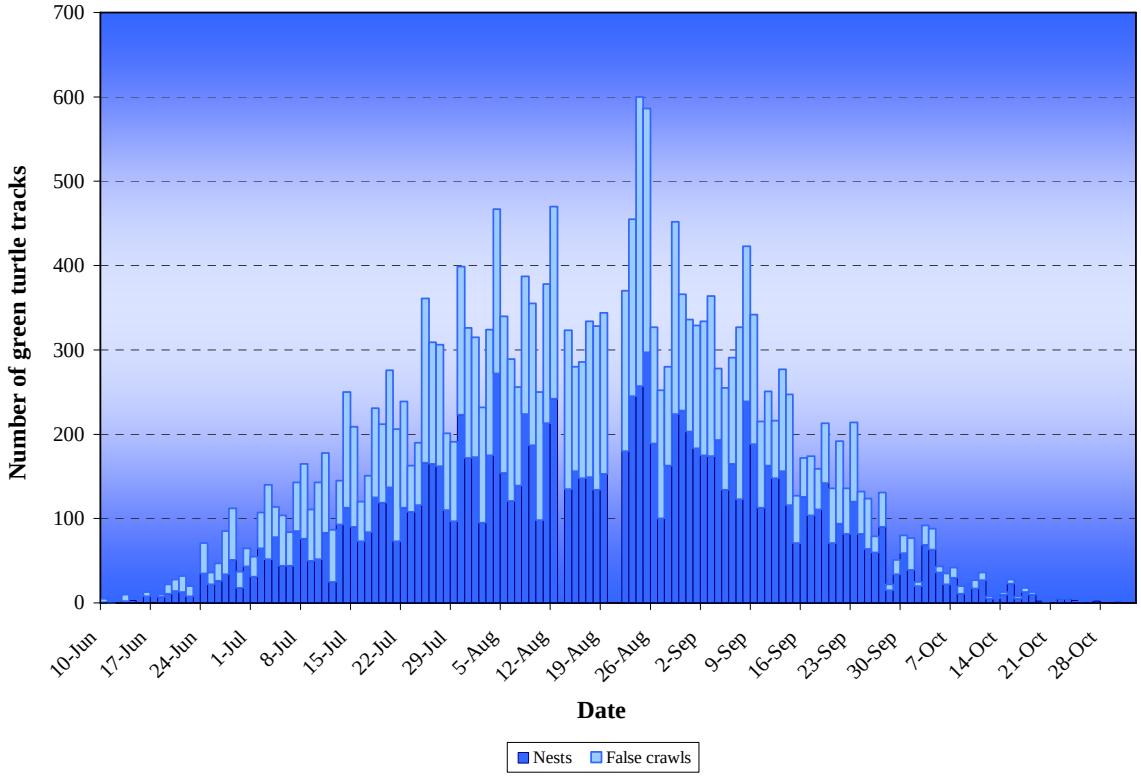
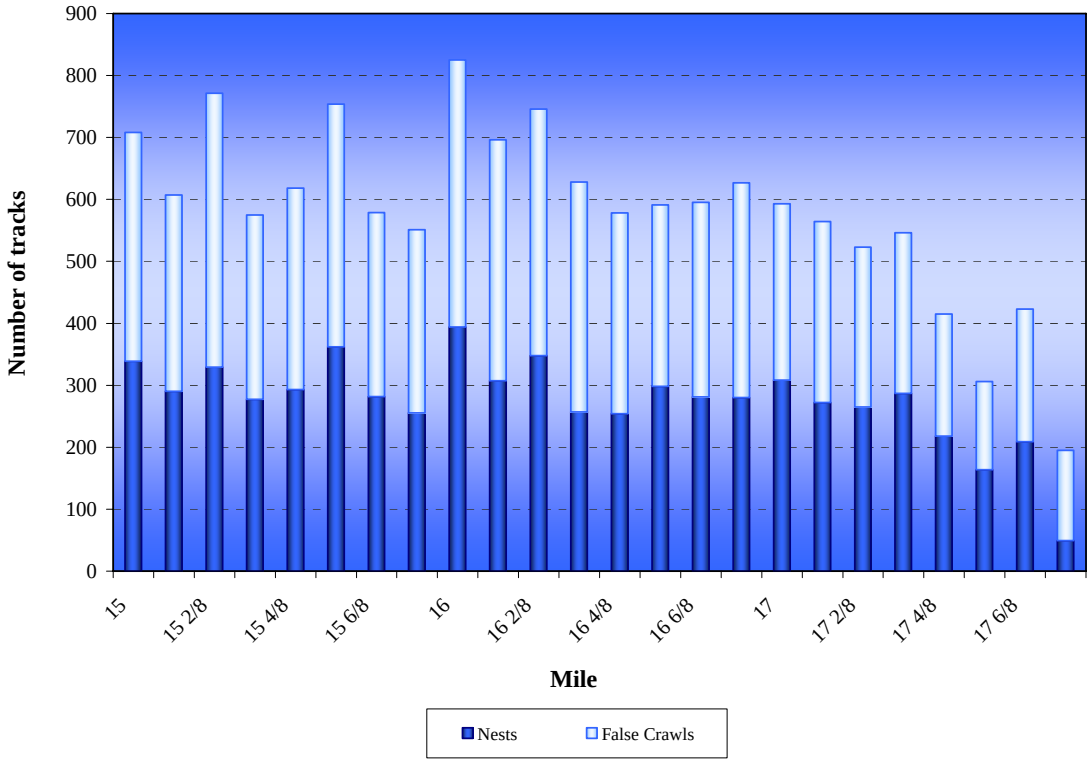
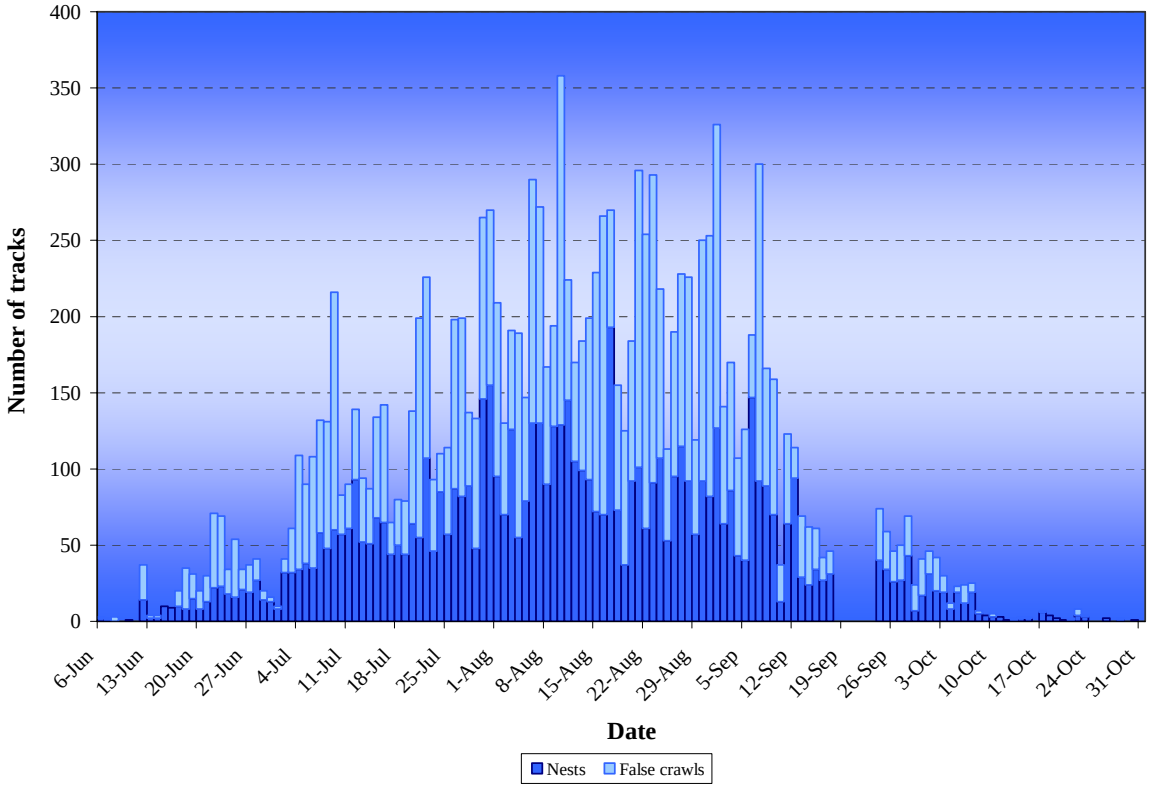


Figure 5. Results of daily track surveys of the southern three miles of beach in 2011

a) Spatial distribution



b) Temporal distribution



3.2.3 Illegal take and nest predation

During the daily track surveys researchers also noted the level of illegal take of both eggs and female turtles (See Figure 6a and 6b). In total, 181 green turtle nests (1.5% of the total number laid) were taken from June – October; three hawksbill nests were also recorded as poached (11.5% of hawksbill nests laid). Twenty-four nests were taken in one night on 18 September (See Figure 6b). No leatherback nests were poached. Thirty-two green turtles and two hawksbill turtles were also observed to have been taken from the nesting beach.

From Figure 6a it can be seen that poaching was observed throughout the five miles of beach; however, the majority of nest poaching occurred towards the Tortuguero river mouth, between mile -1/8 and mile 2/8, although there was also poaching reported close to the village (between miles 2 6/8 and 3 2/8) and within TNP, between miles 3 3/8 - 4. Poaching of nesting turtles was very concentrated around the river mouth at mile -2/8, with a small peak also observed close to the village in mile 2 6/8 (See Figure 5a).

From 12 June - 1 November, poaching (of either nests or turtles) was observed during 71 of 139 (51.1%) track surveys (See Figure 6b). The highest number of poached nests was recorded on 19 September, when 24 green turtle nests were taken in one night; there were also two other nights when more than 10 nests were taken - 24 August and 12 September (See Figure 6b). Poaching was observed throughout the nesting season, although the poaching of nests was more prominent August and September (See Figure 6b).

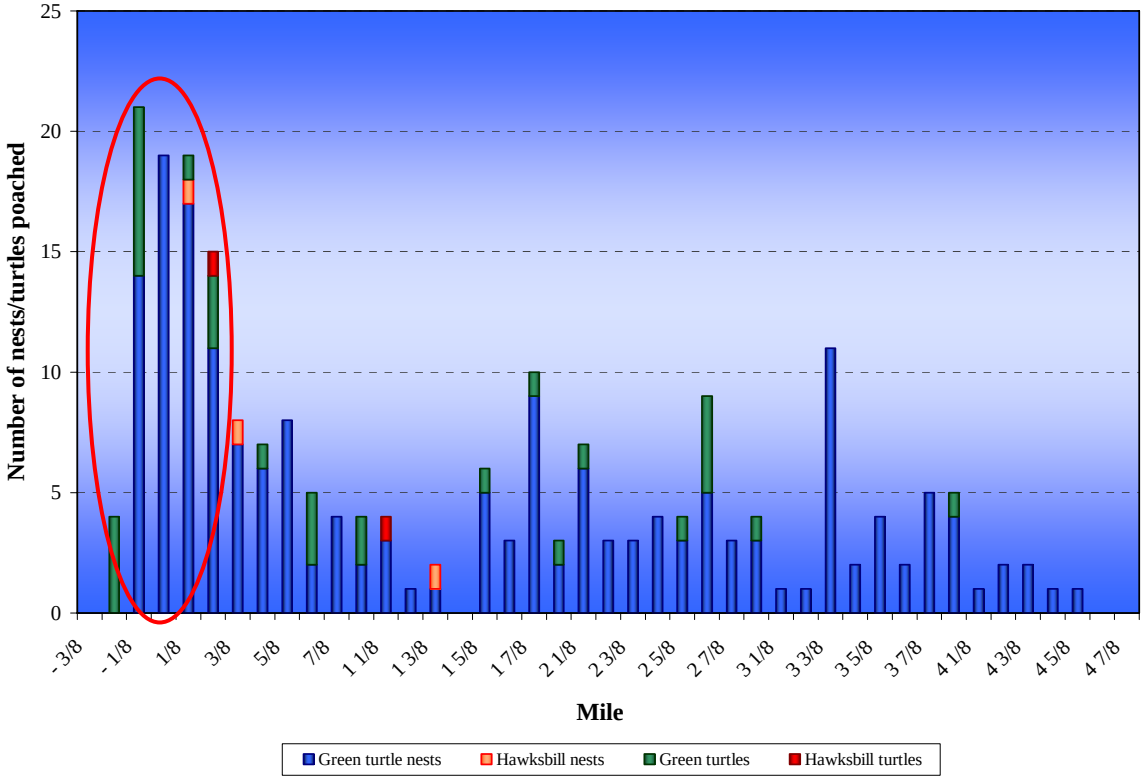
A total of 15 fresh green turtle nests (0.1%) were reported as predated by dogs from June – October in the northern five miles of beach close to Tortuguero village; four older nests were also reported as depredated by dogs. It is known, however, that dogs also predate nests when they are close to hatching, and so the number presented here is probably an underestimation of the total number of nests being affected. One nest was reported depredated by another animal, and 77 nests were destroyed by other females that made their nests in the same place as an old nest.

There was no report of any nest or taken being taken during the track surveys close to Jalova between June – October.

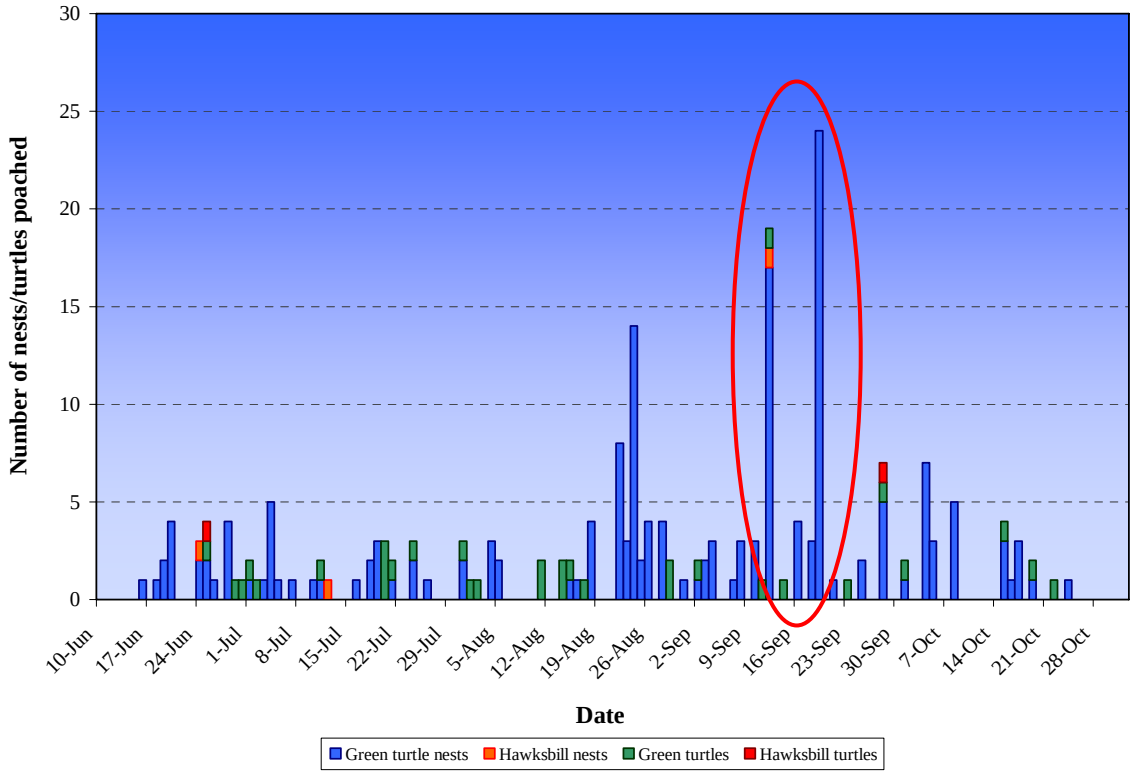
No nest laid between mile 15 – Jalova lagoon was predated by dogs, however, 32 nests were recorded to have been destroyed by another nesting female.

Figure 6. Illegal take of nests and turtles in 2011, as determined from daily track surveys of the northern 5 2/8 miles of beach

a) Spatial distribution



b) Temporal distribution



3.3 Dead Turtles

In addition to the turtles that were reported as poached during the daily track surveys, eight dead green turtles were recorded during monitoring activities (See Table 1). Of these, seven had been killed by jaguars and one stranded dead on the beach and it was not possible to determine the cause of death.

Table 1. Dead turtles encountered during the 2011 Green Turtle Program

Date	Mile	Species	Sex	Comments
15 June	2 3/8	Cm	Female	Stranded dead – no obvious cause of death
20 June	4 6/8	Cm	Female	Killed by jaguar – No tags
1 July	4 7/8	Cm	Female	Killed by jaguar – No tags
7 August	4 7/8	Cm	Female	Killed by jaguar – Tag #s 113050 / 113051
22 August	4 7/8	Cm	Female	Killed by jaguar – No tags
13 September	4 4/8	Cm	Female	Killed by jaguar – No tags
14 October	5	Cm	Female	Killed by jaguar – Tag #s 112507 / 112508
15 October	4 6/8	Cm	Female	Killed by jaguar – Tag # 103554

Cm = Green turtle

Two green turtles were found alive following poaching attempts. One was found by the station security guard, flipped over and tied up on the trail behind the beach. The turtle had a damaged flipper and eye, and was very tired, so a group of RAs and staff stayed with her on the beach for several hours until she could return to the sea (See Appendix 1). The other turtle was encountered during a track survey; she had also been flipped over. Neither of these individuals was encountered stranded dead at a later date, and so it was presumed that they survived.

Table 2. Turtles encountered alive following attempted poaching

Date	Mile	Time	Species	Sex	Comments
5 August	2 4/8	3.00am	Cm	Female	Turtle found alive with damage to left eye and front flipper; assisted back to the sea. Tag # 109747
29 August	3 4/8	6.30am	Cm	Female	Turtle found flipped over on the beach; one flipper damaged; assisted back to the sea.

Cm = Green turtle

3.4 Tagging of Nesting Sea Turtles

Tags used during the 2011 Green Turtle Program (in Tortuguero and Jalova) were National Band & Tag Company Monel #49 VC1219-VC1220 and Inconel #681 120470-120476, 120484-120510, 120516-122519, 122601-123385.

In the northernmost five miles (Tortuguero), a minimum of one night patrol was conducted from 9 June – 30 October, 2011 (except 17 June; 12 and 19 August; 28 and 29 October); a total of 1,749.8 team patrol hours were logged. At the southern end of the nesting beach (Jalova), at least one night patrol was conducted daily from 6 June – 30 October, 2011 (except 9 and 26 June; 2 and 3 July; 4 and 19 August, 8, 9, 11, 14-30 September and 1, 2, 4, 6, 15, 18, 21-23, 28 October); a minimum of 540.4 team patrol hours were logged. Data from both sections of the beach are combined for subsequent analyses, unless indicated.

3.4.1 Green turtles

A total of 1,758 green turtle encounters were recorded in the two sectors at either limit of the beach (Tortuguero in the north and Jalova in the south); 1,342 in Tortuguero and 416 in Jalova (See Appendix 2). These encounters included 1,430 individual females; 1,000 (69.9%) initially observed without tags and 430 (30.1%) who had tags. In addition there were 328 encounters with turtles observed more than once during the 2011 nesting season.

During the 2011 Green Turtle Program, 26 green turtles tagged at other nesting beach projects in Costa Rica were encountered; 11 were tagged by researchers from the Caño Palma turtle monitoring project (north of the Tortuguero river mouth), five were tagged in Mondonguillo, seven in Parismina and three in Pacuare Nature Reserve, which are all beaches south of Tortuguero National Park. The SD is awaiting confirmation of original tagging dates from researchers working at these beaches.

In addition there were three females encountered with tags from countries other than Costa Rica. One had tag #H7916; this turtle was originally tagged in April 2009 in feeding grounds in Nicaragua as part of a project run by Dr. Cynthia Lagueux and Dr Cathi Campbell. Another turtle had tag #AM704; the SD is waiting confirmation of where and when this turtle was tagged, but the tag number is from a series that was used in Mexico. The third turtle had tag #CH3645; she was marked at the STC project at Chiriquí Beach, Panama, earlier in the 2011 nesting season.

The other females that had tags were all originally tagged in Tortuguero. There were 98 individuals that had been tagged more than 10 years previously; of these three were tagged more than 20 years ago. The female with the longest tagging history for 2011 was observed on 21 September; the female with ID#21487 was originally tagged in 1980. She was observed in 10 other nesting seasons in the intervening 31 years; 1983, 1986, 1988, 1991, 1995, 1998, 2001, 2003, 2005 and 2008.

Of 954 newly tagged green turtles checked for the evidence of old tag holes or notches when encountered for the first time during the 2011 Green Turtle Program, 140 (14.7%) had evidence in at least one flipper. It is interesting to note that the percentage of turtles with evidence of tags in Tortuguero was much higher than that in Jalova (17.0% compared to 10.2%, respectively).

Tagging efficiency for green turtles emerging (nests and false crawls) between the Tortuguero river mouth and the mile 5 marker on nights before track surveys from 18 June thru 31 October (after the two-week training week; n = 127) ranged from 0% to 100%, with an overall mean of 14.5%. In Jalova, tagging efficiency from 7 June thru 31 October ranged from 0% to 100%, with a mean of 8.0%

Beach zone was recorded for 1,741 green turtles encounters; 23.7% (n = 412) of those females nested

in the open zone, 61.4% (n = 1,069) were located in the border zone, 14.4% (n = 250 in the vegetation zone and 0.6% were encountered while making a false crawl (n = 10).

3.4.2 Hawksbill turtles

Sixteen hawksbill encounters were logged during the 2011 Green Turtle Program (See Appendix 2). There were 15 individual females (one was encountered twice); 14 were newly tagged and one was previously tagged. The previously tagged female, which was encountered in Jalova, was originally tagged in Parismina. None of the newly tagged hawksbill turtles had evidence of previous tags holes or notches. Four of the 16 hawksbill nests (25.0%) were laid in the open zone, seven (43.8%) in the border zone and five (31.3%) in the vegetation zone.

3.4.3 Leatherback turtles

Only one leatherback was encountered during the 2011 Green Turtle Program; 28 July (See Appendix 2). The female did not have tags. She nested successfully in the open zone.

3.5 Biometric Data Collection

3.5.1 Green turtles

Table 3 shows the mean carapace length of green turtle females measured during the 2011 Green Turtle Program. An initial analysis compared carapace length between turtles encountered in Tortuguero and Jalova; for both newly tagged and previously tagged individuals. The results showed no significant differences, and so data from Tortuguero and Jalova were combined for subsequent analyses (T Test: t = -1.783, p = 0.075 y t = -0.586, p = 0.588, newly tagged and previously tagged turtles, respectively). A second analysis was conducted to see if there was a difference in the CCLmin between newly tagged females with and without evidence of previous tags; the results showed that there was a significant difference (T-Test: t = 2.753, p = 0.006). Another analysis compared CCLmin between newly tagged and previously tagged individuals; results showed a significant difference between the two groups (T-Test: t = -3.045, p = 0.002). Therefore, the data from previously tagged turtles and newly tagged turtles were separated; the newly tagged individuals were divided into two groups (with and without evidence of previous tags – See Table 3). To ensure independence of the data, only the first measurements taken for each individual were included in the analysis.

Table 3. Mean CCLmin of green turtles

Sample	N	$\bar{x}$ ± S.D.
Newly tagged females – no OTH/OTN	782	105.0 ± 4.9
Newly tagged females – OTH/OTN	133	106.3 ± 5.2
Previously tagged females	390	106.2 ± 5.2
All	**1,305**	**105.5 ± 5.0**

OTH = Old tag hole, OTN = Old tag notch

The overall mean curved carapace length (CCLmin) was 105.5cm (Range = 90.3 – 130.5cm). Newly tagged females with no evidence of previous tags were slightly smaller than newly tagged females with evidence of previous tags, and previously tagged females (See Table 3).

Table 4 shows the mean SCLmax measurements for green turtles. An initial analysis compared the SCLmax between turtles encountered in Tortuguero and Jalova, both newly tagged and previously tagged individuals. The results showed a significant difference for newly tagged females, but not for previously tagged individuals (T-Test: t = 2.341, p = 0.019 y t = -1.605, p = 0.109, respectively); therefore, the data from Tortuguero and Jalvoa are shown separately. A second analysis was conducted to see if there was a difference in SCLmax for newly tagged females with and without evidence of previous tags; results showed no significant difference (T-Test: t = 1.295, p = 0.196) and so the data for all newly tagged females were combined. A final analysis compared newly tagged and previously tagged females; the results showed a significant difference between the two groups (T-Test: t = -1.976, p = 0.048), and so the two grups are shown separately (See Table 4). Se realizó otro análsis para ver si había diferencia en el CCLmin entre hembras nuevas marcadas y las previamente marcadas; los resultados indicaron una diferencia significativa (Prueba de. Entonces, los datos de las previamente marcadas y las nuevas fueron analizados separados (ver Tabla 4). To ensure independence of the data, only the first measurements taken for each individual were included in the analysis. Mean SCLmax in Tortuguero was 100.1cm (Range = 86.3 – 120.9cm) and in Jalova it was 99.1cm (Range = 87.1 – 114.0cm); for the entire beach it was 99.8cm (n = 1,218).

Tabla 4. Mean SCLmax of green turtles

Sample	Tortuguero		Jalova	
	n	**$\bar{x}$ ± S.D.**	**n**	**$\bar{x}$ ± S.D.**
Newly tagged females	528	99.9 ± 4.5	328	99.2 ± 4.4
Previously tagged females	341	100.3 ± 4.7	21	98.6 ± 4.2
All	**869**	**100.1 ± 4.6**	**349**	**99.1 ± 4.4**

An analysis of the number of eggs laid by newly tagged and previously tagged females showed a significant difference between the two groups (T-Test: t = 2.372, p = 0.019), and so data are shown separately (See Table 5). Clutch size ranged from 52 – 178 eggs, for all nests counted ($\bar{x}$ = 114.0 eggs, n = 233; See Table 5). Not included in the estimation of mean clutch size of newly tagged females was one nest where the turtle laid only 16 eggs before abandoning the nest. On 36 occasions the female laid yolkless eggs; the number of these eggs ranged from one to eight

Table 5. Clutch size of green turtles

	Number of eggs	
Sample	**n**	**$\bar{x}$ ± S.D.**
Newly tagged females	195	115.6 ± 22.2
Previously tagged females	38	105.8 ± 28.8
All	**233**	**114.0 ± 23.6**

For green turtles there was a significant difference in the precision of CCLmin and SCLmax measurements taken by RAs and Eco-Volunteers (See Table 6a); Mann-Whitney Test: U = 223220.0, p < 0.0001 and U = 181529.5, p < 0.001, respectively). Precision of the two measurements was very similar. For measurements taken within a single encounter, CCLmin and SCLmax measurements were taken with very similar levels of precision (See Table 6a).

For females encountered and measured on two or more occasions in 2011, SCLmax measurements were taken with a higher level of precision than CCLmin measurements (See Table 6b). For both CCLmin and SCLmax measurements there were occasions when the difference between the length measurements on subsequent encounters with the same female was greater than 5cm (See Table 6b).

Table 6. Precision of carapace measurements for green turtle females

a) During the same encounter

Observer	CCLmin / cm			SCLmax / cm		
	n	$\bar{x}$ ± S.D.	Range	n	$\bar{x}$ ± S.D.	Range
Research assistants	1,005	0.3 ± 0.2	0.1 – 1.2	913	0.3 ± 0.2	0 – 1.2
Eco-Volunteers	629	0.5 ± 0.3	0 – 1.3	550	0.4 ± 0.3	0 – 1.5
Total	**1,634**	**0.4 ± 0.3**	**0 – 1.3**	**1,463**	**0.4 ± 0.3**	**0 – 1.5**

b) Between encounters

	CCLmin / cm			SCLmax / cm		
Encounters	n	$\bar{x}$ ± S.D.	Range	n	$\bar{x}$ ± S.D.	Range
2	205	1.4 ± 0.9	0.2 – 4.8	172	1.0 ± 0.9	0 – 6.6
3	35	1.9 ± 1.1	0.3 – 5.3	30	1.2 ± 0.6	0.4 – 2.4
4	5	3.0 ± 1.4	1.7 – 5.0	5	1.5 ± 0.8	0.6 – 2.8
5	1	5.7	-	1	4.3	-

3.5.2 Hawksbill turtles

Carapace measurements were taken for all of the hawksbill females observed during the 2011 Green Turtle Program (See Table 8). CCLmin ranged from 82.6 – 91.2cm and SCLmax from 79.0 – 86.1cm. Seven clutches were counted; average clutch size was 164 (See Table 7)

Table 7. Mean carapace length of hawksbill females

Sample	CCLmin / cm		SCLmax / cm		Clutch size / eggs	
	n	$\bar{x}$ ± S.D.	n	$\bar{x}$ ± S.D.	n	$\bar{x}$ ± S.D.
Newly tagged females	15	87.0 ± 2.6	10	82.1 ± 2.6	6	163 ± 36.4
Previously tagged females	1	90.5	1	86.1	1	175
All	**16**	**87.3 ± 2.6**	**11**	**82.5 ± 2.8**	**7**	**164 ± 33.5**

Precision of SCLmax measurements of hawksbill females was slightly higher than that of CCLmin measurements (See Table 8); data from newly tagged and previously tagged females were combined. An inter-species comparison shows that the precision of SCLmax measurements is the same for hawksbills and green turtles; however, SCLmax measurements have a slightly higher precision for hawksbills than green turtles (See Table 5a and Table 8).

Table 8. Precision of carapace measurements for hawksbill females

Sample	CCLmin / cm			SCLmax / cm		
	n	$\bar{x}$	Range	n	$\bar{x}$	Range
All	13	0.4 ± 0.3	0.1 – 1.0	11	0.3 ± 0.1	0.1 – 0.5

3.5.3 Leatherback turtles

During the 2011 Green Turtle Program biometric data were collected for the only leatherback female encountered. The carapace length (CCLmin) was 164.1cm; the precision of the measurements was 0.8cm. The turtle was encountered when camouflaging the nest, and so no clutch count was made.

3.6 Fibropapilloma Assessment

A total of 189 green turtles were subject to a thorough examination for the presence of fibropapilloma tumors; only one individual (0.5%) was recorded to be affected with the disease. In addition to the females who were checked specifically for the presence/absence of fibropapilloma, tumors were also recorded if observed during the routine check physical abnormalities conducted on all females encountered; an additional 13 individuals were found to have fibropapilloma tumors. All these turtles had tumors on the flippers or on the neck. The tumors ranged in size from 1 – 4cm. Investigators also encountered 17 females with other types of tumors; they ranged in size from 2 – 8cm and up to four tumors were found on a single female.

3.7 Determination of Nest Survivorship and Hatching Success

3.7.1 Green turtles

A total of 220 green turtle nests were marked between 14 April and 10 October, 2011; 91 nests were marked in the northern five miles of beach, while the additional patrols at the southern end of the beach allowed 129 nests to be marked close to the Jalova lagoon. Two nests were marked during the 2011 Leatherback Program.

For 46 nests the fate could not be determined with certainty; either they were not encountered at excavation (n = 32), or the tapes were lost (n = 6), or the excavation data were not recorded (n = 6), or the nest was disturbed by people before it could be excavated (n = 2). For another nine nests the excavation could not be conducted as a fresh nest was encountered very close to the location of the marked nests. Six excavation included eggs from two different nests. Two nests were marked when the turtle did not complete the nesting process successfully; both females deposited a very small quantity of eggs before returning to the sea. Two marked nests were eggs that had been decommissioned by MINAET staff; results from these two nests were presented to MINAET in a separate report entitled "*Informe del Proyecto de Manejo y Monintoreo de Huevos de Tortugas Marinas Decomisados*" (Sea Turtle Conservancy, 2011).

All of these nests (n = 65; 29.5%) were therefore excluded from subsequent analysis, leaving a sample of 155 green turtle nests monitored from the date of oviposition until their fates could be determined. Table 9 lists the fate of all of the green turtle nests marked in 2011.

Table 9. Fate, hatching and emerging success of marked green turtle nests in 2011

Fate	Tort n	Jal n	Total n	% of total	Hatching success (%)	Emerging success (%)
1. Undisturbed	64	65	129	83.2	89.4	88.7
2. Destroyed by another turtle	2	2	4	2.6	11.7	11.7
3. Depredated	2	0	2	1.3	1.6	1.6
4. Depredated by ants	0	1	1	0.6	20.0	20.0
5. Partially depredated	0	3	3	1.9	70.2	69.9
6. Poached	7	0	7	4.5	0.0	0.0
7. Possibly poached	1	1	2	1.3	0.0	0.0
8. Eroded	0	1	1	0.6	0.0	0.0
9. Destroyed by roots	0	2	2	1.3	0.0	0.0
10. Inundated	0	4	4	2.6	0.0	0.0
Total	**76**	**79**	**155**	**100**	**76.7[1]**	**75.6[1]**

Nests not included in analysis	***Tort n***	***Jal n***	***Total n***
Could not find at excavation	*1*	*32*	*33*
One or more flagging tape lost	*2*	*4*	*6*
Incomplete excavation as new nest encountered	*5*	*4*	*9*
Disturbed by a person	*2*	*0*	*2*
Excavated – two nests together	*1*	*5*	*6*
Unhatched – small number of eggs laid	*0*	*1*	*1*
Depredated – small number of eggs	*0*	*1*	*1*
Excavation data not recorded	*2*	*4*	*6*
Eggs decommissioned by MINAET staff	*2*	*0*	*2*
Total	***15***	***51***	***66***

Tort = Tortuguero (northern five miles); Jal = Jalova (southern three miles); [1]Calculated as the mean of all 154 nests

From Table 9 it can be seen that the majority of nests (included in the analysis) (83.2%) remained undisturbed during incubation (n = 129). Of those nests that were disturbed the majority were poached (4.5%), disturbed by another nesting female (2.6%) or inundated (2.6%). Poaching was only observed in the northern five miles of beach close to Tortuguero. No nests were depredated by dogs; those that were classed as predated were by crabs or other predators within the nest.

Overall hatching success was calculated as 76.7% and overall emerging success was estimated as 75.6% (See Table 9). These values were determined as the mean of all 154 marked nests for which the fate could be determined. If anthropogenic disturbances (poached and possibly poached) are removed from the determination of the overall hatching and emerging success the values are 81.5% and 80.3%, respectively. Data from the nest excavations of the 155 green turtle nests monitored through incubation are summarized in Table 10.

Table 10. Summary of excavation data for green turtle nests marked in 2011 – data combined from Tortuguero and Jalova

Fate[1]	n	Hatchlings		Empty shells	Pipped eggs	Unhatched eggs			Depredated eggs	Destroyed eggs	Yolkless eggs
		Live	Dead			No embryo	Embryo	Full embryo			
1	129	152	70	12,424	92	611	165	67	524	26	19
2	4	0	0	7	0	0	0	0	40	0	1
3	2	0	0	2	2	3	3	0	52	0	1
4	1	0	0	6	0	0	0	24	0	0	0
5	3	0	1	293	0	0	1	2	129	0	0
6	7	0	0	0	0	0	0	0	0	0	0
7	2	0	0	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0	0
9	2	0	0	15	0	0	0	0	0	0	0
10	4	0	0	0	0	0	0	0	0	0	0
Total	**155**	**152**	**71**	**12,747**	**94**	**614**	**169**	**93**	**745**	**26**	**21**

[1]For fate code descriptions see Table 9

Average clutch size (determined from egg counts conducted at the time of oviposition) was 111.5 eggs with a range of 9 – 178 eggs (n = 218); this value includes nests that were subsequently excluded from the analysis of hatching and emerging success. If the two nests for which the female did not complete the nesting process are excluded, the mean clutch size is 112.4 eggs.

A comparison between egg counts at the time of oviposition and at excavation for a sample of undisturbed nests (n = 127) shows a mean of 5.4 fewer eggs counted at the time of excavation than at the time of oviposition (range: -114 to +62 eggs).

The distance between the sand surface and the top eggshell at the time of excavation for undisturbed nests (n = 127) ranged between 17 – 93cm with a mean of 59.0cm. The distance between the sand surface and the bottom of the egg chamber (n = 126) varied between 46 – 118cm with a mean of 75.2cm.

The duration of the incubation period, for nests where hatching data was recorded (n = 54) varied between 43 – 70 days, with a mean of 58 days.

Unhatched eggs that contained albino, twin or deformed embryos accounted for only 0.19% of all eggs laid in undisturbed and disturbed nests that were excavated (See Table 11). Of the deformed embryos; one had the internal organs outside the body, others had deformities of the flippers, carapace or head, and one had two heads and five flippers.

Table 11. Incidence of albinism, twins and deformed embryos in 2011 – Tortuguero and Jalova

Type of abnormality	n	% of total
Albino	3	0.02
Twin embryo	7	0.05
Deformed embryo	18	0.12
Total	**28**	**0.19**

3.7.2 Hawksbill turtles

Thirteen hawksbill nests were marked between 10 May – 17 August, 2012; of these two were marked during the 2011 Leatherback Program. Two nests were excluded from the determination of hatching and emerging success; one could not be found during the excavation and for one the excavation could not be conducted as a new nest was found close to the location of the marked nest. The results of the excavations of the other 11 hawksbill nests are summarized in Table 12; data are combined for Tortuguero and Jalova.

Mean hatching success was 70.9% and emerging success was 69.0% (See Table 12); these values were determined as the mean for all 11 nests. If the poached nest is excluded from these calculations the values are 78.0% and 75.9%, respectively.

Evidence of hatching was observed for four nests; the mean incubation period was calculated as 63 days, with a range of 57 – 67 days.

The mean distance between the sand surface and the top eggshell at the time of excavation for undisturbed hawksbill nests (n = 6) was 41.8cm (Range = 30 - 70 cm). The mean distance between the sand surface and the bottom of the egg chamber was 50.0cm (Range = 36 - 75cm).

Table 12. Summary of hawksbill nest excavations from 2011

Fate[1]	n	Hatchlings		Empty shells	Pipped eggs	Unhatched eggs			Depredated eggs	Yolkless eggs	Hatching success %	Emerging success %
		Live	Dead			No embryo	Embryo	Full embryo				
1	7	14	8	771	38	10	13	51	15	0	88.2	85.7
2	3	3	0	211	0	38	38	8	104	4	54.0	53.0
3	1	0	0	0	0	0	0	0	0	0	0.0	0.0
Total	**11**	**17**	**8**	**982**	**38**	**48**	**51**	**59**	**119**	**4**	**70.9[2]**	**69.0[2]**

[1]For fate code descriptions see Table 9; [2]Calculated as the mean of all 11 nests

3.7.3 Leatherback turtles

The hatching and emerging success of leatherback nests laid at Tortuguero during 2011 is discussed in detail in the 2011 Leatherback Report.

3.8 Physical Data Collection

3.8.1 Rainfall

Rainfall was recorded daily from January – December, 2011, during the Leatherback and Green Turtle Programs (See Table 13).

Table 13. Summary of rainfall data – January to December, 2011

Month	Total rainfall mm/month	$\bar{x}$ rainfall mm/24 hours[1]
January	555.1	17.9
February	608.4	21.7
March	136.5	4.4
April	145.6	4.9
May	722.3	23.3
June	190.1	6.3
July	474.1	15.3
August	107.2	3.5
September	82.1	2.7
October	364.2	11.7
November	1,254.5	41.8
December	964.6	31.1
Total	**5,604.7**	**15.4**

[1] Data for 48 hours: 27-28 November; Data for 96 hours: 18-21 May

The driest month was September with a total of 82.1mm of rain recorded; the wettest month was November, with 1,254.4mm of rain recorded (accounting for 22.4% of the rain for the entire year). January, February, May and December were also very wet months, with over 500mm of rain (See Table 13). The total amount of rain recorded at the station during 2011 was 5,604.7mm; an average of 15.4mm per day. Average daily rainfall each month ranged from 2.7mm to 41.8mm per day (September and November, respectively). The highest rainfall recorded for a single 24 hour period was on 25 November, with 262.0mm.

3.8.2 Air temperature

No air temperatures were recorded during 2011, as the thermometer that broke at the end of 2010 was not replaced.

3.8.3 Sand temperature

Unfortunately the data loggers lost during the 2009 Green Turtle Program were not replaced until

August, 2011, and so there is only data available for September thru November for the open and border zones (See Table 14). For the dataloggers in the vegetation zone an error was encountered when trying to download the data at the end of the program, and so no data could be retrieved.

Tabla 14. Promedio mensual de temperature de arena en el 2011

Zone	Border $\bar{x}$ temperature / ºC			Open $\bar{x}$ temperature / ºC		
Depth/ cm	**30**	**50**	**70**	**30**	**50**	**70**
August[1]	31.0	30.6	30.2	N/A	31.7	31.3
September	31.5	31.1	30.8	N/A	32.0	31.8
October	29.6	29.9	29.9	N/A	30.5	30.6
November[2]	29.5	26.8	27.0	N/A	27.7	28.1
Mean	**29.5**	**29.6**	**29.5**	**N/A**	**30.5**	**30.4**

N/A = No datalogger at that depth during that month; [1] From 5 August; [2] Till 27 November

In both zones the temperature increased during August and September, and then dropped in October and November. Mean sand temperatures were high in August and September; more than 30ºC at all depths. The range of temperatures in the border zone was 22.9 – 33.9ºC and in the open zone it was 23.9 – 33.6ºC.

3.9 Collection of Human Impact Data

3.9.1 Visitors to STC Natural History and Visitor Centre

The number of visitors registered at the STC Visitor Center decreased in 2011 to 23,529 visitors; continuing the trend observed since 2006 (See Table 15).

Table 15. Number of visitors to the STC Natural History and Visitors Center 2009 - 2011

Month	2009		2010		2011	
	Total	**$\bar{x}$ / day**	**Total**	**$\bar{x}$ / day**	**Total**	**$\bar{x}$ / day**
January	4,001	129	3,114	101	3,347	108
February	3,617	129	3,221	115	4,081	146
March	4,100	132	3,719	120	4,398	142
April	2,382	79	2,476	83	1,810	60
May	963	31	1,012	33	936	30
June	1,492	50	1,628	54	1,126	38
July	2,385	77	2,099	68	1,450	47
August	2,024	65	1,390	45	1,116	36
September	815	27	590	20	443	15
October	1,328	43	832	27	848	27
November	1,879	63	2,060	69	1,791	60
December	2,579	83	2,513	81	2,183	70
Total	**27,565**	**76**	**24,654**	**68**	**23,529**	**64**

The pattern of visitation was similar to that observed previously; most visitors came in January – March, with a significant decline in May. There was a slight increase in visitation observed during June and July; this coincides with increased green turtle nesting, which is the major tourist attraction in the area. There was a dramatic decrease in September, with an average visitation of just 15 people per day (See Table 15).

The mean number of visitors per day in 2011 ranged from 15 (September) to 146 (February), with an average of 64 visitors per day for the year, which was less than that recorded for 2009 and 2010. However, in three months (January, February and March) visitation was higher in 2011 than in 2010.

3.9.2 Visitors to Tortuguero National Park

The number of people visiting Tortuguero National Park increased in 2011 (See Table 16). Data from ACTo show that 117,817 tourists were registered as paying the entrance fee to the park in 2011; this is almost 3,000 more visitors than in 2010. However, it should be noted that the number of Costa Rican visitors includes 13,225 local people (guides, boat captains, etc), who entered the Park in the capacity of their work. Admission fees to TNP in 2011 raised ¢394,911,518, which is approximately $789,823.

Table 16. Number of paying visitors to Tortuguero National Park, 2002 - 2011

Year	Costa Rican visitors	Foreign visitors	Total no. of visitors
2002	5,745	44,594	50,339
2003	8,643	59,026	67,669
2004	9,545	71,912	81,457
2005	9,292	77,291	87,083
2006	21,257	80,087	101,344
2007	23,898	92,853	116,751
2008	26,727	107,963	134,690
2009	23,632	90,691	116,323
2010	25,592	89,296	114,888
2011	26,753	91,064	117,817

Data from MINAET - ACTo

3.9.3 Turtle tours

Since 2005 the Turtle Spotter Program (TSP) has been implemented along the entire 5-mile stretch of beach (from the Tortuguero river mouth to mile 5) where tourism is permitted by MINAET. In 2011, STC continued to play a central role in the TSP committee, along with representatives from ACTo, the Tortuguero Development Association, the Tour Guide Association, the Turtle Spotter Association and the local hoteliers.

In 2011 there was no TSP Coordinator; daily supervision of the turtle spotters and program activities was provided by one of the committee members. Fifteen turtle spotters were hired for the official green turtle season (1 July – 31 October). Of these 15, one was designated as the Supervisor, who helped oversee the other turtle spotters on the beach, and one was assigned to maintenance of the trails and tourist waiting areas; this person also acted as a replacement spotter if necessary. Two other people were hired to receive donations from the tour guides, and to manage the data relating to brochure sales.

TNP staff registered a total of 32,199 tourists who participated in turtle tours during the months that the TSP was running (July – October); this represents a decline of almost 1,300 people in comparison to 2010, and continues the trend in turtle tourism observed since 2008. An average of 262 tourists per night participated in turtle tours during the four months (See Table 17); this calculation does not include additional nights in November when tours may have been permitted after the end of the official TSP.

Table 17. Number of tourists participating in turtle tours each month; July – October, 2011

Month	Number of tourists	Mean per night
July	11,754	379
August	12,361	399
September	4,879	163
October	3,205	103
Total	**32,199**	**262**

Data from MINAET - ACTo

As in 2010, following the studies of STC to investigate the impact of tourist activities on the behavior of green turtles, during 2011 there was a limit of 20 tourists (plus guides) for each turtles. Unfortunately, during the 2011 Green Turtle Program, there were various occasions when STC investigators observed more than 20 people around one turtle.

3.9.4 Artificial lights

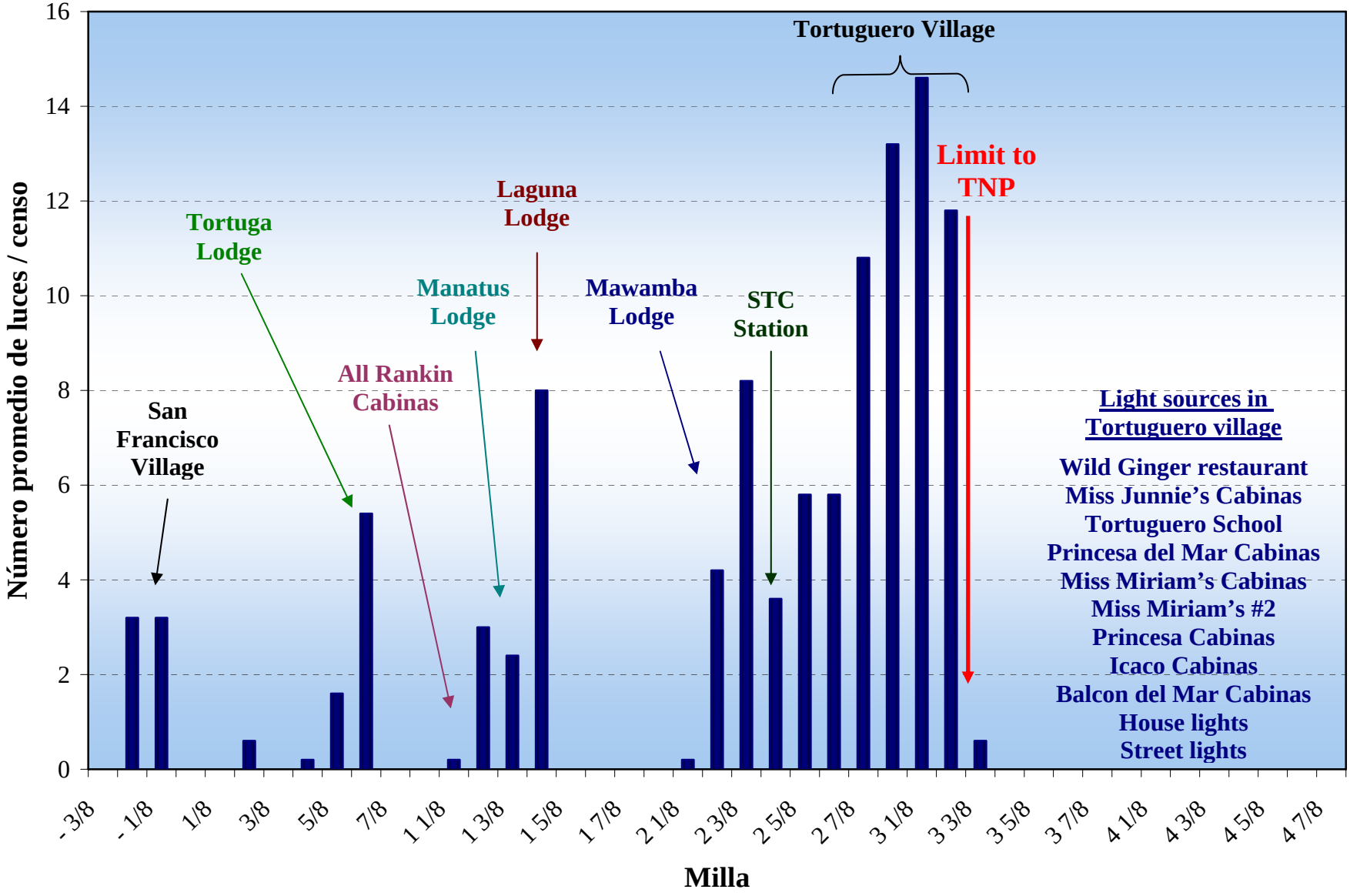
Five light surveys were conducted during the 2011 Green Turtle Program from June to October. The results from these surveys are summarized in Figure 7. As in previous years, most of the lights visible on the beach were from Tortuguero village, between miles 2 6/8 - 3 3/8 (See Figure 7); these included cabinas, restaurants, houses, street lights and the school. In addition, clusters of lights were also visible from the lodges located north of the village, including some from the opposite side of the river. As can clearly be seen from Figure 7, there are no artificial lights within TNP, due the absence of any buildings past mile 3 3/8. At the end of the 2011 Green Turtle Program several property owner between the STC station and the village cut down the vegetation in front of their homes, and this significantly increased the number of artificial lights visible from the beach.

ICE staff worked closely with STC during 2011 to reduce the negative impact of the public lights in the village. They made several survyes at night, accompanied by the FRC, to determine which lights were causing most problems, and to find a viable solution. In August a group of ICE technicians, accompanied by a film crew, visited Tortuguero to discuss the light problem with STC. During this visit, they filmed the beach at night; the idea being to make a short video for other ICE employees, explaining the collaborative project with STC in Tortuguero, to find a solution to the problem of light pollution on the turtle nesting beach, that could be used as an example for other communities close to other turtle nesting beaches in Costa Rica.

3.9.5 Hatchling disorientation

Evidence of hatchling disorientation was recorded twice during the 2011 Green Turtle Program. On 1 October several hatchlings were found at around 2.00am walking in the vegetation in front of the Wild Ginger restaurant (mile 2 6/8) and on 17 October, at 12.00am, RAs found disorientated hatchlings in front of the school (mile 2 7/8).

Figure 7. Summary of monthly light surveys conducted during the 2011 Green Turtle Program



3.10 Environmental Education and Community Outreach Activities

3.10.1 Environmental education program

There was no dedicated OEC for the 2011 Green Turtle Program, and so it was not possible to develop an intensive education program; the FRC and the RAs were responsible for conducted several activities, in Tortuguero, and also at a near-by coastal community. Appendix 4 includes photographs of the activities that were conducted.

Two activities were held at the Tortuguero school, on 28 September and 13 October; during these visits the RAs spoke about various different topics related to sea turtles, their threats, conservation efforts, the work of STC and the importance of recycling. They also discussed with students how they could help protect turtles, such as not eating turtle eggs or meat, recycling and reducing garbage. They also performed a dramatization of the work of STC on the beach, to demonstrate the field equipment to the students.

In addition to the activities conducted with the students at Tortuguero, the FRC and the RAs also participated in a community beach-clean up activity in September. This event was organized by one of the local hotels, with support from the community, STC and National Park staff. The objective was to clean the five miles of beach where tourism activities are permitted, although it was not possible, due to limited personnel to complete the entire five miles.

On 28 October, the FRC and the RAs visited the Caribbean School in Limon to conduct an environmental education activity for students. The RAs spoke about sea turtles, performed a dramatization of the nesting process and the work of STC researchers and also discussed specific threats to turtles in the region, such as consumption of eggs and meat, and pollution.

3.10.2 Veterinary Clinic

The STC continued to be involved in the organization of the veterinary clinic in 2011, together with MINAET, ProParques and interested local residents from Tortuguero and San Francisco. Veterinary support was provided by the Association for Animal Protection in Costa Rica (AHPPA). Two clinics were held in 2011, one in May during the 2011 Leatherback Program, and the other in November. Vets held clinics on 12 November in Tortuguero, and 13 November in San Francisco. The SD and RAs provided support to the vets as necessary during the clinics, and STC provided board and lodging for the vets during their stay. Table 18 summarizes the results from the November clinic. Since the start of the veterinary clinic program in 2008 a total of 395 animals have been spayed/neutered.

Table 18. Summary of veterinary clinics conducted in November, 2011

Place	# animals attended	# animals spayed/neutered	# animals desparasitized[1]	# animals not spayed/neutered
Tortuguero	67	26	28	13[2]
San Francisco	50	9	24	17
Total	**117**	**35**	**52**	**30**

[1] Previously spayed/neutered in another clinic; [2] Includes five puppies that were too young to spay/neuter

3.11 Satellite Telemetry Project

Two satellite transmitters were successfully attached to green turtles in July 2011. The first turtle was

encountered nesting close to the STC station, at mile 2 4/8, on 9 July; she measured 106.5cm CCLmin, 100.6cm SCLmax, and laid 95 eggs. The transmitter was attached the following morning and her sponsors (Shark Reef at Mandalay Bay) gave her the name 'Odessa'. Her 'cause' for the 2011 Tour de Turtles was the impact of sea level rise and climate change on sea turtles and their habitats. Following her release 'Odessa' stayed close to the nesting beach for a couple of months; she was observed nesting again on 11 September, when she was encountered by the Spotters, who advised the FRC. She was tracked for 258 days, during which time she swam a total of 978 miles (1,574km); when her transmitter stopped sending signals in February, 2012 she was located in the coastal waters of Nicaragua, presumably in an area with sea grass (See migration map in Appendix 3).

The second turtle was encountered in mile 2 6/8 on 10 July; she measured 103.3cm CCLmin and 97.4cm SCLmax. She was sponsored by STC and was given the name 'Adele', in honor of the mother of one of STC's employees. Following her release 'Adele' also remained close to the nesting beach for several weeks and she was encountered by STC researchers on 31 July. The RAs checked the condition of the transmitter and did not report any problems. She wasn't seen again on the beach, and in August was tracked heading north away from Tortuguero. 'Adele' was tracked for 254 days, during which time she travelled 1,743 miles (2,805km) to coastal waters in the Gulf of Mexico, off the Yucatan Peninsula (See migration map in Appendix 3).

4. Discussion

4.1 Preparations

The agreement with GVI for the second year allowed additional patrols to be conducted at the southern end of the beach, close to the Jalova lagoon. The continued involvement of GVI staff and volunteers throughout the 2011 Green Turtle Program helped to increase the amount of beach that could be patrolled on a daily basis, and also allowed nests to be marked and monitored in this section of the beach.

The intensive training and orientation program given to the RAs by the FRC is essential for them to learn the monitoring protocol in detail, and to give them the opportunity to practice various important skills, such as tagging, carapace measurements and nest marking, under supervision. Even for RAs with previous experience working with sea turtles these theoretical and practical sessions ensure that everyone collects data according to the STC protocol. It is important that all members of GVI staff receive adequate training and have regular contact with the FRC to address any issues that may arise.

Constant supervision throughout the program is also very important; the FRC should work with all the RAs regularly to evaluate the standard of data collection, and bring to their attention any errors that are being made at the soonest opportunity to ensure a high level of accuracy in the data being collected.

It is not only important to teach the RAs about the monitoring protocol; it is also very important that they learn how to work efficiently around a turtle, how to correctly manage a group of volunteers and how to interact with groups of tourists, guides and turtle spotters on the beach. This type of training might avoid problems that sometimes arise when the RAs have to work with a turtle in front of a tour group, and should be incorporated into the training schedule in future programs.

Fortunately the majority of the beach markers placed at the start of the 2011 Leatherback Program were still in excellent condition at the start of the 2011 Green Turtle Program; the FRC and RAs were limited to replacing an occasional missing marker and repainting those still in place. This activity, though somewhat time consuming, is important as it provides the opportunity to teach the RAs the need to familiarize themselves with the beach and the mile markers to facilitate the night patrols. For

future years it might be worth investigating the possibility of using reflective paint or tape for the beach markers to assist with finding them at night.

4.2 Track Surveys

4.2.1 Green turtles

Green turtle nesting was observed from June to October, with a peak in August. The season, in comparison to previous years, was very short; very few nests were observed before June, and nesting dropped off rapidly in October (See Figure 1).

The estimation of just 78,852 green turtle nests laid during the 2011 season is less than half the number calculated for 2010, when more than 180,000 nests were estimated. However, this pattern (a high season followed by a low season) has been observed at Tortuguero on other occasions; for example 1993-1994 and 1998-1999 (See Figure 2). Therefore, it was expected that the 2011 season would be low, as 2010 was a record nesting season for green turtles in Tortuguero. It will be interesting to see the trend for 2012; if it follows the typical pattern it should be a better season than 2011.

It is important to mention that these values for green turtle nesting are estimates; it would be impossible to conduct a total count of the beach each day, which is the only method to ensure that the values are real, not estimated. In Tortuguero, the key is to ensure that the methodology used is standardized, so that the data collected each year are comparable. To have the same person conducting the weekly track surveys helps significantly to standardize the data, as it reduces observer variability.

The spatial distribution of nests along the beach was similar to that observed in recent years, with a distinctive increase in nesting noted between miles 4 – 13, with a peak in the middle of the beach (See Figure 3). The two ends of the beach, as always, had the lowest levels of nesting; possibly as they are the most unstable parts of the beach, and more prone to erosion.

The daily track surveys conducted by the FRC and RAs from June - November between the Tortuguero river mouth and the mile 5 marker require considerable effort but provide invaluable data relating to spatial and temporal nest distribution, level of illegal take of nests and females, and dog predation. In 2011, as in 2010, it was possible to conduct daily track surveys of the southern three miles, between mile 15 and the Jalova lagoon (mile 18).

The number of green turtle nests recorded in the northern five miles of beach, and the three miles at the southern limit was much lower than in 2010; 12,420 compared to 33,559 and 6,618 compared to 28,274, respectively. It was interesting to note in the southern end of the beach that a higher proportion of false crawls were recorded in 2011 than the previous year (53% compared to 35%, respectively). This could be a reflection of the difficulty of identifying a successful nest with such a high density of nesting activity as that observed in 2010; or it may be incorrect identification of nest/false crawls by researchers close to Jalova, suggesting that GVI staff and volunteers need additional training. Comparing the percentages recorded in Tortuguero; 52% in 2010 and 47% in 2011.

Interestingly, temporal distribution of nesting observed from the daily track surveys showed different patterns at the northern and southern ends of the beach, as also seen in 2010. However, in 2011, the nesting pattern in Tortuguero was similar to that seen in the weekly surveys (See Figures 1 and 4b); close to Jalova there was no obvious peak in nesting (See Figure 5b). At both ends of the beach there was an obvious decline in nesting at the end of September (See Figures 4b and 5b). It will be interesting to monitor these differences in nesting patterns in future season.

Illegal take of nests and turtles was observed infrequently during weekly track surveys in 2011;

however, it was discouraging to see that there was a night when 11 green turtles were reported as poached within TNP.

As in 2010, there was a difference in the level of take of females and nests observed at the northern ans southern ends of the beach; close to Tortuguero, poaching was observed throughout the season, while close to Jalova there was no reports of nests or females being taken. Also, following trends observed in other seasons, poaching near Tortuguero was very concentrated in the first 3/8 mile close to the Tortuguero river mouth (See Figure 6a). This section of beach is a designated protected area (Archie Carr Nature Refuge), and so it is disappointing to see that there was no sufficient vigilance on the part of MINAET to ensure the protection of females when they came ashore to lay their eggs, or nests laid in this stretch of beach. We hope that these data can be used by ACTo as justification to solicit the necessary additional resources to improve the protection offered to turtles in this area, and the rest of the Tortuguero nesting beach.

4.2.2 Hawksbill turtles

Few hawksbill nests were observed during the weekly track surveys of the entire nesting beach in 2011; just ten hawksbill nests were observed from May – November. However, daily track surveys of the northern five miles and the southern three miles reported at total of 45; more than in 2010. It is possible that this represents a real increase in the number of hawksbill nests, but it might also simply be that the reduced number of green turtle tracks in 2011 facilitated the detection of the smaller hawksbill tracks.

It was interesting to observe that close to Jalova GVI staff reported two loggerhead nests during track surveys. However, there was no observation of the female, and therefore, it is possible that there was confusion between loggerhead and hawksbill tracks; the tracks of both species are very similar in size and form. It is important, therefore, to ensure that all personnel conducting track surveys receive good training, so that they can clearly differentiate between the different species nesting at Tortuguero.

4.2.3 Leatherback turtles

A comprehensive discussion of leatherback nesting at Tortuguero in 2011 can be found in the 2011 Leatherback Program Report. Leatherback nesting density continued to decline at Tortuguero, which is of concern to STC and other organizations involved in leatherback conservation efforts along the Caribbean coast. It was interesting to see this species nesting in July; there were also fresh leatherback tracks observed in October and November, by GVI staff conducting other monitoring activities. It is very unusual to observe leatherback nesting so late in the season.

4.3 Dead Turtles

In 2011 there were reports of various dead turtles on the beach; the majority were killed by jaguars, and only one was encountered stranded dead, and there was no obvious cause of death visible. Jaguar predation increased in 2011 compared to levels observed in 2010; during the weekly track surveys, 57 turtles were killed by jaguars from January – December (as in 2010, the first turtle that nested was killed). It was also interesting to observe that there was another leatherback turtle killed by jaguars in 2011. Jaguars are active along the majority of the beach, south of Tortuguero village; noted by the presence of their tracks on the beach. The number of turtles reported during the weekly track surveys should be seen as a minimum number killed, as only turtles from the previous night are registered. The track surveyor also observed turtles on the beach during the weekly surveys in 2011.

4.4 Tagging of Nesting Sea Turtles

4.4.1 Green turtles

It was a little difficult to achieve the goal of 1,000 newly tagged green turtles in 2011; the FRC and RAs conducted additional patrols between miles 5-9, but even in this section of the beach where there is a higher level of nesting they did not find as many turtles as in other years. They did, however, tag 1,000 new turtles, the last of which was not tagged until the final week of patrols in October. It is important that the FRC keeps careful track of the data during the season, to be able to meet the target of 1,000 newly tagged females; organizing extra patrols if it is necessary, to take more turtles, especially when there are Eco-Volunteer groups at the station, providing additional personnel.

Les than 2,000 encounters with green turtles were recorded in 2011, much less than in other seasons. The percentage of previously tagged turtles was different at the two ends of the beach, as observed in 2010; close to Jalova only 6.5% of individuals were tagged, while in Tortuguero more than 38% of the females encountered had tags. This could reflect a high level of nesting site fidelity for green turtles, especially considering the fact that there have been very few individuals tagged close to Jalova in previous years. There were only a couple of turtles that were observed in both sectors of the beach during the season.

The percentage of females encountered with tags was very similar to other years; around 30% of the individuals observed. For another consecutive year there were numerous females that were originally tagged more than 10 years ago; 98 females were first seen at Tortuguero more than a decade ago. There were also three females that were tagged more than 20 years previously. The turtle with the longest nesting history for 2011 was a female seen for the first time in 1980, 31 years ago; this was a new record for the project. It is good to see that there are a considerable number of older females that return to nest each year, and that there are still plenty of 'new' (untagged) females being encountered; which suggests a balance of different age classes within the Tortuguero nesting population.

Turtles encountered with tags from other countries are always exciting, and in 2011 there were three individuals that had tags from outside Costa Rica (Mexico, Nicaragua and Panama). Unfortunately, it has not been possible to obtain more information about the turtle that was tagged in Mexico; only, that the tag number was in a series possibly used at feeding sites, probably in the Yucatan Peninsula. It was interesting to see that one of the turtles tracked using satellite telemetry in 2011 went to this location; suggesting that this is maybe another feeding ground for green turtles that nest at Tortuguero. The turtle with tags from Nicaragua was tagged in-water in a foraging area close to the coast of Nicaragua. For the researchers at this project this was the first encounter of one of their turtles being encountered in Tortuguero, and they were very pleased to receive the information about this turtle. The turtle with tags from Panama was not tagged at a feeding site, but at Chiriquí Beach, where STC has another turtle monitoring and conservation project. It is unusual for a green turtle to nest in two different beaches; normally this species shows strong site fidelity. What is more interesting still, is that this turtle was tagged in Panama at the start of the 2011 nesting season, and so used two different beaches within the same season.

4.4.2 Hawksbill turtles

The number of hawksbill encounters (n = 16) is within the range observed in other seasons. The number of encounters at the northern and southern ends of the beach was the same; eight individuals were seen in both locations. The only hawksbill female encountered with tags (at Jalova) was originally tagged in Parismina, just to the south of the Jalova lagoon.

Considering the low nesting density of this species at Tortuguero, it is important that all RAs realize

the importance of every encounter with a nesting hawksbill during night patrols as they provide very valuable information on the species.

The protocol to not show hawksbill turtles to tour groups (first implemented in 2008 following a request by the Scientific Director to the Turtle Spotter Program committee) was continued in 2011; however, on at least one occasion groups of tourists observed this species. This was due to the misidentification of the turtle as a green turtle (by the turtle spotter and the guides). The incident clearly demonstrates the importance of ensuring that all of the spotters (especially the new ones employed each season) and the tour guides receive adequate training at the start of the season, to reduce the possibility of committing basic errors such as this.

4.4.3 Leatherback turtles

The 2011 Leatherback Program Report includes a detailed review of the tagging of leatherback turtles at Tortuguero in 2011. Once again, however, there was an encounter with a leatherback turtle during night patrols at the start of the 2011 Green Turtle Program.; normally leatherbacks finish nesting in June or early July, and so it was unusual for a female of this species to be nesting so late in the year.

4.5 Biometric Data Collection

4.5.1 Green turtles

The overall mean curved carapace length (CCLmin) was 105.5cm and the mean straight carapace length (SCLmax) was 99.8cm. These measurements are consistent with those obtained from the Tortuguero green turtle population in previous seasons, and they also show a typical range from very small to very large individuals (90.0 – 130.5cm CCLmin; 86.3 – 120.9cm SCLmax). In addition, the mean clutch size of 114 eggs was very similar to that determined in other years. It was interesting to observe several large green turtles in 2011, with CCLmin measurements greater than 120cm; the largest measured 130.5cm, which is the largest female observed during all the years of the program.

RAs were slightly more precise than Eco-Volunteers when taking CCLmin and SCLmax measurements. It is important that all Eco-Volunteers be provided with adequate training before taking part in night patrols, including sufficient practice in taking carapace measurements; the RAs are also responsible for properly overseeing all data collection by Eco-Volunteers during night patrols, both when working directly with the turtle, or when recording data in the field books.

There was considerable variability in the measurements taken of the same female when she was observed on more than one occasion (up to 6.6cm), and so care should be taken during training sessions, with RAs and Eco-Volunteers, to ensure that everyone is measuring the carapace in the same manner, using the same start and end points. A suggestion for future programs is that Eco-Volunteers only observe the data collection process during their first night patrol, and receive a practical training session during their second day in Tortuguero. This additional training could help to avoid problems with data taken incorrectly. It is also important that measurements be clearly and accurately recorded in the field data books, to ensure that during the transcription of data to the data base no errors occur.

CCLmin and SCLmax measurements were taken with the same degree of precision, and it is suggested that both measurements continue to be taken for a sample of females nesting at Tortuguero.

4.5.2 Hawksbill turtles

Carapace measurements obtained for hawksbill turtles during the 2011 Green Turtle Program were within the range observed in previous years. CCLmin measurements were taken with the same level of

precision as for green turtles, but SCLmax measurements were taken with a slightly higher degree of precision for hawksbills. The mean clutch size for hawksbills (164 eggs) was within the normal ranged observed in other years.

4.5.3 Leatherback turtles

The 2011 Leatherback Program Report summarizes biometric data collected from leatherback turtles nesting in Tortuguero in 2011 from March to June. For the female observed during the 2011 Green Turtle Program, the CCLmin was 164.1cm; within the normal range for this species at Tortuguero.

4.6 Fibropapilloma Assessment

There were more incidents of green turtles with fibropapilloma tumors recorded in 2011; 14 females in total, one of which was examined specifically for the disease, plus and additional 13 with tumors that were observed during the routine body check provide to all turtles encountered during night patrols. The tumors were mainly observed on the flippers and the neck. It is important that the RAs are trained to distinguish between fibropapilloma tumors, which have a very distinct form, and other types of skin tumors. There were various females that had other types of tumors, up to four on one individual, and sizes up to 8cm diameter. The routine body check conducted on all females is important to detect the level of such anomalies, and so should be continued in the future.

4.7 Determination of Nest Survivorship and Hatching Success

4.7.1 Green turtles

A total of 220 green turtle nests were marked during the 2011 Green Turtle Program; 91 in Tortuguero and 129 in Jalova. For these it was only possible to determine the fate of 155 nests. It was disappointing that there were 32 nests (14.6% of those marked) that could not be found at excavation; 31 of these were in Jalova. These nests were not reported to have been disturbed, poached, depredated or eroded during the incubation period. This suggests that either AIs were not paying sufficient attention to the marked nests during the daily monitoring, and failed to register important information that could have helped determine the fate of the nest; or that they did not receive sufficient training in the excavation protocol.

For one nest that could not be found at excavation, revision of the daily revision data showed that the nest was inundated a few days after it was laid, and the tapes were removed, so it was possible to assign a fated to this nest. In the future it must be stressed to the RAs the importance of recording possible signs of disturbance to marked nests during the daily nest checks, as this is the only information available to explain any anomalous findings at the time of excavation. Special attention should be made to teach RAs the difference between predation by animals and poaching, to ensure that levels of these causes of nest loss are accurately assessed.

During 2011 the majority (around 59%) of marked nests remained undisturbed and hatched successfully; the major cause of loss of nests due to poached (in Tortuguero) or disturbance by other females that subsequently nested close to the site of the original marked nest (See Table 9).

Nests close to the predicted emerging date should also be carefully inspected for signs of hatching (depressions or hatchling tracks); in 2011 the incubation period could only be determined for nests in Jalova. Although depressions and hatchling tracks can be quickly eliminated by heavy rain or strong winds it should be possible to detect evidence of hatching if RAs are more conscientious.

Overall hatching and emerging success of marked nests was lower in 2011 than in 2010, 76.7% and

80.4% respectively. For undisturbed nests (n = 129) emerging and hatching success were very high, 89.4% and 88.7%, respectively (See Table 9). The estimation of overall hatching and emerging success was affected by nests that were disturbed by other nesting females, poached, possibly poached, depredated or inundated (such nests had a hatching and emerging success of 0%, obviously). Very few deformed, albino or twin embryos were recorded; as in previous years.

4.7.2 Hawksbill turtles

It was possible to mark and monitor 13 hawksbill nests during 2011; two during the Leatherback Program, the remainder during the Green Turtle Program. Hatching and emerging success of undisturbed nests were high (88.2% and 85.7%, respectively), higher than that observed in 2010 for this species. Overall hatching and emerging success was affected by depredated nests and those disturbed by other nesting females, which had very low success rates.

It is hoped that the policy to not show hawksbill turtles to tour groups will allow CCC personnel priority access to this species, and that in future more nests will be marked and followed during the incubation period, to gain a further insight into the survivorship and hatching success of this critically endangered species at Tortuguero.

4.7.3 Leatherback turtles

A discussion of leatherback nest survivorship and hatching success in Tortuguero during 2011 can be found in the 2011 Leatherback Program Report.

4.8 Physical Data Collection

4.8.1 Rainfall

The pattern of precipitation observed in 2011was quite atypical; the peak months of green turtle nesting (June – September) were all relatively dry, with an increase in rainfall in October. Also, little rainfall was registered in March and April. November was the wettest month, with more than 1,250mm of rainfall recorded; more than 260mm was registered in one 24-hour period in this month. It is important that STC continues to collect rainfall data at Tortuguero as part of the standard monitoring protocol, to evaluate potential impacts on nest survivorship and hatching success, and to provide long-term trends in precipitation.

4.8.2 Air temperature

It was not possible to measure air temperature in 2011 as the thermometer that was damaged in 2010 was not replaced. As for rainfall data, it is important to replace the air temperature thermometer, and record daily air temperatures as part of the standard monitoring protocol in future programs.

4.8.3 Sand temperature

Unfortunately, it was not possible to replace the dataloggers lost in 2009 until August 2011, and do the data were restricted to August thru November. There was another error in downloading the information at the end of the season, and so the data from the vegetation zone were unfortunately lost. However, from the data obtained from the border and open zones it was obvious that the temperature, at depths within the range for leatherback and green turtles, were very high; in the range that could limit embryo development or even cause embryo mortality.

In future programs it is important to continue to monitor sand temperatures at Tortuguero, as for the other physical data that are recorded each day, this information will allow the detection of any changes

to the nesting habitat environment that could be a result of global climate change.

4.9 Collection of Human Impact Data

4.9.1 Visitors to STC Visitors Centre

For the fourth consecutive year there was a decrease in the number of tourists to the STC Visitor Centre; 1,125 fewer people were recorded in 2011 than in 2010. It is discouraging to observe that some of the tour guides pass by the Visitor Centre, and use the information panels outside to inform their tourists about sea turtles, and yet do not support STC by bringing their groups in to the Visitor Centre. Unfortunately the new video was no finished until the end of the year; STC hopes that this new video will be more attractive to the guides, who have commented that the information in the current video is outdated. The construction of the new building was finished in September; this new space will be more comfortable for visitors, and allow one group to watch the video while another groups perusing the information in the Visitor Centre. With the new video, and the new space, STC hopes to offer a better service to tourists, and hopefully increase the amount of money received.

4.9.2 Visitors to Tortuguero National Park

Data from 2011 showed that there was a slight increase in tourist visitation to TNP; almost 2,000 more visitors paid the entrance fee to the Park in 2011 than in 2010 (See Table 16). The increase was observed for both foreign and Costa Rican tourists.

4.9.3 Turtle tours

The number of people that participated in turtle tours during the official 2011 green turtle season (June – October) was slightly less than in 2010; 32,199 compared to 32,813, respectively, continuing the trend observed since 2008.

The STC was pleased that the limit of 20 tourists (plus tour guide) per turtle was implemented again in 2011; but it was disappointing that there were still several occasions when the RAs observed more than 20 people with one turtle. In general, however, the limit was respected. The STC will strongly recommend that this limit be maintained in the future. It is also important to conduct a carrying capacity study; this was discussed with TNP staff again in 2011. STC will work with TNP personnel to provide them with information from similar studies that have been conducted at other nesting beach locations.

The changes to the STC protocol that were implemented in 2010, for occasions when RAs are working with a turtle in the presence of tour groups, were continued in 2011, to try to avoid situations with tour guides. There were fewer incidents than in other years, but there are unfortunately a minority of tour guides that have a bad attitude towards the RAs on the beach. It is important in the future to work with all of the groups involved in the Turtle Spotter Program (MINAET, spotters, guides and STC) to establish guidelines for interactions on the beach.

The TSP committee also continued their discussion about the possibility of making the purchase of a brochure mandatory for all tourists participating in turtle tours, to ensure that sufficient funds are generated to cover program expenses and also provide additional money for donations to TNP and community projects. The legal issues associated with this change from a voluntary fee are still being explored by MINAET.

4.9.4 Artificial Lights

Throughout 2011 STC worked together with staff from ICE to resolve the problem of artificial lights on the beach. There was considerable interest from ICE to continue to work with STC to determine which were the problematic lights, and to search for the best way to cover them, without reducing the level of light necessary for residents of the village. The production of a video for other ICE employees was very encouraging; ICE want to use Tortuguero as an example to other communities that are located close to turtle nesting beaches, where artificial light might also be causing negative impacts. This collaboration with ICE should continue in the future.

It was discouraging to see that various people were cutting down vegetation in front of their houses during 2011. This strip of vegetation behind the beach not only helps to reduce the light visible on the beach, but also plays an important role in stabilizing the beach. A suggestion for future programs is to establish a revegetation program, to plant native species. This possibility was discussed with ICE staff who were keen to support such an initiative; possibly by cultivating plants in their own nurseries. This project could be a joint effort between STC, ICE and MINAET.

4.9.5 Hatchling disorientation

There were only two reported hatchling disorientation events in 2011. One of these was in front of one of the building where the owners had cut down the vegetation, and is evidence that such actions can have negative consequences for the survival of hatchlings, and is another reason why it is important to maintain the vegetation cover between the beach and buildings in the village.

4.10 Environmental Education and Community Outreach Activities

4.10.1 Environmental education program

It was unfortunate that it was not possible to employ a dedicated Outreach and Education Coordinator during the 2011 Green Turtle Program. The lack of a person dedicated to developing and supervising the implementation of a structured environmental education program was very noticeable, in that very few activities were conducted. While the focus of STC's work in Tortuguero is obviously the continued of the long-term monitoring program, the success of the program depends very much on the support of the local community. Such support itself depends on the divulgence of the information and results generated through the monitoring activities, and an awareness of the continued problems facing Tortuguero's sea turtle populations and how each person can make a difference. Thus, a critical aspect of future programs should be environmental education and outreach. These programs provide STC with an excellent opportunity to raise its profile within the community, generate awareness about the work of the organization and build local support for conservation initiatives aimed at protecting natural resources within the area. They can also help create a conservation ethic, especially within the younger generations.

Having one person who can act as a liaison between STC, the community and national park staff has been shown in the past to be key to the success of an environmental education program, and so hopefully in the future dedicated funds can be secured to contract a full-time Outreach and Education Coordinator.

4.10.2 Veterinary clinic

The veterinary clinic held in November, 2011, was once again, a great success; more than 100 animals were treated in Tortuguero and San Francisco. The entire program, since it began in 2008 has been very successful, with 395 animals spayed/neutered in the four years. There are, however, still a lot of

dogs in both communities, but at least the percentage of castrated individuals is increasing with each clinic conducted.

4.11 Satellite Telemetry Project

The two turtles fitted with satellite transmitters during the 2011 Green Turtle Program will provide important information about the migration behavior of the green turtle population nesting at this beach. It was interesting to track the two females during part of the inter-nesting period, during which both turtles remained close to the nesting beach for a period of a few weeks to almost two months. Once they had finished nesting both turtles left the beach and traveled north; one to Nicaragua and the other to Mexico (See maps in Appendix 3). When they arrived at their foraging grounds the two turtles remained with a defined area for the duration of the period for which they were tracked.

Satellite telemetry is a useful tool for researchers studying sea turtle migration behavior once they leave the nesting beach, and to determine the location of foraging areas; it can also indicate potential threats that turtles may face en route to, or at their feeding sites. Furthermore, it can be a useful educational tool, providing an entertaining way to be able to teach the general public about research and conservation initiatives. Both turtles participated in the on-line Tour de Turtles event organized by STC, which allows people an opportunity to follow turtles on-line during their migrations, and at the same time, raise awareness about a variety of different threats to sea turtles and their habitats, through campaigns for each turtle in the 'competition'. At Tortuguero, hundreds of people, tourists and local community residents, could observe the process of the transmitter application, and then the release of the turtles. The project, therefore, was considered a great success, both from a scientific perspective as well as a public awareness opportunity.

5. References

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6. Appendices

Appendix 1. Photographs of a green turtle found on 5 August, 2011

Turtle found flipped over and tied up on the trail

Track of turtle that had been flipped over and dragged along the beach

Appendix 1. Continued

The left eye was swollen and injured

The turtle finally returned to the sea

Appendix 2. Nightly sea turtle encounters for the 2011Green Turtle Program

a) Encounters in the northernmost 5 miles of beach (Tortuguero)

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
9-Jun				0				0				0
10-Jun				0				0				0
11-Jun				0				0				0
12-Jun				0	1	2		3				0
13-Jun				0	2			5				0
14-Jun				0	1			6				0
15-Jun				0	2	1		9				0
16-Jun				0		1		10				0
17-Jun				0				10				0
18-Jun				0	1	2		13				0
19-Jun				0	2	1		16	1			1
20-Jun				0	1	3		20				1
21-Jun				0	3	2		25				1
22-Jun				0	5	2		32				1
23-Jun				0	7	2	2	43				1
24-Jun				0	4	1		48			1	2
25-Jun				0	5	1		54				2
26-Jun				0	3	4	1	62				2
27-Jun				0	4	6		72				2
28-Jun				0	5	4		81				2
29-Jun				0	3		1	85				2
30-Jun				0	7	1		93				2
1-Jul				0	4	5	2	104				2
2-Jul				0	1	3	1	109				2
3-Jul				0	7	1	1	118				2
4-Jul				0	4	1		123	1			3
5-Jul				0	4	2	1	130				3
6-Jul				0	8	5		143				3
7-Jul				0	5	5	1	154				3
8-Jul				0	3	5	2	164				3
9-Jul				0	6	3	3	176				3
10-Jul				0	5	3	1	185				3
11-Jul				0	4	4	2	195				3
12-Jul				0	10	3		208				3
13-Jul				0	9	5	1	223				3
14-Jul				0	5	4	2	234				3
15-Jul				0	3	8	1	246				3

Appendix 2a. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
16-Jul				0	4	2	1	253	1			4
17-Jul				0	4	2	1	260				4
18-Jul				0	7	4	4	275				4
19-Jul				0	8	3	3	289				4
20-Jul				0	8	2	1	300				4
21-Jul				0	6	10	1	317				4
22-Jul				0	3	4		324				4
23-Jul				0	7	4	3	338				4
24-Jul				0	3	1	1	343				4
25-Jul				0	5	3		351				4
26-Jul				0	5	8		364				4
27-Jul				0	7	3	2	376				4
28-Jul				0	5	2		383				4
29-Jul				0	3	3	1	390				4
30-Jul				0	2	4	1	397				4
31-Jul				0	4	3	3	407	1			5
1-Aug				0	6	3	2	418				5
2-Aug				0	10	3	1	432				5
3-Aug				0	9	4	2	447				5
4-Aug				0	8	4	2	461				5
5-Aug				0	4	4		469				5
6-Aug				0	2	1	2	474				5
7-Aug				0	4	1	1	480				5
8-Aug				0	5	6		491				5
9-Aug				0	8		1	500				5
10-Aug				0	4	3	2	509				5
11-Aug				0	8	5	1	523	1			6
12-Aug				0	0	0		523				6
13-Aug				0	1		3	527				6
14-Aug				0	8	2	1	538				6
15-Aug				0	5	4	6	553				6
16-Aug				0	6	2	4	565				6
17-Aug				0	3	5	1	574				6
18-Aug				0	5	6	5	590				6
19-Aug				0				590				6
20-Aug				0	3	1	1	595				6
21-Aug				0	4	2	3	604				6
22-Aug				0	3	3		610				6

Appendix 2a. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
23-Aug				0	3			613				6
24-Aug				0	1	1		615				6
25-Aug				0	3	2	1	621				6
26-Aug				0	5	2	2	630				6
27-Aug				0	1	1	1	633				6
28-Aug				0	4	4	2	643				6
29-Aug				0	3	6	2	654				6
30-Aug				0	6	3	2	665				6
31-Aug				0	5	2	3	675				6
1-Sep				0	6	1	2	684				6
2-Sep				0	5	3	1	693				6
3-Sep				0	3	5	2	703				6
4-Sep				0	4	2	3	712				6
5-Sep				0	5	3	5	725	1			7
6-Sep				0	9	6	6	746				7
7-Sep				0	10	3	3	762				7
8-Sep				0	4	8	2	776				7
9-Sep				0	7	4	1	788				7
10-Sep				0	3	3	3	797				7
11-Sep				0	6	5	1	809				7
12-Sep				0	10	4	6	829				7
13-Sep				0	4	6	1	840				7
14-Sep				0	5	4	1	850				7
15-Sep				0	5	5	8	868				7
16-Sep				0	10	8	4	890				7
17-Sep				0	6	6	1	903				7
18-Sep				0	11	11	9	934				7
19-Sep				0	14	4	4	956				7
20-Sep				0	11	6	3	976				7
21-Sep				0	9	4	4	993				7
22-Sep				0	5	4	2	1004				7
23-Sep				0	16	7	5	1032				7
24-Sep				0	6	2	1	1041				7
25-Sep				0	3	5	1	1050				7
26-Sep				0	7	4	5	1066				7
27-Sep				0	4	2	3	1075				7
28-Sep				0	6	2	2	1085				7
29-Sep				0	11	7	5	1108				7

Appendix 2a. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
30-Sep				0	15	5	2	1130				7
1-Oct				0	4	1	2	1137				7
2-Oct				0	15	9	9	1170				7
3-Oct				0	13	10	7	1200				7
4-Oct				0	10	2	4	1216				7
5-Oct				0	6	2	3	1227				7
6-Oct				0	6	1	6	1240				7
7-Oct				0	1	2	2	1245				7
8-Oct				0	3	1	1	1250				7
9-Oct				0	2	1	5	1258				7
10-Oct				0	4	2	4	1268				7
11-Oct				0	0	0	3	1271				7
12-Oct				0	2		5	1278				7
13-Oct				0	3	0	4	1285				7
14-Oct				0	7	2	9	1303				7
15-Oct				0	2	2	1	1308				7
16-Oct				0	3	1	4	1316				7
17-Oct				0		1	4	1321				7
18-Oct				0			1	1322				7
19-Oct				0	0	0	1	1323				7
20-Oct				0	0	0	0	1323				7
21-Oct				0	1	2	2	1328	1			8
22-Oct				0	1		2	1331				8
23-Oct				0			3	1334				8
24-Oct				0			1	1335				8
25-Oct				0			2	1337				8
26-Oct				0	1		1	1339				8
27-Oct				0	1		2	1342				8
28-Oct				0				1342				8
29-Oct				0				1342				8
30-Oct				0				1342				8
STT	**0**	**0**	**0**	**0**	**657**	**406**	**279**	**1342**	**7**	**0**	**1**	**8**

Key to table

New – Turtles that had no tags on first encounter in 2011
REM – Remigrant turtles that had tags from previous years/other projects on first encounter in 2011
REN – Renester turtles that were encountered on more than one occasion during 2011
STT – Sub-total of encounters for Tortuguero

Appendix 2. Continued

b) Encounters in the southernmost four miles of beach (Jalova)

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
6-Jun				0				0				0
7-Jun				0	1			1				0
8-Jun				0	1			2				0
9-Jun				0				2				0
10-Jun				0	3			5				0
11-Jun				0	2			7				0
12-Jun				0	2			9	1			1
13-Jun				0	1			10				1
14-Jun				0	2			12				1
15-Jun				0				12				1
16-Jun				0	7			19				1
17-Jun				0	2			21				1
18-Jun				0				21				1
19-Jun				0	2			23				1
20-Jun				0	2			25				1
21-Jun				0	2			27				1
22-Jun				0	2	1		30				1
23-Jun				0	1			31				1
24-Jun				0	2			33				1
25-Jun				0				33				1
26-Jun				0	3			36				1
27-Jun				0			1	37	1			2
28-Jun				0	1			38				2
29-Jun				0	0			38	1			3
30-Jun				0	1			39				3
1-Jul				0	3			42				3
2-Jul				0				42				3
3-Jul				0				42				3
4-Jul				0	3		1	46				3
5-Jul				0	1			47				3
6-Jul				0		1		48				3
7-Jul				0	1		1	50				3
8-Jul				0	3			53				3
9-Jul				0	1	1		55				3
10-Jul				0	3			58				3
11-Jul				0	4			62				3
12-Jul				0	3	1		66				3
13-Jul				0	6		1	73				3

Appendix 2b. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
14-Jul				0	4	1	1	79				3
15-Jul				0	2	1		82				3
16-Jul				0	8			90				3
17-Jul				0	5		1	96				3
18-Jul				0	3			99				3
19-Jul				0	4			103				3
20-Jul				0	2			105				3
21-Jul				0				105				3
22-Jul				0	3			108				3
23-Jul				0	3			111				3
24-Jul				0	6		1	118				3
25-Jul				0	2	1	2	123				3
26-Jul				0	2	1		126				3
27-Jul				0	8	1		135				3
28-Jul	1			1	2			137				3
29-Jul				1	6		1	144				3
30-Jul				1	6	1	1	152		1		4
31-Jul				1	5			157				4
1-Aug				1	5	1		163	1			5
2-Aug				1	7	1		171				5
3-Aug				1	5			176				5
4-Aug				1				176				5
5-Aug				1	5			181				5
6-Aug				1	4			185				5
7-Aug				1	2	1		188				5
8-Aug				1	1	1	1	191				5
9-Aug				1	4			195				5
10-Aug				1	5	1	2	203				5
11-Aug				1	4			207				5
12-Aug				1	2		1	210				5
13-Aug				1	7		2	219				5
14-Aug				1	3			222				5
15-Aug				1	6			228				5
16-Aug				1	9		2	239	1			6
17-Aug				1	6			245	1			7
18-Aug				1	2		3	250				7
19-Aug				1				250				7
20-Aug				1	4			254				7
21-Aug				1	3	1	1	259				7

Appendix 2b. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
22-Aug				1	11			270				7
23-Aug				1	4		1	275				7
24-Aug				1	4			279				7
25-Aug				1	2			281				7
26-Aug				1	2			283				7
27-Aug				1	3	1	1	288				7
28-Aug				1	4		1	293				7
29-Aug				1	10	1	2	306				7
30-Aug				1	10			316				7
31-Aug				1	11	1		328				7
1-Sep				1	4	1	2	335				7
2-Sep				1		2	1	338				7
3-Sep				1	5		1	344				7
4-Sep				1	6		2	352				7
5-Sep				1	4		1	357				7
6-Sep				1	8	1	2	368				7
7-Sep				1	2		3	373				7
8-Sep				1				373				7
9-Sep				1			1	374				7
10-Sep				1	13	1	2	390				7
11-Sep				1				390				7
12-Sep				1	2		1	393	1			8
13-Sep				1	1		1	395				8
14-Sep				1				395				8
15-Sep				1				395				8
16-Sep				1				395				8
17-Sep				1				395				8
18-Sep				1				395				8
19-Sep				1				395				8
20-Sep				1				395				8
21-Sep				1				395				8
22-Sep				1			1	396				8
23-Sep				1				396				8
24-Sep				1				396				8
25-Sep				1				396				8
26-Sep				1				396				8
27-Sep				1				396				8
28-Sep				1				396				8

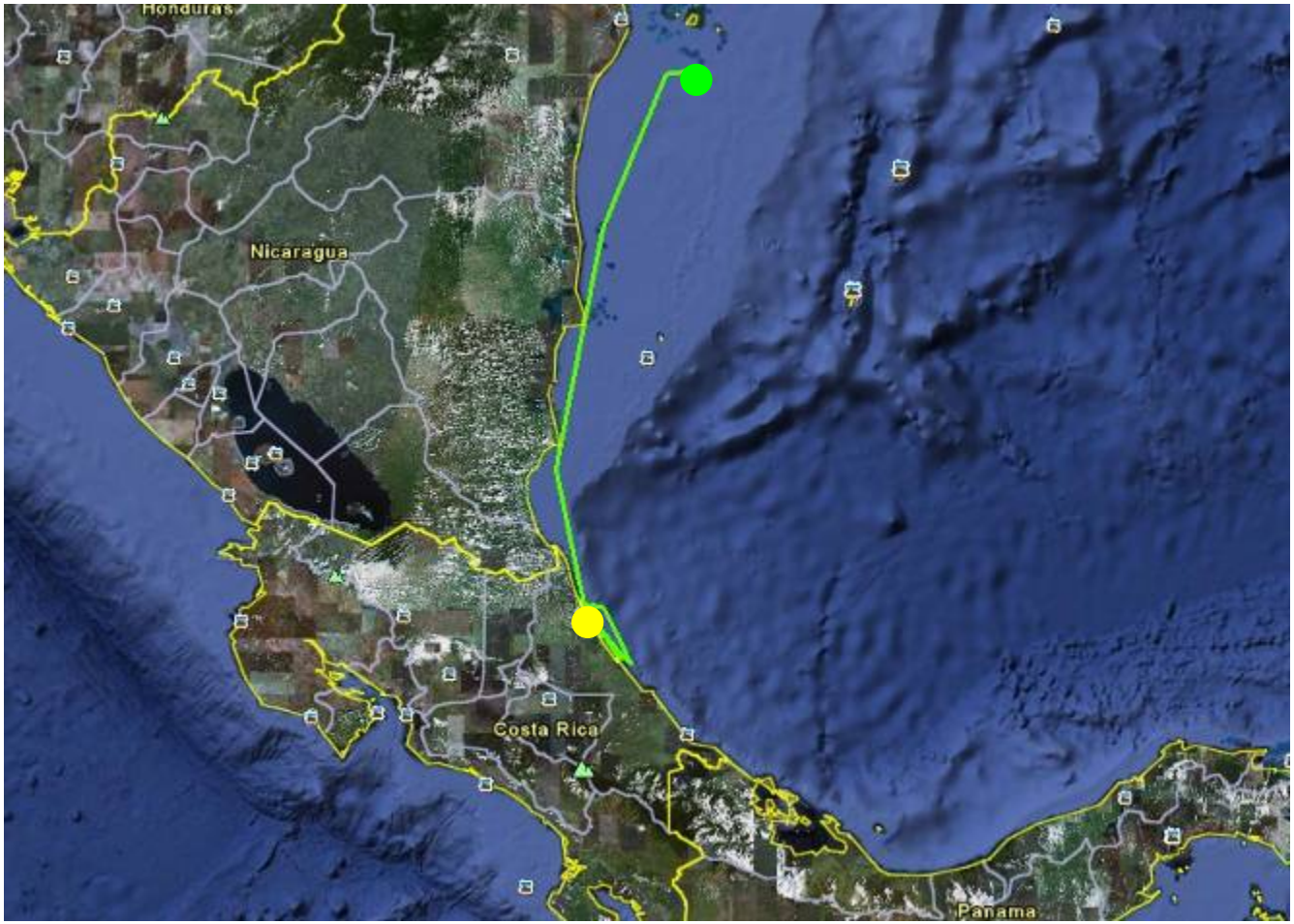
Appendix 2b. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
29-Sep				1				396				8
30-Sep				1				396				8
1-Oct				1				396				8
2-Oct				1				396				8
3-Oct				1				396				8
4-Oct				1	3		1	400				8
5-Oct				1	2			402				8
6-Oct				1				402				8
7-Oct				1	2			404				8
8-Oct				1	1			405				8
9-Oct				1	1			406				8
10-Oct				1	1		1	408				8
11-Oct				1				408				8
12-Oct				1	1			409				8
13-Oct				1				409				8
14-Oct				1	1			410				8
15-Oct				1				410				8
16-Oct				1				410				8
17-Oct				1	2			412				8
18-Oct				1	1			413				8
19-Oct				1	1			414				8
20-Oct				1			1	415				8
21-Oct				1				415				8
22-Oct				1				415				8
23-Oct				1				415				8
24-Oct				1				415				8
25-Oct				1				415				8
26-Oct				1				415				8
27-Oct				1				415				8
28-Oct				1				415				8
29-Oct				1	1			416				8
30-Oct				1				416				8
STJ	**1**	**0**	**0**	**1**	**343**	**24**	**49**	**416**	**7**	**1**	**0**	**8**
Total	**1**	**0**	**0**	**1**	**1000**	**430**	**328**	**1758**	**14**	**1**	**1**	**16**

Key to table
New – Turtles that had no tags on first encounter in 2011
REM – Remigrant turtles that had tags from previous years/other projects on first encounter in 2011
REN – Renester turtles that were encountered on more than one occasion during 2011
STJ – Sub-total of encounters for Jalova
Total – Combined total of encounters from Tortuguero and Jalova

Appendix 3. Migration maps of green turtles tracked using satellite telemetry in 2011

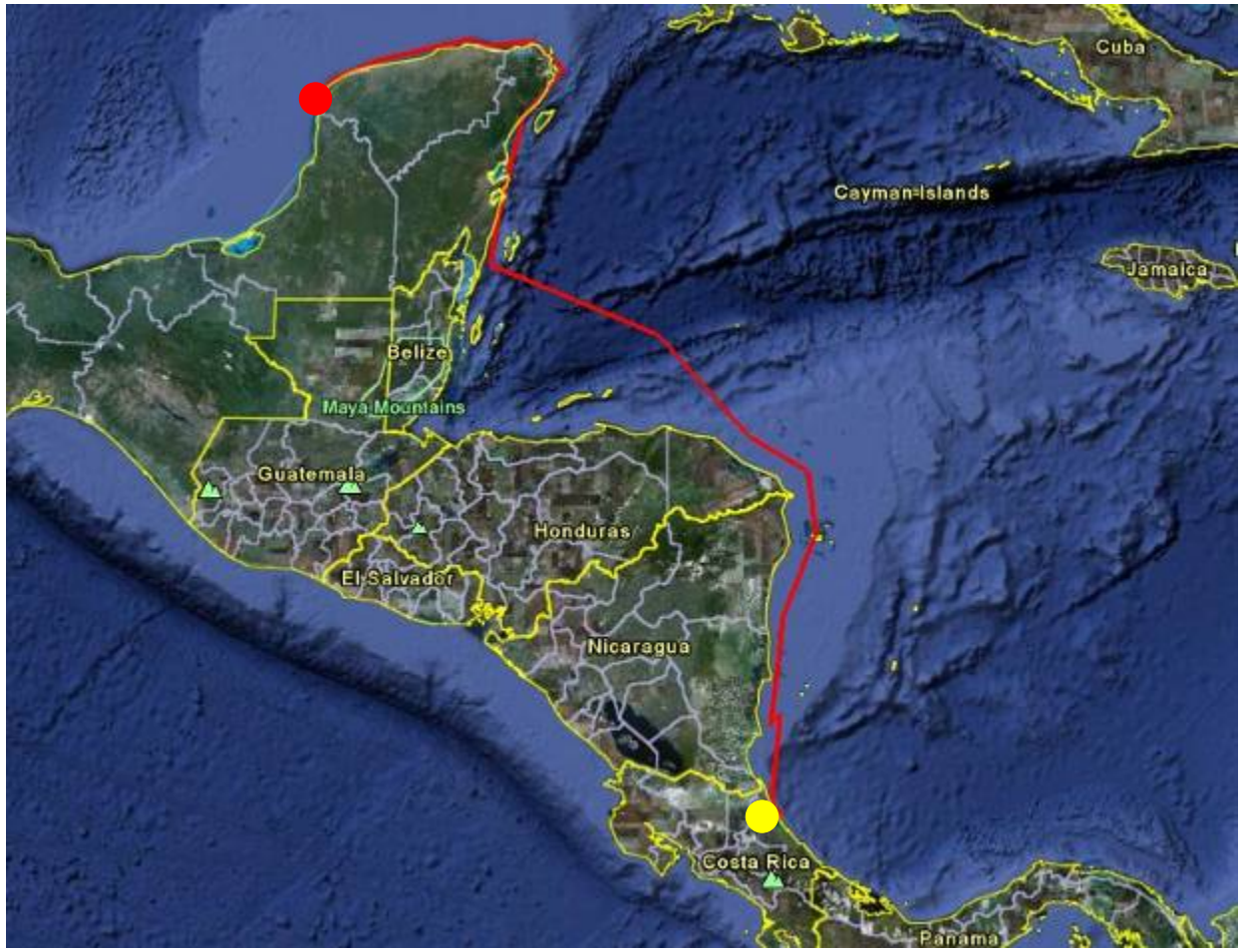
a) 'Odessa'



The turtle remained close to Tortuguero (yellow circle) for various months before heading north.
The green circle shows the location of the turtle when the transmitter stopped sending signals in February, 2012

Appendix 3. Continued

b) 'Adele'



The turtle remained close to Tortuguero (yellow circle) for several weeks before heading north. The red circle shows the location of the turtle when the transmitter stopped sending signals in March, 2012

Appendix 4. Environmental education activities conducted in 2011

STC RAs show students at the school in Moin where to apply a flipper tag

RAs and interns from a local high school teach students in Moin about sea turtles

Appendix 4. Continued

Students in Tortuguero learn about the life cycle of sea turtles

Students in Tortuguero see how the RAs work with a turtle on the beach