REPORT ON THE 2014 GREEN TURTLE PROGRAM AT TORTUGUERO, COSTA RICA

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Sea Turtle Conservancy
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Acknowledgments

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Executive Summary

Monitoring and Research Activities Conducted

1 During 2014, a total of 52 track surveys were conducted along the entire 18 miles of beach between Tortuguero river mouth and Jalova lagoon.

2 Green turtle nesting was observed regularly between March and November; with the first nest recorded on 1 February.

3 Peak nesting was recorded on 19 September; 1,669 green turtle nests were counted in a single night.

4 An estimated 92,749 green turtle nests were laid during 2014. This equates to a population of 15,458 – 33,125 nesting females.

5 A total of 28.7% of all green turtle nests recorded during track surveys were deposited between Tortuguero river mouth (mile –2/8) and mile 5, and between mile 15 and the Jalova lagoon.

6 Hawksbill nesting density was in the normal range for this species, with 15 nests were recorded from February – November.

7 During daily track surveys conducted by the FRC and RAs between 3 June and 1 November a total of 18,663 green turtle nests and 23,086 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 7,999 nests and 5,624 false crawls.

8 Nineteen leatherback and 57 hawksbill nests were recorded.

9 A total of 24 fresh nests were recorded as poached during daily track surveys; 23 green turtles and one hawksbill. In addition, 15 old green turtle nests and three old hawksbill nests were also taken.

10 Twenty-nine adult green turtles were poached from the beach.

11 Eighteen green turtle nests were depredated by dogs in the northern five miles of beach.

12 Jaguars killed a minimum of 71 green turtles and one hawksbill in 2014.

13 Fourteen green turtles were found alive, following poaching attempts; 12 in a single night. All were successfully released.

14 2,089.7 team hours of night patrols were conducted from 4 June – 30 October; 1,560.2 hours in Tortuguero and 529.5 hours in Jalova.

15 A total of 1,276 green turtles were newly tagged, 649 green turtles had tags, and 359 females were encountered more than once during night patrols.

16 183 of the previously tagged turtles had been originally been tagged in Tortuguero more than 10 years ago and seven more than 20 years ago.

17 The oldest turtle encountered was originally tagged at Tortuguero in 1982, 32 years ago.

18 Thirty-one green turtles were encountered in 2014 with tags from other projects; two were tagged at Pacuare Nature Reserve, two at Mondonguillo, two at Moín, one at Parismina and 24 at Caño

Palma.

19 One turtle was encountered with tags from a location outside of Costa Rica; she was tagged in Florida, USA.

20 Newly tagged green turtles had evidence of old tag holes or notches in at least one front flipper in 15.4% of cases.

21 Green turtles encountered during night patrols nested in the open zone in 23.3% of cases, 65.0% were located in the border zone, 9.4% in the vegetation zone and 2.3% of turtles were encountered during a false crawl emergence.

22 Twenty newly tagged and four previously tagged hawksbill turtles were encountered during the 2014 Green Turtle Program.

23 Six encounters with leatherback turtles were reported during the 2014 Green Turtle Program; the last was on 22 June.

24 Mean carapace length for green turtles was 105.7cm (CCLmin - Tortuguero) and 105.1cm (CCLmin – Jalova) and 98.5cm (SCLmax – Tortuguero) and 98.4cm (SCLmax – Jalova).

25 Mean clutch size for green turtles was 110.9 eggs.

26 Precision of CCLmin and SCLmax measurements of green turtles was the same within a single encounter; 0.4 cm. For turtles seen more than once, the measurements were taken with different levels of precision.

27 Mean carapace length for hawksbill turtles was 87.9cm (CCLmin) and 82.0cm (SCLmax).

28 Mean clutch size of hawksbill nests was 185.9 eggs.

29 The mean CCLmin for leatherback turtles was 155.1cm (CCLmin).

30 Mean clutch size for leatherback nests was 81.5 yolked eggs and 36.0 yolkless eggs.

31 Of 153 green turtles checked for fibropapiloma only one female had tumors present. Fibropapilloma tumors were observed on one other turtle during the general body check.

32 A total of 182 green turtle nests were marked and the fate was determined for 167 nests.

33 Overall mean hatching success was estimated at 68.7% and overall mean emerging success at 66.8%.

34 Mean depth for undisturbed green turtle nests at excavation was 59.4cm (n = 127) from the sand surface to the top egg and 73.9cm (n = 127) to the bottom of the egg chamber.

35 A total of one albino, one twin embryo and seven deformed embryos were observed in unhatched eggs, accounting for 0.041% of eggs.

36 Fifteen hawksbill nests were monitored and the fate was determined for 14 nests.

37 Mean hatching and emerging success of hawksbill nests (n = 14) was 54.0% and 45.8%, respectively.

38 Mean depth for hawksbill nests from the sand surface to the top egg was 31.3cm and to the bottom

of the egg chamber was 48.4cm.

39 Rainfall was monitored from March – December 2014; September was the driest month (219.1mm) and July was the wettest month (1,116.7mm).

40 Sand temperature in the vegetation zone ranged from 23.7 – 27.4ºC; in the border zone it ranged from 24.7 – 31.2ºC and in the open zone from 24.8 – 34.5ºC.

41 A total of 15,626 people visited the STC Visitors Center in 2013; an average of 43 people per day.

42 Despite the help of the Costa Rican Electricity Institute (ICE) to minimize the problem of public street lights, there was still a considerable number of artificial lights visible from the beach, especially in front of Tortuguero village.

43 There were no incidents of hatchling disorientation observed in 2014.

44 Two green turtles and one hawksbill were tracked using satellite telemetry. The hawksbill went to Nicaragua and the greens travelled to Belize and Cuba.

Recommendations

1 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.

2 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. TNP staff should also receive regular reports regarding observations of illegal poaching activities.

3 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.

4 The Turtle Spotter Program should continue in future years and STC should remain an integral part of the committee responsible for overseeing the development and implementation of the program activities, to provide technical advice regarding the potential impacts of tourist activities on sea turtle populations at Tortuguero.

5 A carrying capacity study should be conducted to determine the maximum limits related to tours to observe sea turtle nesting on the beach at night; to include the total number of people permitted per night or per section of beach, the total number of people permitted to observe each turtle, and establish a minimum distance between turtles being observed to prevent crowding.

6 A revegetation program should be initiated to replace native vegetation between the beach and village buildings, to help reduce the problem of artificial light that is negatively impacting sea turtle hatchlings.

7 The satellite tracking project should continue in future years; it is a great way to find out the migration routes of turtles nesting at Tortuguero, to determine what possible threats turtles may face during migration and also know where their feeding areas are located.

8 It is very important to have strong collaboration between STC and the authorities, to help with sea turtle protection and conservation initiatives within TNP.

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 2014 Green Turtle Program represents the seventeenth consecutive year of implementing the revised monitoring protocol.

The objectives of this report are to summarize and discuss the results of the 2014 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 2014, STC signed an agreement with Global Vision International (GVI), a volunteer organization that has a project in Tortuguero National Park. 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 2014 Green Turtle Program the Research Assistants (RAs) completed an extensive 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. They were also taken on a canal tour to learn about the flora and fauna of the park.

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. GVI staff and volunteers replaced and repainted mile markers from mile 15 – 18.

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 at the Tortuguero river mouth, or at Tortuguero village, and finished 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) and the southern three miles at Jalova (from Jalova lagoon to mile 15) from June - October. 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
- 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
- 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
- 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.

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; hard-shelled species 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.

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

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 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 (*Eretmochelys imbricata*) 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 2012 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 the presence of fibropapilloma tumors was also conducted. All soft body parts, including the cloacal region, were inspected, 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.

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. Evidence of depredation, poaching or beach erosion 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 recorded. 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 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 2014 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 2012 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 2014 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 2014.

2.9.3 Turtle tours

The number of tourists going on guided turtle tours during the 2014 Green Turtle Program was determined from the permits issued to tour guides by ACTo. In 2014, the Turtle Spotter Program

(TSP), the visitation system introduced in 2004 that aimed to reduce negative impacts of tourism on nesting sea turtles, was implemented along the northern five miles of beach where tourism is permitted (from the Tortuguero river mouth to the mile 5 marker). Turtle 'spotters' patrolled the beach searching for nesting turtles, and reported their location to the tour groups waiting with their guides at designated areas behind the beach. When the turtle was close to laying eggs, guides led their group to her location using a path behind the beach, thus reducing the number of people walking along the beach who could potentially disturb other turtles as they came ashore to nest.

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 section
- Number of lights visible from the beach
- Light source (if possible to determine)

To avoid duplicate recording of the same light source in multiple 1/8 mile sections 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 Satellite Tracking Project

Continuing the satellite tracking project that has been conducted by STC within the Caribbean region since 2001, in 2014 three satellite transmitters were available for attachment to a green or hawksbill turtle during the Green Turtle Program. These turtles were included in the 2014 Tour de Turtles; an on-line education event run by STC to raise awareness about sea turtles, their migration behavior and threats that they face.

The transmitters were attached during the middle of the nesting season; the data would provide information on inter-nesting behavior between nesting emergences and also post-nesting migrations to feeding grounds away from Costa Rica.

The turtles were selected by researchers depending on their size, physical characteristics of the carapace (to aid attachment by not having any deformities or irregularities in the scutes) and distance from the field station (to facilitate their relocation to the station where they were retained overnight).

The transmitter was attached at 6.00am the following morning, using the protocol detailed in Coyne *et al*.(2008). Visitors from the lodges and cabinas, and members of the community were invited to observe the attachment procedure and subsequent release of the turtle. STC researchers were available to answer any questions about sea turtles, satellite telemetry or the work of STC.

Data from the transmitters were used to produce migration maps which were regularly updated on the Tour de Turtles website (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 2014 Green Turtle Program, and the additional personnel allowed beach patrols to be conducted in the section of beach close to Jalova for the second consecutive green turtle nesting season.

The RAs arrived in Tortuguero on 2 June, 2014. During the first two weeks of the 2014 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 and Scientific Director (SD). 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/SD demonstrated field techniques and supervised RAs tagging and measuring turtles, and recording data in the field books.

To have a better understanding of TNP and Costa Rican environmental laws, RAs received a talk from park rangers. They also had an opportunity to speak to 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, so that the directors and teachers could meet the EOC and RAs before they started activities with the students.

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; GVI personnel checked the markers between miles 15 – 18. These markers were put in the same locations as those positioned at the start of the 2014 Leatherback Program.

3.2 Track Surveys

3.2.1 Weekly track surveys

Fifty-two weekly track surveys were conducted from 4 January to 27 December, 2014. The first green turtle nest was recorded on 1 February, 2014, with regular nesting observed from March – November (See Figure 1). There were two nesting peaks, one towards the end of August and another during the middle two weeks of September. The night with the highest level of nesting was 19 September, when 1,669 nests were recorded (See Figure 1). Using the methodology of Troëng & Rankin (2005), it was estimated that 92,749 green turtle nests were laid along the entire 18 miles of beach during the 2014 nesting season (See Figure 2). This equates to a population of between 15,458 – 33,125 nesting females.

The pattern of green turtle nesting was different to that typically observed. As in previous years nesting increased within TNP (after mile 3), but the peak was at mile 5, not in the middle of the beach as often seen (See Figure 3); 9% of all the nests were reported in this mile. Nests laid between the Tortuguero river mouth and the mile 5 marker, and between miles 15 – 18 in Jalova, where nightly beach patrols were regularly conducted, accounted for 28.7% of all nests laid on the entire beach (See Figure 3).

Figure 1. Temporal distribution of green turtle nesting at Tortuguero in 2014, as determined from weekly track surveys

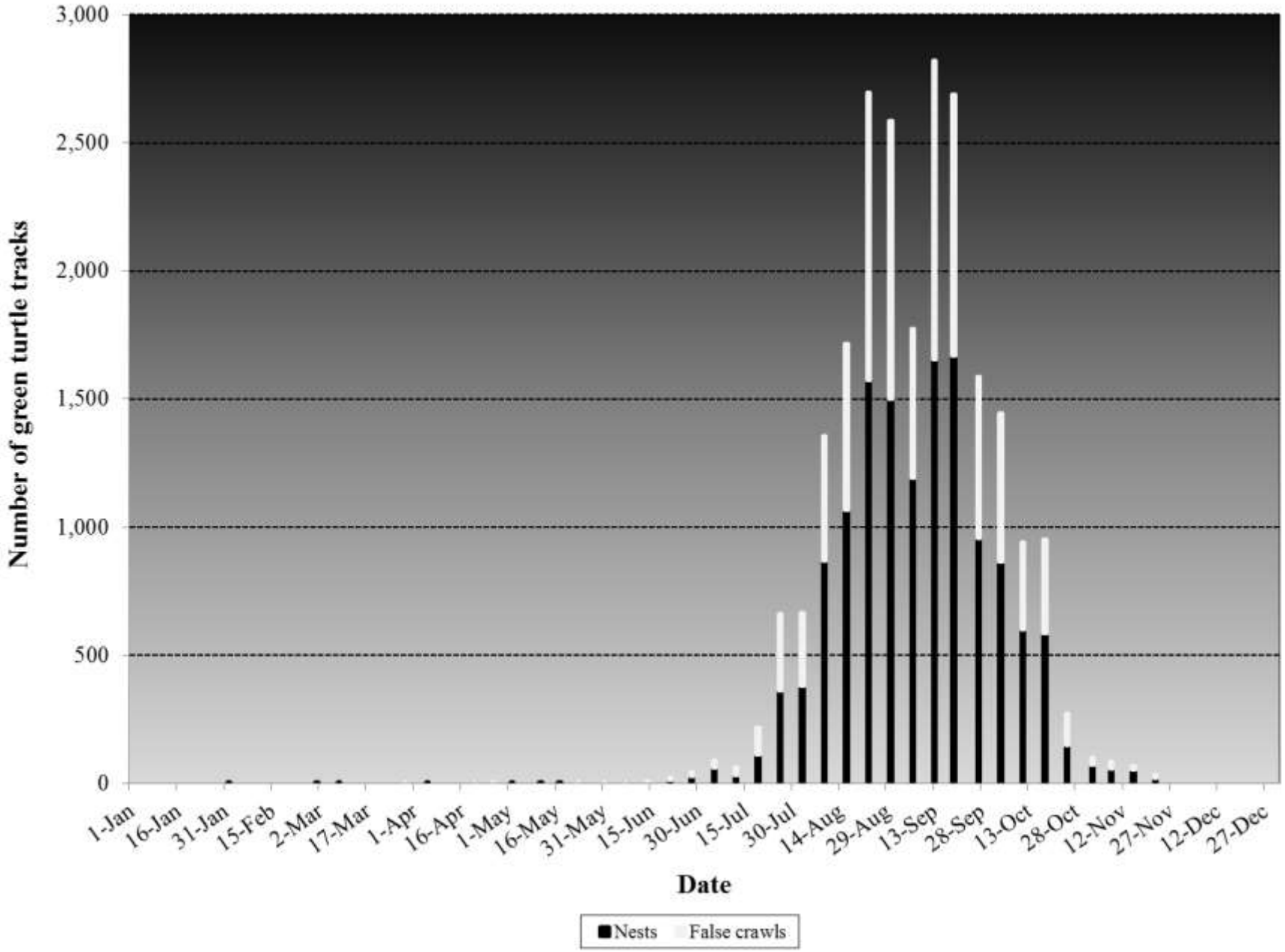


Figure 2. Green turtle nesting trend at Tortuguero, 1986 - 2014, as determined by weekly track surveys of the entire beach

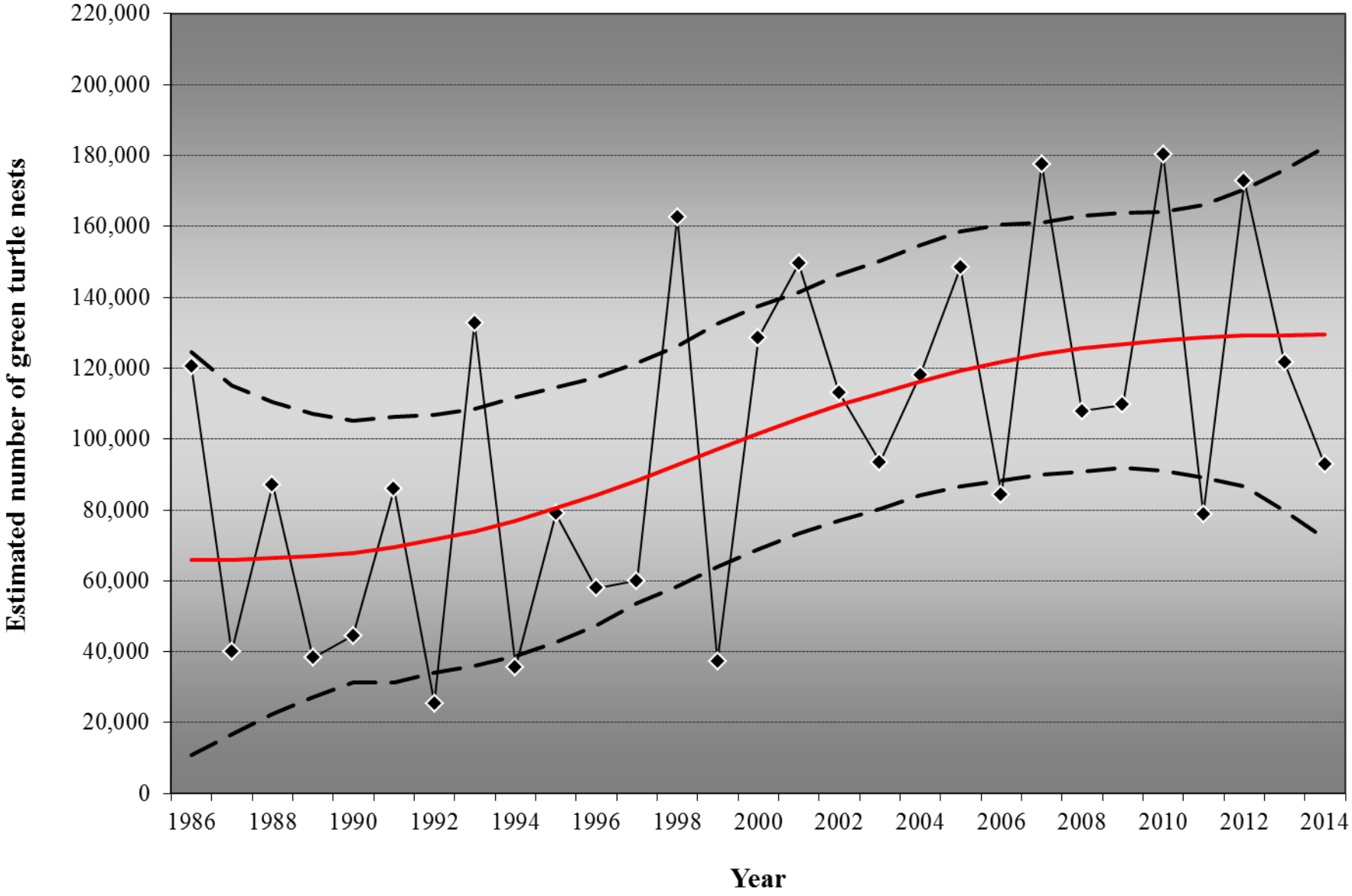
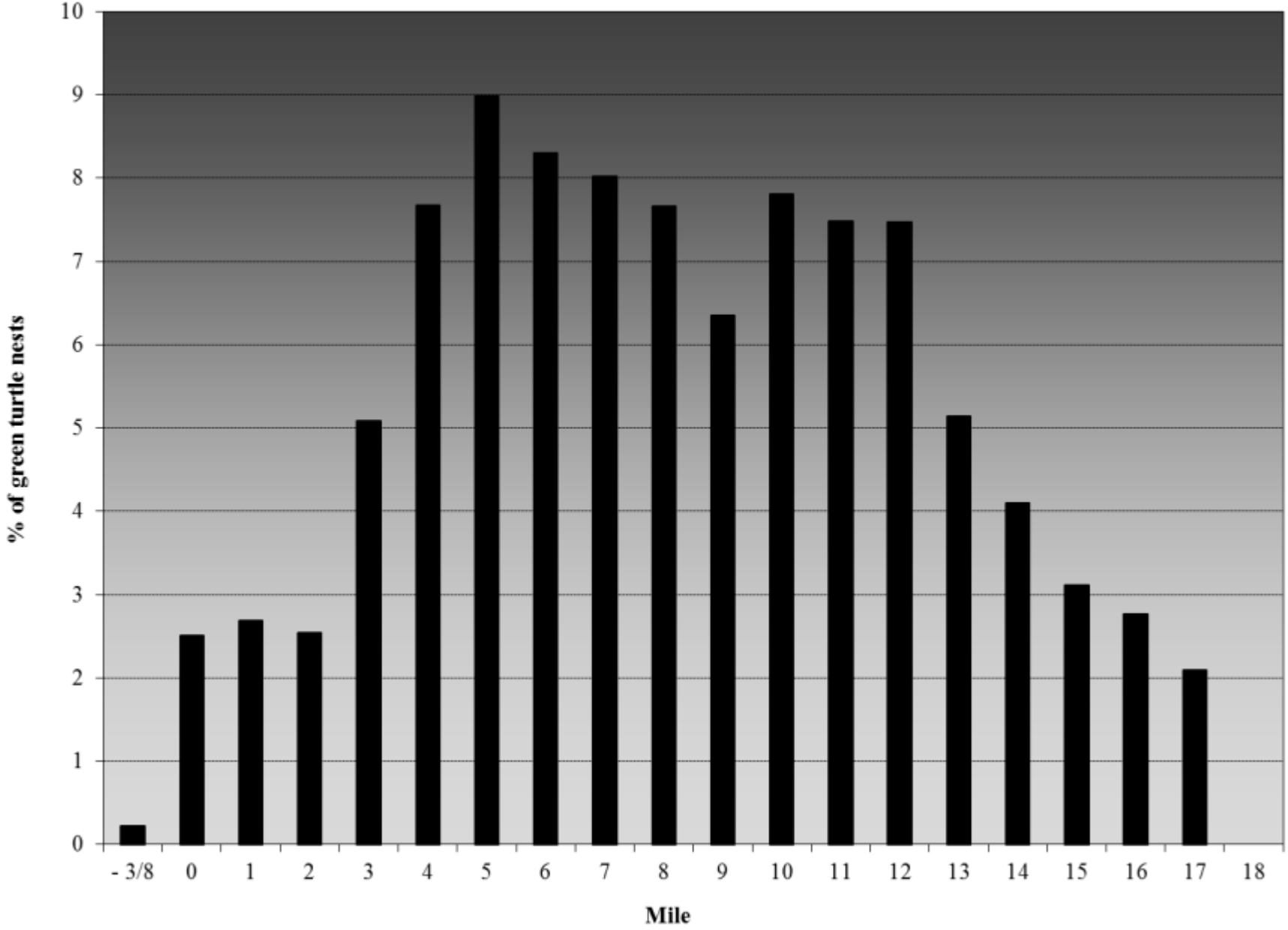


Figure 3. Spatial distribution of green turtle nesting at Tortuguero in 2014, as determined from weekly track surveys



The number of green turtle nests recorded as poached during weekly track surveys decreased in 2014; a total of 30 nests were taken between August and October. However, there were two surveys (on 18 and 25 October) when more than 10 nests were taken in a single night. Also, there was an increase in the number of turtles that were taken; in October there was evidence that 36 females had been flipped over and dragged off the beach. Of these, 24 were taken in a single night (25 October). Unfortunately, the majority of poached nests and turtles were taken from within TNP, between miles 6 and 14 4/8, but there were also various nests poached close to the Tortuguero river mouth, between miles 0 – 1/8.

Fifteen hawksbill nests were observed between February and November, 2014; the first track was seen on 25 January. No hawksbill nests or turtles were recorded as poached.

A detailed discussion on the temporal and spatial distribution of leatherback nesting in 2014 can be found in the 2014 Leatherback Program Report.

3.2.2 Daily track surveys

Daily track surveys were conducted by the FRC and RAs between 3 June and 1 November; partial surveys were conducted on 3 July and 1 November. A total of 18,663 green turtle nests and 23,086 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 44.7% 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 TNP, past mile 3 3/8 (See Figure 4a); in total, 51.3% of all nests were laid between mile 3 3/8 and mile 5. The 1/8 mile with highest nesting was mile 3 5/8, with 1,031 nests. 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 2014 Green Turtle Program is shown in Figure 4b. The season was delayed in comparison with other years; peak nesting was recorded on 16 September, when 519 green turtle nests were recorded from the previous night.

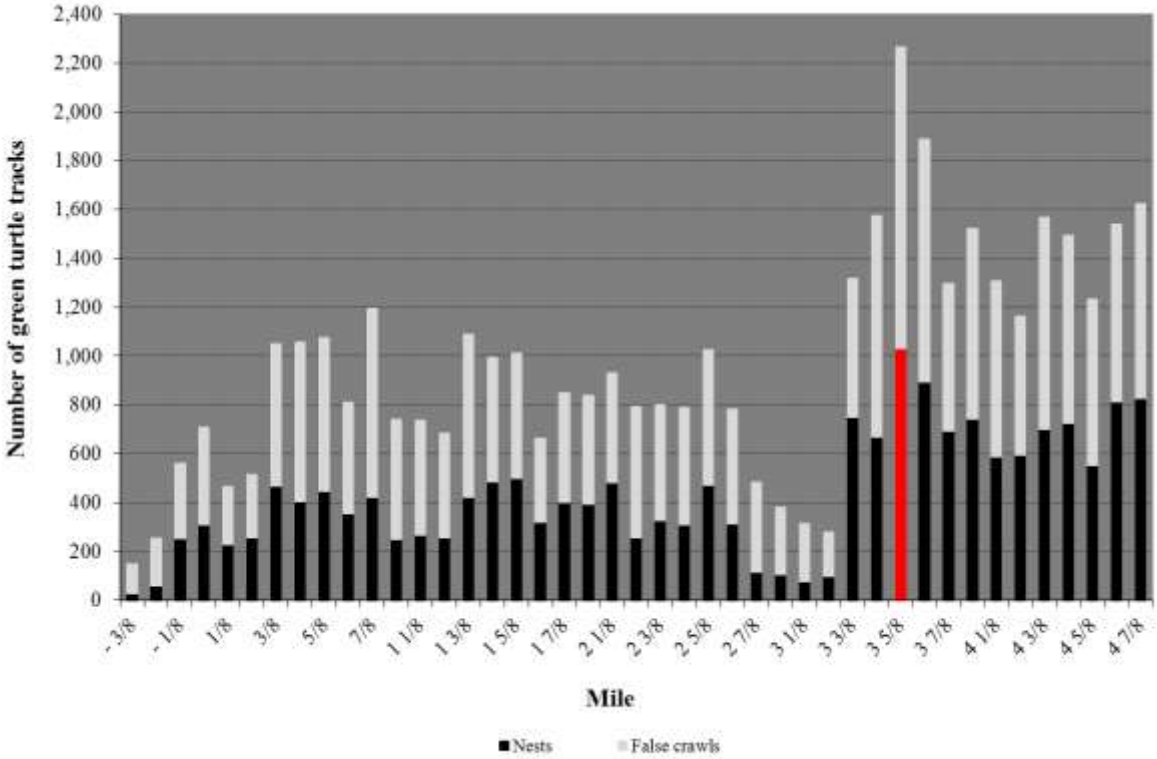
Eight leatherback nests were counted at the start of the 2014 Green Turtle Program; the last was observed on 9 June. Hawksbill nesting activity was observed throughout the program; the first nest was recorded on 4 June and the last on 21 October. A total of 30 nests and 46 false crawls were recorded during track surveys.

Daily track surveys were conducted by the GVI staff and volunteers between 4 June and 27 October. A total of 7,999 green turtle nests and 5,624 green turtle false crawls were recorded between mile 15 and the Jalova lagoon (See Figure 5a and 5b); successful nesting was observed in 58.7% of green turtle emergences at the southern end of the beach. The peak of nesting was several weeks before the peak observed at the northern end of the beach; it was seen on 27 August, when 245 green turtle nests were counted from the previous night (See Figure 5b)

In addition, 11 leatherback nests and one false crawl were recorded during daily track surveys close to Jalova; the last nest was on 16 June. Hawksbill nesting was observed from June – September; a total of 27 nests and 35 false crawls were registered.

Figure 4. Results of daily track surveys of the northern 5 2/8 miles of beach in 2014

a) Spatial distribution



b) Temporal distribution

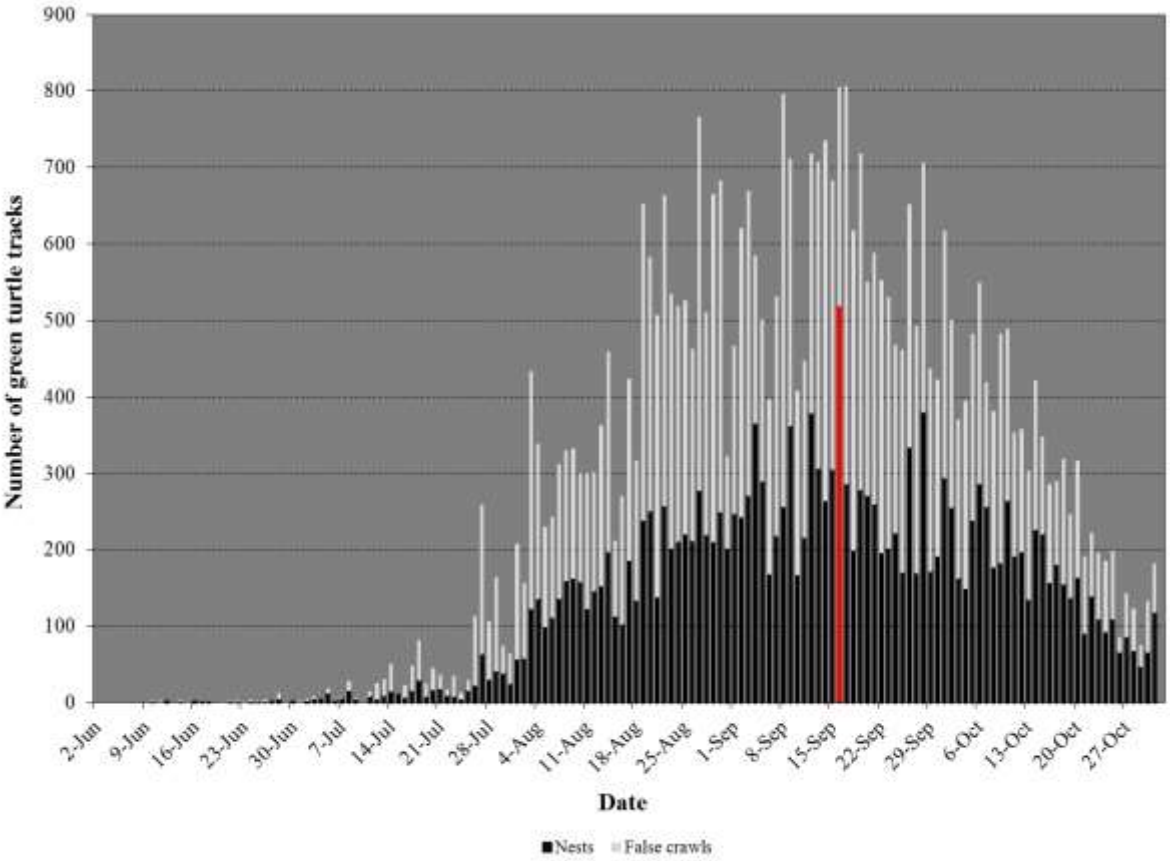
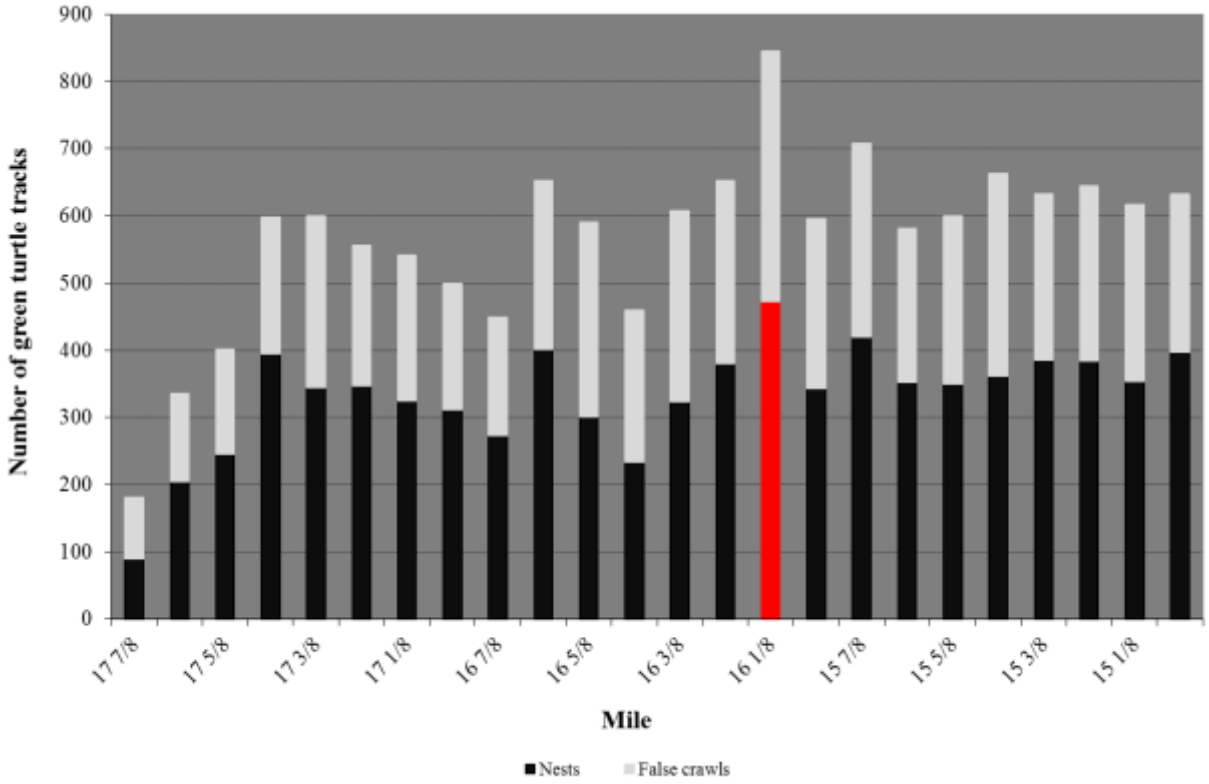
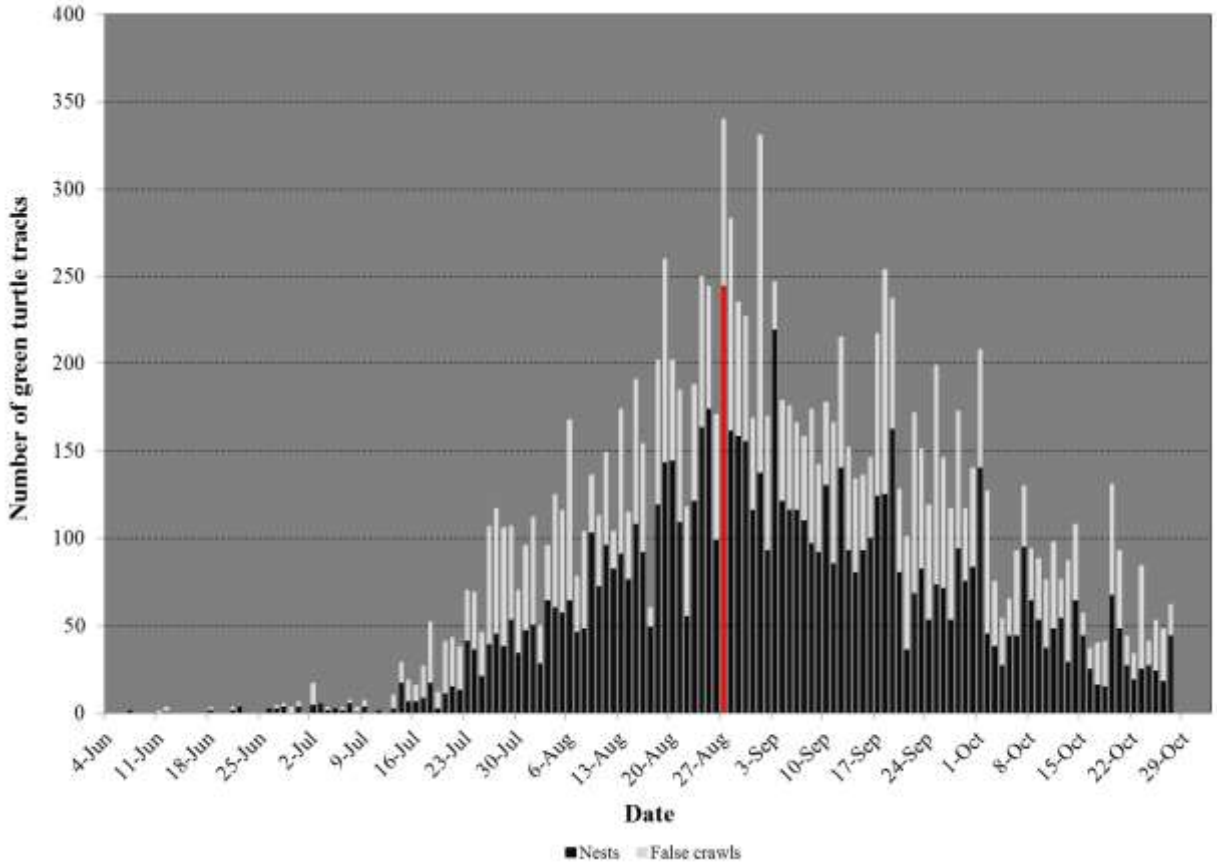


Figure 5. Results of daily track surveys of the southern three miles of beach in 2014

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, 23 fresh nests were taken from June – October; 22 green turtle nests (0.1% of the total) and one hawksbill. A further 15 old (more than one day) green turtle nests and three hawksbill nests were also taken. Twenty-seven green turtles were taken from the nesting beach. During monitoring activities in November a further three green turtles were poached.

From Figure 6a it can be seen that nest poaching occurred along the entire five miles of beach surveyed, but there was a peak just on the limit of TNP at mile 3 3/8. The take of turtles was registered from the river mouth to mile 3 5/8, but it was concentrated at the northern end of the beach, between mile -1/8 and 1/8 (See Figure 6a).

From June - October, poaching (of either nests or turtles) was observed during 37 of 153 (24.2%) track surveys (See Figure 6b). The worst night was 5 September, when five turtles were taken (See Figure 6b). Poaching of nests and turtles was observed throughout the nesting season, although more nests were taken at the start of the season, and more turtles towards the end (See Figure 6b).

The level of predation of nests by dogs fell in 2014; 18 green turtle nests (0.1%) were predated between June – October in the northern five miles of beach, close to Tortuguero village. There were also many nests that were destroyed by other nesting females.

Only one green turtle nest was reported as poached during the surveys of the three miles of beach close to Jalova from June – October; on 24 August. No turtles were taken and no green turtle nests were reported as predated by dogs close to the Jalova lagoon.

3.3 Dead Turtles

3.3.1 Turtles killed by jaguars

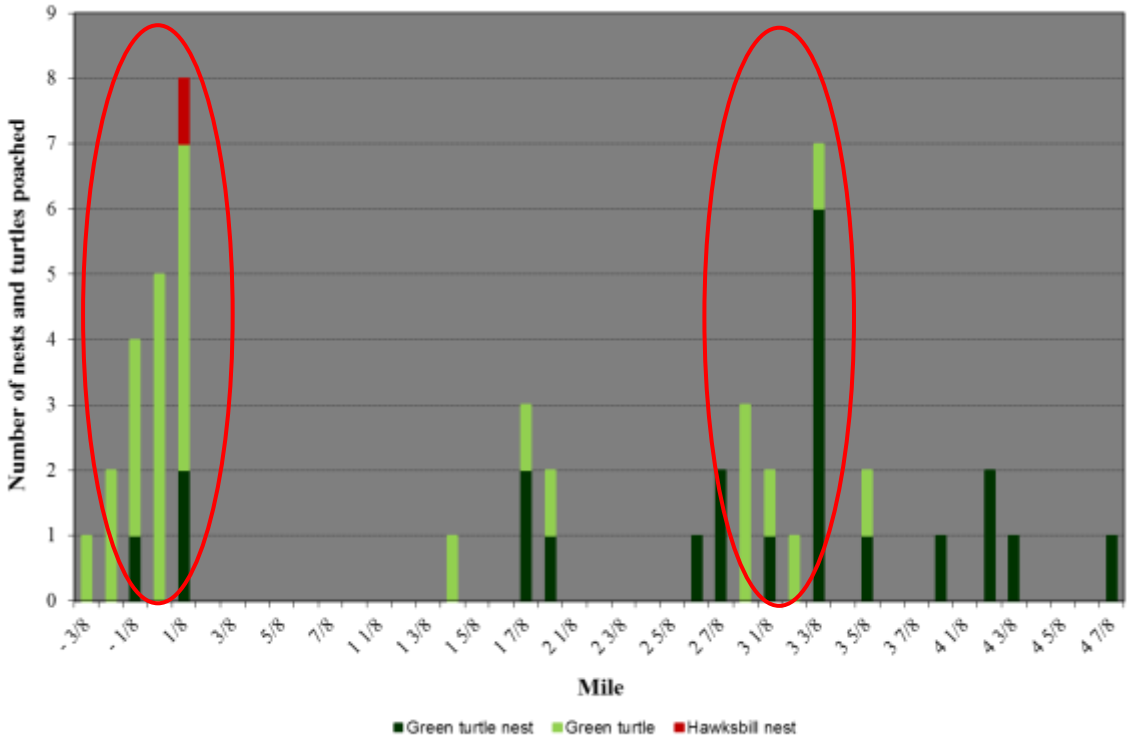
A total of 71 green turtles and one hawksbill were reported killed by jaguars during the 2014 Green Turtle Program (See Appendix 1); the majority of these turtles were found during the weekly track surveys of the 18 miles of beach. There were several surveys when five turtles were found dead in a single night. Only turtles from the previous night were counted during these surveys, so this value should be considered as a minimum number of turtles killed by jaguars.

3.3.2 Turtles found flipped over and alive

Fourteen green turtles were found flipped over and alive during the 2014 Green Turtle Program (See Table 1). On 15 October, 12 turtles were encountered during a track survey; 11 were in the section of beach between the Tortuguero river mouth and the landing strip. All were helped to the beach and returned to the sea; none of these individuals were encountered stranded afterwards, and so it was assumed that they survived.

Figure 6. Illegal take of nests and turtles in 2014, as determined from daily track surveys of the northern 5 2/8 miles of beach

a) Spatial distribution



b) Temporal distribution

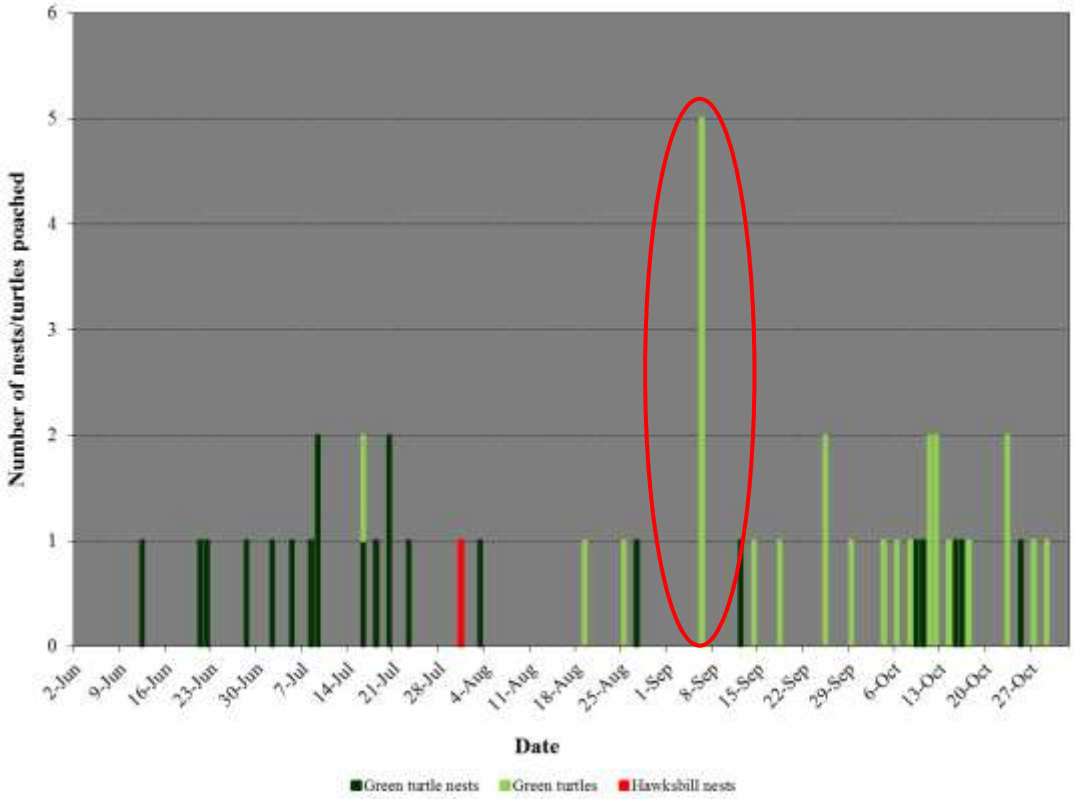


Table 1. Turtles encountered alive following attempted poaching

Date	Mile	Species	Sex	Comments
15-Oct	-1/8	Cm	Female	4 turtles found flipped over in the vegetation; 2 with tags: #133616 / 133617 & #CP2960 / CP2961
	1/8	Cm	Female	2 turtles found flipped over in the vegetation; no tags
	3/8	Cm	Female	Turtle found flipped over in the vegetation; no tags
	4/8	Cm	Female	4 turtles found flipped over in the vegetation close to the river; 3 with tags: #106137 / 106138, #111814 & #133524
	2 6/8	Cm	Female	Turtle found flipped over in the vegetation; no tags
17-Oct	-1/8	Cm	Female	Turtle found flipped over in the vegetation; no tags
23-Oct	0	Cm	Female	Turtle found flipped over in the vegetation; no tags

Cm = *Chelonia mydas* – Green turtle

3.4 Tagging of Nesting Sea Turtles

Tags used during the 2014 Green Turtle Program (in Tortuguero and Jalova) were National Band & Tag Company Inconel #681 tags 131907-131916, 131923-135400 and Monel #49 VC1986-VC1989.

In the northernmost five miles (Tortuguero) and the southern three miles of beach (Jalova), a minimum of one night patrol was conducted from 4 June – 30 October, 2014 (except 6 June, 4 July and 22 August). A total of 2,089.7 team patrol hours were logged; 1,560.2 in Tortuguero ad 529.5 in Jalova. Data from both sections of the beach are combined for subsequent analyses, unless indicated.

3.4.1 Green turtles

A total of 2,284 green turtle encounters were recorded; 1,695 in Tortuguero and 589 in Jalova (See Appendix 2). These encounters included 1,925 individual females; 1,276 (66.3%) initially observed without tags and 649 (33.7%) who had tags. In addition there were 359 encounters with turtles observed more than once during the 2014 nesting season.

During the 2014 Green Turtle Program, 31 green turtles tagged at other nesting beach projects in Costa Rica were encountered; 24 were tagged by researchers from the Caño Palma turtle monitoring project (north of the Tortuguero river mouth), two in Mondonguillo, two in Pacuare Nature Reserve, two in Moín and one in Parismina, which are all beaches south of TNP. The SD is awaiting confirmation of original tagging dates from researchers working at that beach.

In addition there was one female encountered with tags from another country; SSQ229 and SSQ230. This turtle was originally tagged in April 1997 in the canal at the hydroelectric plant at Hutchinson Island, Florida, USA. In 1997 she was identified as female and measured 93.0cm; in 2014 she had grown to 111.2cm.

The other females that had tags were all originally tagged in Tortuguero. There were 183 individuals that had been tagged more than 10 years previously; of these, seven were tagged more than 20 years ago. The longest recapture was female #23358; she was originally tagged in 1982, and was seen in six nesting season in the intervening 32 years; 1986, 1990, 1996, 2001, 2008 and 2011).

Of 1,276 newly tagged green turtles checked for the evidence of old tag holes or notches when encountered for the first time during the 2014 Green Turtle Program, 196 (15.4%) had evidence in at least one flipper.

Beach zone was recorded for 2,284 green turtles encounters; 23.3% (n = 533) of those females nested in the open zone, 65.0% (n = 1,483) were located in the border zone, 9.4% (n = 215) in the vegetation zone and 2.3% were encountered while making a false crawl (n = 53).

3.4.2 Hawksbill turtles

Twenty-four hawksbill encounters were logged during the 2014 Green Turtle Program (See Appendix 2); 20 newly tagged and four previously tagged individuals. Two of the previously tagged females were tagged in Tortuguero, in 2010 and 2012, and the other two turtles were tagged at Caño Palma. Four (20%) of the newly tagged females had evidence of old tag holes or notches. Five of the 27 hawksbill nests (18.5%) were laid in the open zone, 10 (37.0%) in the border zone, 11 (40.8%) in the vegetation zone and one (3.7%) female did not lay successfully.

3.4.3 Leatherback turtles

Six leatherback encounters were recorded during the 2014 Green Turtle Program. The last encounter was on 22 June. All of the females nested successfully and all nests were laid in the open zone.

3.5 Biometric Data Collection

3.5.1 Green turtles

Table 2 shows the mean curved carapace length (CCLmin) of green turtle females measured during the 2014 Green Turtle Program. An initial analysis compared carapace length between females encountered in Tortuguero and Jalova (T-test: t = -0.1063, p = 0.9154 and t = 2.0188, p = 0.0461, for newly tagged and previously tagged females, respectively). Results indicated a very slight significant difference for previously tagged turtles; therefore data for the two sites were analyzed separately. Another analysis compared the CCLmin between newly tagged and previously tagged turtles in Tortuguero and Jalova; there was only a significant difference in Tortuguero (T-test: t = -7.1725, p < 0.0001 and t = -1.4267, p = 0.1564, respectively). To ensure independence of the data, only the first CCLmin measurement taken for each individual was included in the analysis.

The overall mean CCLmin in Tortuguero was 105.7cm (Range = 89.2 – 121.6cm) and in Jalova it was 105.1cm (Range = 92.8 – 120.6 cm). Newly tagged females were slightly smaller than previously tagged females in both sites (See Table 2).

Table 2. Mean CCLmin of green turtles

Sample	Tortuguero		Jalova	
	n	**$\bar{x}$ ± S.D.**	**n**	**$\bar{x}$ ± S.D.**
Newly tagged females	844	105.0 ± 4.8	399	105.0 ± 4.6
Previously tagged females	532	106.9 ± 4.6	77	105.8 ± 4.3
All	**1,376**	**105.7 ± 4.8**	**476**	**105.1 ± 4.6**

Table 3 shows the mean straight carapace length (SCLmax) of green turtles. An initial analysis

compared SCLmax between newly tagged turtles and previously tagged turtles encountered in Tortuguero and Jalova (T-test: t = -7.1725, p = 0.0.348 and t = 1.6338, p = 0.1055, respectively). Results showed a significant difference for newly tagged females, to data from Tortuguero and Jalova were analyzed separately. A second analysis compared SCLmax between newly tagged and previously tagged turtles; the results showed a significant difference in Tortuguero (T-test: t = -7.4229, p < 0.0001) but not in Jalova (T-test: t = -0.8015, p = 0.4246). Therefore, data for newly tagged and previously tagged turtles were analyzed separately (See Table 3). To ensure independence of the data, only the first SCLmax measurement taken for each individual was included in the analysis. Mean SCLmax in Tortuguero was 98.5cm (Range = 84.6 – 115.2cm) and in Jalova it was 98.4cm (Range = 87.2 – 111.1cm).

Table 3. Mean SCLmax of green turtles

Sample	Tortuguero		Jalova	
	n	**$\bar{x}$ ± S.D.**	**N**	**$\bar{x}$ ± S.D.**
Newly tagged females	810	97.7 ± 4.5	382	98.3 ± 4.4
Previously tagged females	513	99.6 ± 4.3	75	98.8 ± 4.1
All	**1,323**	**98.5 ± 4.5**	**457**	**98.4 ± 4.3**

An analysis comparing the number of eggs laid in Tortuguero and Jalova (for newly tagged and previously tagged turtles) showed no significant difference (T-test: t = 0.1213, p = 0.9037 and t = -0.1975, p = 0.8483, respectively), so data from the two sections of beach were analyzed together. A second analysis compared clutch size between newly tagged and previously tagged females; again, there was no significant difference (T-test: t = -0.1337, p = 0.894), therefore all the data were analyzed together (See Table 4). On 57 occasions females laid yolkless eggs, the number ranged from one to 17.

Table 4. Mean clutch size for green turtles

n	**$\bar{x}$ ± S.D.**	**Range**
172	110.9 ± 26.2	45 - 200

For green turtles, the precision of CCLmin and SCLmax measurements taken during a single encounter was the same ($\bar{x}$ = 0.4cm; See Table 5a).

Table 5. Precision of carapace measurements for green turtles

a) During the same encounter

CCLmin / cm			SCLmax / cm		
n	**$\bar{x}$ ± S.D.**	**Range**	**n**	**$\bar{x}$ ± S.D.**	**Range**
2,109	**0.4 ± 0.2**	**0.0 – 1.5**	**2,102**	**0.4 ± 0.2**	**0.0 – 1.5**

Table 5. Continued

b) In different encounters

Encounters	CCLmin / cm			SCLmax / cm		
	n	$\bar{x}$ ± S.D.	Range	n	$\bar{x}$ ± S.D.	Range
2	229	1.6 ± 1.3	0.2 – 11.0	213	1.3 ± 1.2	0.2 – 10.1
3	44	1.6 ± 0.7	0.2 – 3.2	39	1.9 ± 1.6	0.3 – 6.1
4	3	1.4 ± 1.4	0.6 – 3.0	1	0.7	-
5	1	1.6	-	1	3.7	-
6	0	-	-	1	1.4	-
7	1	2.5	-	0	-	-

For females encountered and measured on two or more occasions in 2014, neither of the two measurements was consistently taken with a higher level of precision (See Table 5b). 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; the maximum difference recorded was 11.0cm (See Table 5b).

3.5.2 Hawksbill turtles

Carapace measurements were taken for 23 of the 24 hawksbill turtles observed during the 2014 Green Turtle Program (See Table 6). CCLmin ranged from 79.3 – 98.2cm and SCLmax from 74.6 – 88.1cm. Clutch size ranged from 141 – 257 eggs (see Table 6).

Table 6. Mean carapace length and clutch size of hawksbill turtles

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	20	88.1 ± 5.0	15	81.9 ± 4.1	6	174.0 ± 22.9
Previously tagged females	3	86.4 ± 1.0	3	82.3 ± 2.1	1	257
All	**23**	**87.9 ± 4.7**	**18**	**82.0 ± 3.8**	**7**	**185.9** ± 37.7

Precision of CCLmin measurements of hawksbill females was slightly higher than that of SCLmax measurements (See Table 7); data from newly tagged and previously tagged females were combined.

Table 7. Precision of carapace measurements for hawksbill turtles

Sample	CCLmin / cm			SCLmax / cm		
	n	$\bar{x}$ ± S.D.	Range	n	$\bar{x}$ ± S.D.	Range
All	26	0.4 ± 0.2	0.1 – 0.8	21	0.5 ± 0.2	0.1 – 1.0

A species comparison shows that the precision of CCLmin and SCLmax measurements was very similar for both species (See Table 5a and Table 7).

3.5.2 Leatherback turtles

During the 2014 Green Turtle Program biometric data were collected for the six leatherback turtles encountered. CCLmin ranged from 152.7 – 159.9cm, with a mean of 155.1cm. The precision of measurements ranged from 0.1 – 0.7cm, with a mean of 0.4cm. Two clutches were counted; the mean number of eggs was 81.5 yolked and 36.0 yolkless.

3.6 Fibropapilloma Assessment

A total of 153 green turtles were subject to a thorough examination for the presence of fibropapilloma tumors; only one individual (0.7%) 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 for physical abnormalities conducted on all females encountered; one individual was found with a very large (~20cm) fibropapilloma tumor on her neck.

Researchers encountered a further 17 turtles that had other types of tumors; the majority on the flippers and neck. These tumors ranged in size from 1 – 8cm.

3.7 Determination of Nest Survivorship and Hatching Success

3.7.1 Green turtles

A total of 182 green turtle nests were marked between 29 March and 2 October, 2014; 126 nests were marked in the northern five miles of beach and 56 nests were marked close to the Jalova lagoon. Seven of these nests were marked during the 2014 Leatherback Program.

For 15 nests the fate could not be determined with certainty; either they were not encountered at excavation (n = 5), or the tapes were lost (n = 1), or the measurements were not recorded correctly (n = 2), or the data from the excavation were not registered (n = 3). For another two nests the excavation could not be conducted as a fresh nest was found close to the site of the marked nest. One excavation included eggs from two different nests and the egg chamber of one nest was inundated with water during the excavation. All of these nests (n = 15; 8.2%) were excluded from the analyses, leaving a sample of 167 green turtle nests that were monitored from the date of oviposition until their fate could be determined. Table 8 lists the fate of all of the green turtle nests marked in 2014.

From Table 8 it can be seen that the majority of nests included in the analysis (76.0%) remained undisturbed during the incubation period (n = 127). The majority of disturbed nests were either destroyed or disturbed by another nesting turtle (6.6% in total), or predated or partially predated by dogs (6.0%). Seven nests (4.2%) were poached or possibly poached in the northern five miles close to Tortuguero. Seven nests were eroded.

Overall hatching success was calculated as 68.7% and overall emerging success was determined as 66.8% (See Table 8). These values were determined as the mean of all 167 marked nests for which the fate could be determined. Undisturbed nests had very high hatching and emerging success (87.8% and 85.5%, respectively). A summary of the excavations of the 167 green turtle nests monitored throughout the incubation period is shown in Table 9.

Table 8. Fate, hatching and emerging success of marked green turtle nests in 2014

Fate	Tort n	Jal n	Total n	% of total	Hatching success (%)	Emerging success (%)
1. Undisturbed	86	41	127	76.0	87.8	85.5
2. Unhatched	0	1	1	0.6	0.0	0.0
3. Destroyed by another turtle	9	1	10	6.0	0.0	0.0
4. Disturbed by another turtle	2	0	2	1.2	61.8	61.8
5. Predated	5	0	5	3.0	0.0	0.0
6. Partially predated	1	3	4	2.4	38.7	38.7
7. Poached	6	0	6	3.6	0.0	0.0
8. Possibly poached	1	0	1	0.6	0.0	0.0
9. Eroded	2	5	7	4.2	0.0	0.0
10. Partially eroded	1	0	1	0.6	40.0	6.7
11. Inundated	1	0	1	0.6	0.7	0.0
12. Possibly inundated	1	1	2	1.2	5.4	5.4
Total	**115**	**52**	**167**	**100**	**68.7[1]**	**66.8[1]**

Tort = Tortuguero (five northern miles); Jal = Jalova (southern three miles); [1]Calculated as the mean of all 67 nests

Nests not included in analysis	***Tort n***	***Jal n***	***Total n***
Could not find at excavation	*5*	*0*	*5*
Incomplete excavation as new nest encountered	*2*	*0*	*2*
Data from excavation not recorded	*0*	*3*	*3*
Excavated – two nests together	*1*	*0*	*1*
One or more tapes removed	*1*	*0*	*1*
Measurements recorded incorrectly	*2*	*0*	*2*
Nest inundated with water during excavation	*0*	*1*	*1*
Total	***11***	***4***	***15***

Twenty-three nests were marked that contained eggs that were confiscated by MINAE personnel; the success of these nests was presented in the report entitled "*Informe final del proyecto del manejo y monitoreo de huevos de tortugas marinas decomisados 2013*" (Final report on the project for the management and monitoring of confiscated sea turtle eggs 2014 – Sea Turtle Conservancy, 2014).

The distance between the sand surface and the top eggshell at the time of excavation for undisturbed nests (n = 127) ranged between 21 - 94cm with a mean of 59.4cm. The distance between the sand surface and the bottom of the egg chamber (n = 127) varied between 34 - 130cm with a mean of 73.9cm.

Incubation period, for nests for which hatching was observed (n = 81) ranged from 40 – 80 days, with a mean of 61 days.

Table 9. Summary of excavation data for green turtle nests marked in 2014 – data combined from Tortuguero and Jalova

Fate[1]	n	Hatchlings		Empty shells	Pipped eggs	Unhatched eggs			Depredated eggs	Destroyed eggs	Yolkless eggs	Deformed embryos[2]
		Live	Dead			No embryo	Embryo	Full embryo				
1	127	171	144	12,065	26	868	260	17	420	43	37	3
2	1	0	0	0	0	94	0	0	0	0	0	0
3	10	0	0	0	0	0	0	0	0	0	0	0
4	2	0	0	18	4	1	10	0	0	0	0	0
5	5	0	0	0	0	0	0	0	0	0	0	0
6	4	0	0	138	0	46	3	9	186	0	2	0
7	6	0	0	1	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0	0	0
9	7	0	0	0	0	0	0	0	0	0	0	0
10	1	0	5	6	1	1	7	0	0	0	0	0
11	1	1	0	1	118	0	26	0	1	0	0	0
12	2	0	0	10	2	124	29	0	11	0	0	0
Total	**167**	**172**	**149**	**12,239**	**151**	**1,134**	**335**	**26**	**618**	**43**	**39**	3

[1]For fate code descriptions see Table 8; [2]Includes albino embryos and twins

Unhatched eggs that contained albino or deformed embryos accounted for only 0.041% of all eggs laid in the disturbed or undisturbed nests that were excavated (See Table 10).

Table 10. Incidence of albinism, twins and deformed embryos in 2014

Type of abnormality	n	% of total
Albino	1	0.007
Twin embryos	2	0.014
Deformed embryo	3	0.021
Total	**6**	**0.041**

3.7.2 Hawksbill turtles

Fifteen hawksbill nests were marked between 12 August – 28 September, 2014. One nest was excluded from the determination of hatching and emerging success; it was not found during excavation. The results of the excavations from the other 14 hawksbill nests are summarized in Table 11; data from Tortuguero and Jalova are combined.

Mean hatching success was 54.0% and emerging success was 45.8% (See Table 11); these values were determined as the mean for all 14 nests. Undisturbed nests had a much higher hatching and emerging success (77.3% and 63.2%, respectively).

Evidence of hatching was observed for seven nests; the mean incubation period was 71 days, with a range of 64 – 75 days.

The mean distance between the sand surface and the top eggshell at the time of excavation for undisturbed hawksbill nests (n = 8) was 31.3cm (Range = 11 - 42 cm). The mean distance between the sand surface and the bottom of the egg chamber was 48.4cm (Range = 27 - 63cm).

3.7.3 Leatherback turtles

The hatching and emerging success of leatherback nests laid at Tortuguero during 2014 is discussed in detail in the 2014 Leatherback Program Report.

Table 11. Summary of hawksbill nest excavations from 2014

Fate[1]	n	Hatchlings		Empty shells	Pipped eggs	Unhatched eggs			Depredated eggs	Deformed embryos	Yolkless eggs	Hatching success (%)	Emerging success (%)
		Live	Dead			No embryo	Embryo	Full embryo					
1	8	205	7	1,031	37	94	83	29	55	1	5	77.3	63.2
3	1	0	0	0	0	0	0	0	0	0	0	0.0	0.0
4	1	1	0	70	0	1	1	0	8	0	0	87.5	86.3
6	1	0	0	14	0	6	5	0	3	0	0	50.0	50.0
7	2	0	0	0	0	0	0	0	0	0	0	0.0	0.0
9	1	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Total	**14**	**206**	**7**	**1,115**	**37**	**101**	**89**	**29**	**66**	**2**	**5**	**54.0[2]**	**45.8[2]**

[1]For fate code descriptions see Table 8; [2]Calculated as the mean for all 14 nests

3.8 Physical Data Collection

3.8.1 Rainfall and air temperature

Rainfall and air temperature were recorded daily during the 2014 Green Turtle Programs (See Table 12). Data for March to May are included as there were some green turtle nests incubating during those months.

Table 12. Summary of rainfall and air temperature data – March to November, 2014

Month	Total rainfall mm / month	$\bar{x}$ rainfall mm / 24 hours	Mean temperature / °C	Temperature range / °C
March[1]	56.7	6.3	26.9	25.0 – 30.0
April	289.1	9.61	27.0	24.0 – 31.0
May[2]	435.0	14.0	26.9	24.0 – 31.0
June	967.0	32.2	26.1	24.0 – 31.0
July[3]	1,116.7	36.0	26.0	22.0 – 31.0
August	717.1	23.1	26.3	23.0 – 30.0
September[4]	219.1	7.3	26.6	24.0 – 30.0
October	273.6	8.8	27.2	23.0 – 31.0
November[5]	720.1	24.0	25.6	20.0 – 31.0
Total	**4,794.4**	**20.1**	**26.5**	**20.0 – 31.0**

[1]Data from 23 March; [2]Data for 48 hours from 30 April – 1 May; [3]Data for 48 hours 10-11 July; [4]Data for 48 hours 20-21 September; [5]Data until 16 November

The driest month was September, with a total of 219.1mm of rain recorded (March data were incomplete); the wettest month was July, with 1,116.7mm of rain recorded, but it should be noted that data for November were only for part of the month. Rainfall was much higher than other years, and data for November and December are not included, which are typically very wet months. The highest rainfall recorded for a single 24 hour period was on 23 July, with 174.4mm.

During the months of March to November, mean monthly air temperature only varied by 1.6°C, between 25.6 – 27.2°C. Temperature ranged from 20.0 – 31.0°C, and the overall mean temperature for 2014 (excluding December) was 26.5°C (See Table 12).

3.8.2 Sand temperature

Table 13 shows mean sand temperatures from April – November 2014. Unfortunately there were no data loggers in the vegetation zone at 70cm or in the border zone at 30cm during this period. The data loggers for the open zone were only placed in September; before that time the beach was very eroded and there was no safe location to bury them.

In all months, and at all depths, the temperature in the vegetation zone was lower than in the border or open zones. In all zones, monthly mean temperature did not fall below 26.0°C. Maximum temperature registered was in the open zone at a depth of 30cm; on 11 September the temperature rose to 34.5°C. The minimum temperature recorded was 23.7°C, in the vegetation zone at a depth of 30cm on 3 November. Temperature in the open zone ranged from 23.7 – 27.5°C; in the border zone it ranged from 24.7 – 31.2°C and in the open zone it ranged from 24.5 – 34.5°C.

Table 13. Mean monthly sand temperature in 2014

Zone	Vegetation $\bar{x}$ temperature / ºC			Border $\bar{x}$ temperature / ºC			Open $\bar{x}$ temperature / ºC		
Depth/ cm	**30**	**50**	**70**	**30**	**50**	**70**	**30**	**50**	**70**
April[1]	26.6	26.8	N/A	N/A	29.2	29.1	N/A	N/A	N/A
May	26.6	26.7	N/A	N/A	28.7	28.5	N/A	N/A	N/A
June	26.0	26.1	N/A	N/A	27.0	27.2	N/A	N/A	N/A
July	25.7	25.8	N/A	N/A	26.4	26.5	N/A	N/A	N/A
August	25.6	25.7	N/A	N/A	27.0	26.8	N/A	N/A	N/A
September	26.1	26.1	N/A	N/A	28.4	28.0	30.6[2]	30.4[2]	30.1
October	26.1	26.2	N/A	N/A	29.6	28.9	30.8	30.6	30.4
November[3]	25.1	25.2	N/A	N/A	27.1	27.1	28.5	28.6	28.9
Mínima	**26.0**	**26.1**	**N/A**	**N/A**	**27.9**	**27.7**	**30.0**	**29.9**	**29.8**
Máxima	**23.7**	**23.9**	**N/A**	**N/A**	**24.7**	**24.7**	**24.8**	**24.5**	**24.7**
Promedio	**27.4**	**27.5**	**N/A**	**N/A**	**31.2**	**29.9**	**34.5**	**33.2**	**31.4**

N/A = No datalogger at that depth in that month; [1]From 2 April; [2]From 4 September; [3]Until 29 November

3.9 Collection of Human Impact Data

3.9.1 Visitors to STC Natural History and Visitor Centre

Visitation to the STC Visitor Center in 2014 decreased significantly to just 15,626 visitors (See Table 14); more than 9.000 fewer people than in 2013. Mean daily visitation at the center was 43 visitors, with a range of 17 (September) to 85 (February).

Table 14. Number of visitors to the STC Natural History and Visitors Center 2012 - 2014

Month	2012		2013		2014	
	Total	**$\bar{x}$ / day**	**Total**	**$\bar{x}$ / day**	**Total**	**$\bar{x}$ / day**
January	3,697	119	3,223	104	1,765	57
February	4,304	148	4,194	150	2,388	85
March	4,616	149	4,536	146	2,281	74
April	2,129	71	2,020	67	1,225	41
May	833	27	742	24	542	18
June	1,190	40	1,127	38	824	28
July	1,818	59	1,867	60	1,695	55
August	1,304	42	1,213	39	1,265	41
September	550	18	819	27	499	17
October	665	21	849	27	597	19
November	1,892	63	1,937	65	1,621	54
December	2,242	72	2,147	69	924	30
Total	**25,240**	**69**	**24,674**	**68**	**15,626**	**43**

The pattern of visitation was similar to that observed previously; most visitors came in January – March, with a significant decline starting in April. A slight increase in visitation was observed in July; this coincides with increased green turtle nesting, which is the major tourist attraction in the area. There was a dramatic decrease in September and October, with an average visitation of just 17 – 19 people per day (See Table 14).

3.9.2 Artificial lights

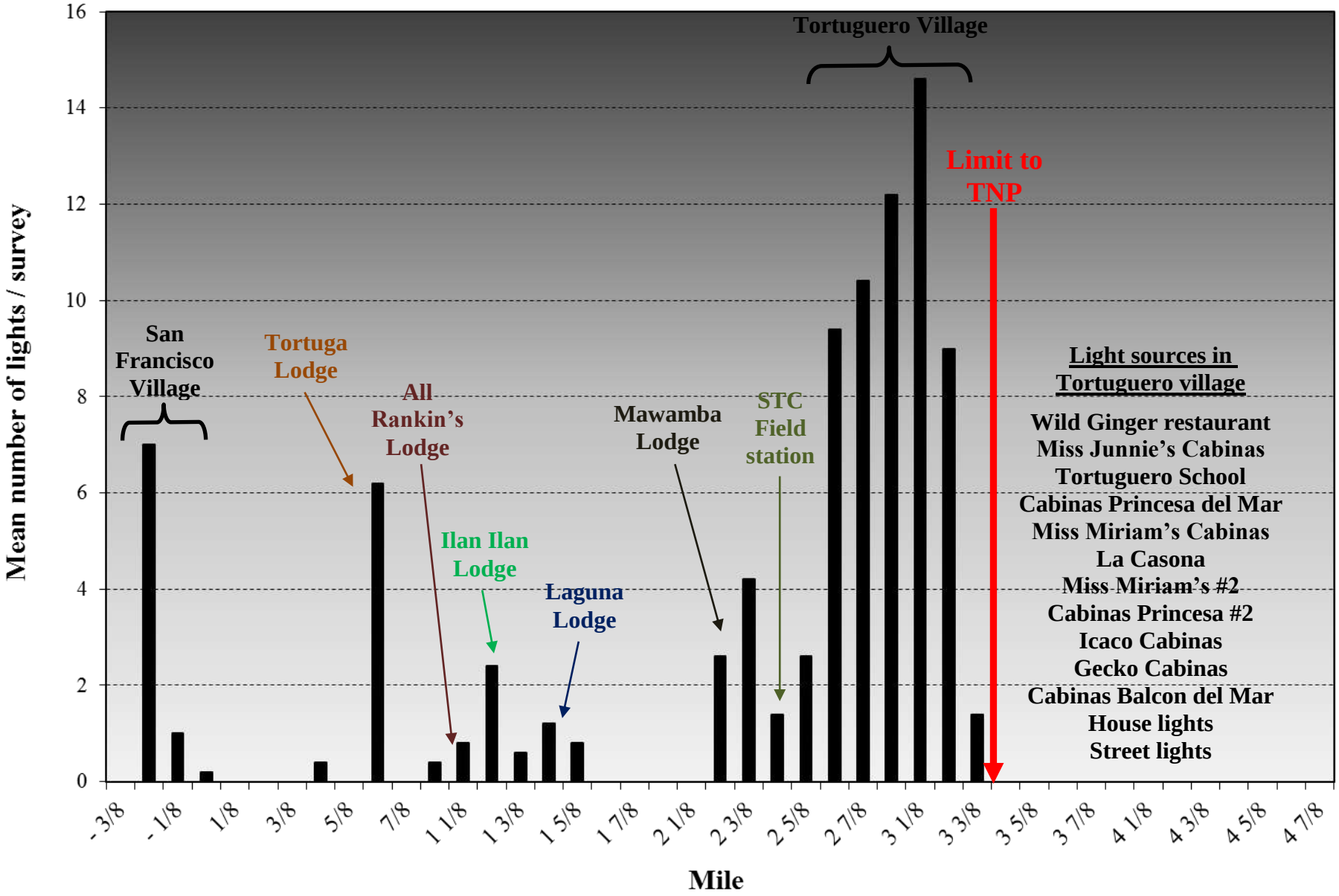
Five light surveys were conducted during the 2014 Green Turtle Program between June and October. The results from these surveys are summarized in Figure 7. As in previous years, most of the lights visible on the beach were from Tortuguero village, between miles 2 6/8 - 3 3/8; these included cabinas, 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 located on the opposite side of the river. As Figure 7 clearly shows, there are no artificial lights within TNP, due the absence of any buildings past mile 3 3/8. The problem resulting from the removal of vegetation from behind the beach continued during the 2014 Green Turtle Program; this significantly increased the number of lights visible on the beach.

ICE staff worked closely with STC during 2014, to reduce the negative impact caused by street lights in the village. They conducted several surveys at night with the EOD to identify the problematic lights and find ways to cover them. They also participated in a revegetation event, in collaboration with TNP staff and village residents. The problem of artificial lights was one of the topics included in the community education and outreach program in 2014; trying to raise awareness among residents about the problems that lights can cause for nesting turtles and hatchlings.

3.9.3 Hatchling disorientation

There were no incidents of hatchling disorientation events reported during 2014 Green Turtle Program monitoring activities.

Figure 7. Summary of monthly light surveys conducted during the 2014 Green Turtle Program



3.10 Satellite Tracking Project

Three turtles were tracked using satellite telemetry in 2014; two green turtles and one hawksbill. It was very lucky to be able to track the hawksbill, as STC has had very few opportunities to study the migration of this species from Tortuguero. The turtle was encountered on 4 July; following her release she travelled south, almost to Moín. She returned to Tortuguero in August and was encountered nesting by researchers at Playa Norte. At the end of August she began her migration north, following the Nicaragua coast, and when her transmitter stopped sending signals in December 2014 she was located 50km from the Miskito Cays Biological Reserve. She was tracked for 236 days and travelled a total of 2,692km (1,672 miles).

The first green turtle was encountered on 3 July; after her release she stayed close to Tortuguero for several weeks before heading north. Interestingly, she did not stop in Nicaragua as expected, but continued migrating, and in January 2015 she was found close to the south coast of Cuba, close to the Gardens of the Queen Archipelago. The SD contacted researchers in Cuba for information about the habitat in that location.

The other green turtle was encountered on 4 July; she also stayed close to the nesting beach for several week and was also seen nesting on another occasion. In September she began to migrate north, travelling close to the Nicaragua and Honduras coast, and continuing to Belize, where she stayed from October 2014 to date. Up to now she has travelled a total of 2,184km (1,357 miles).

The migration routes of all three turtles are show on the map in Appendix 3, and they are available on-line at http://www.conserveturtles.org/seaturtletracking.php?page=currentsatelliteturtles.

4. Discussion

4.1 Preparations

The intensive training and orientation program given to the RAs by the FRC is important 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. 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 also important that all members of GVI receive adequate training and have regular contact with the FRC to address any issues that may arise. In 2014 it was good to have an ex-STC Research Assistant in charge of data collection in Jalova.

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 that the RAs learn the monitoring protocol, but also that they are taught how to correctly manage Eco-volunteer groups when working with a turtle, and how to interact with tour groups, spotters and guides on the beach. This type of training will help eliminate problems when the RAs need to work a turtle in front of a group of tourists. Such practice sessions should be continued in the training program for future years.

Fortunately the majority of the beach markers placed at the start of the 2014 Leatherback Program were still in excellent condition at the start of the 2014 Green Turtle Program; the FRC and RAs replaced an occasional missing marker and repainted 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 markers to facilitate the night patrols.

4.2 Track Surveys

4.2.1 Green turtles

The green turtle nesting season started very slowly in 2014; the level of nesting in June was very low, and only started to improve during July (See Figure 1). This also affected timing of peak nesting, which was in September, not the end of August as normal. Also, in October there was a higher number of nests than normally recorded in this month. The estimate of 92,749 green turtle nests laid during the 2014 season was much less than the number for 2013, when more than 120,000 nests were estimated. These fluctuations are part of the normal cycle for sea turtles (See Figure 2). Talking with other green turtle researchers they also stated that nesting at their beaches in 2014 was lower than normal, so it appears to be a phenomenon for the region in general, not just at Tortuguero.

It is important to mention that these nesting values for green turtles are estimates; it would be impossible to do a total count for the whole beach every day, which would be the only way to guarantee real counts and not estimates. At Tortuguero, the key is to ensure that standard methodology is used every year, so that the data are comparable. Having the same person conduct the weekly track surveys helps standardize the data, by reducing observer variation.

Overall spatial distribution of nesting along the beach was also not typical; in other seasons there was a distinct peak in the percentage of nests deposited in the middle of the beach (between miles 8 – 10), but in 2014 the peak of nesting occurred further north (See Figure 3).

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.

The number of green turtle nests laid in the northern five miles of beach and the southernmost three miles was a little lower than that observed in 2013; 18,663 compared to 20,766 and 7,999 compared to 10,495, respectively. Given that it was overall quite a low nesting season, it was interesting to see such a high level of nesting at the northern end of the beach; this may reflect the change in nesting distribution observed in the weekly track surveys.

Interestingly, the temporal distribution of nesting observed from the daily track surveys showed different patterns in the north and south of the beach, as seen in other seasons. In Tortuguero the peak was observed at the beginning of September, while in Jalova the peak was reported in August (See Figure 4b and 5b). At both ends of the beach nesting decreased at the end of September and October, but there was no sudden decline as seen in some previous season. .

Unfortunately, there was a lot of illegal take of nests and turtles observed during weekly track surveys in 2014. There was more than one survey during which more than 10 nests had been poached from the previous night. There was also an increase in the number of turtles taken; including one night in October when 24 green turtles were poached.

Poaching (of nests or turtles) was observed in more than 20% of daily track surveys along the northern five miles of beach. The spatial distribution of poaching was similar to that observed in other seasons, with a peak between miles -2/8 and 1/8 and another, smaller, peak between miles 3 2/8 and 3 4/8, close to the TNP boundary (See Figure 6a). The section of beach close to the river mouth is actually within a

protected area (Archie Carr Nature Refuge), so it was discouraging to see that there was insufficient vigilance from MINAE to ensure the protection of nesting females in those miles of beach. There was on morning in October when STC researchers encountered various green turtles flipped over in the vegetation; the police and park rangers were called to assist, and it was a great collaborative rescue mission. A total of 11 turtles were found that day, all of them hidden in the vegetation. They were only found because STC researchers were conducting the daily track survey; which demonstrates the importance of continuing these surveys and highlights the need for collaboration between the various authorities and STC. We hope that this cooperation can continue and that TNP administrators can use the data from the track surveys provided by STC to focus their protection efforts during turtle nesting season.

4.2.2 Other species of turtles

A comprehensive discussion of leatherback nesting is included in the 2014 Leatherback Program Report. Leatherback nesting density continues to decline in Tortuguero, which is worrying for STC and other organizations involved in leatherback conservation efforts along the Caribbean coast.

2014 was a good nesting season for hawksbills; 27 nests were observed during daily track surveys. This pattern was also reported at other turtle nesting beaches for this species in the Caribbean.

4.3 Dead Turtles

There were no reports of turtles stranded dead on the beach in 2014. The only dead turtles encountered were those that had been killed by jaguars. The number of turtles predated by jaguars (n = 71) was more than the number reported in 2013; but the number recorded should be seen as a minimum, as the majority were encountered during the weekly track surveys, and only those turtles killed the night before the survey were counted. The track surveyor also observed jaguars on the beach on various occasions during the weekly surveys throughout 2014.

4.4 Tagging of Nesting Sea Turtles

4.4.1 Green turtles

The goal of 1,000 newly tagged green turtles was accomplished in 2014; the FRC and RAs conducted additional patrols between miles 5 and 7 to increase the number of encounters with newly tagged turtles. It is important that the FRC carefully monitors the data throughout the season, to be able to reach the objective of tagging 1,000 new turtles; organizing additional patrols when necessary to tag more turtles.

More than 2,250 green turtle encounters were registered in 2014, within the range observed in other seasons. As seen in previous years, the percentage of tagged turtles encountered in Jalova was much lower than in Tortuguero, although there were more individuals encountered with tags in 2014 than in 2013 (14.6% compared to 8.2%, respectively). This may be because we are starting to encounter turtles that have been tagged in Jalova since 2012 when GVI moved there operations base to the south of the beach. It will be interesting to see if the percentage of tagged individuals continues to increase in the next few years. As on other occasions, there were very few females that were encountered at both extremes of the beach during the season.

The overall proportion of turtles encountered with tags is similar each year; around 34% of individuals seen have tags. For another consecutive season, there were a lot of turtles that had been originally tagged more than 10 years ago; 183 females were seen for the first time in Tortuguero more than a decade ago. Additionally, there were seven turtles that were originally tagged more than 20 years

previously. The turtle with the longest nesting record observed in 2014 was a female first encountered in 1982, 32 years ago. As always 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 2014 there was one green turtles with tags from a project at a hydroelectric plant in Florida, USA. The researchers at this project were very excited to receive the news that one of their turtles had nested at Tortuguero. Once again, this encounter highlights the fact that sea turtles really are a shared international resource, and their investigation, protection and conservation is dependent on good cooperation at all of the habitats that they rely on during their life span.

4.4.2 Hawksbill turtles

The number of hawksbill encounters (n = 27) in 2014 reflected the high level of nesting observed for this species during the season. The number of encounters and the north and south of the beach was almost identical; 13 in Tortuguero and 14 in Jalova. There were only four hawksbills encountered with tags, similar to other seasons; half were originally tagged in Tortuguero and the others were tagged at Caño Palma, to the north.

Given the low nesting density of this species at Tortuguero, it is important that the 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 SD to the TSP committee) was continued in 2014 and STC recommends that this practice continue in the future.

4.4.3 Leatherback turtles

The 2014 Leatherback Program Report includes a detailed review of the tagging of leatherback turtles at Tortuguero in 2014. Once again, however, there were encounters with leatherback turtles in June, during night patrols for the 2014 Green Turtle Program, at the end of the typical nesting season for this species.

4.5 Biometric Data Collection

4.5.1 Green turtles

The overall mean curved carapace length (CCLmin) was 105.7cm (Tortuguero) and 105.1cm (Jalova) and the mean straight carapace length (SCLmax) was 98.5cm (Tortuguero) and 98.4cm (Jalova). 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 (CCLmin: 89.2 – 121.6cm; SCLmax: 84.6 – 115.2cm). In addition, the mean clutch size of 110.9 eggs was very similar to that determined in other years.

There was considerable variability in the measurements taken of the same female when she was observed on more than one occasion (up to 10cm), and so more care should be taken during training sessions with the RAs, to emphasize the importance of taking the carapace measurements carefully, and not simply trying to collect all the information as quickly as possible. It is also important to ensure that measurement data are correctly recorded in the field data books, to avoid errors during data transcription.

CCLmin and SCLmax measurements were taken with a similar 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 2014 Green Turtle Program were within the range observed in previous years; CCLmin 79.3 – 98.2cm and SCLmax 74.6 – 88.1cm. Both carapace measurements were taken with the same level of precision as for green turtles.

The range of clutch size for hawksbill nests was very broad, from 141 – 257 eggs, but it was within the normal range for this species seen at Tortuguero.

4.5.3 Leatherback turtles

The 2014 Leatherback Program Report summarizes biometric data collected from leatherback turtles nesting in Tortuguero in 2014 from March to May. The range of CCLmin measurements for the females observed during the 2014 Green Turtle Program was 152.7 – 159.5cm; within the normal range for this species at Tortuguero.

4.6 Fibropapilloma Assessment

Only two incidents of fibropapiloma were registered in 2014; one turtle examined specifically for the presence of fibropapiloma had the disease and another very large tumor (~20cm) was found on a turtle during the routine health and body check conducted as part of the data collection process. It is important that the RAs receive sufficient training in how to distinguish FP tumors, that have a distinctive form compared to other types of growths and tumors. There were various females encountered that had other types of tumors, often more than one on an individual, and up to sizes of 8cm in diameter. The revision of females to note such anomalies is very important to provide information on the general health status of the nesting population, and should continue in the future.

4.7 Determination of Nest Survivorship and Hatching Success

4.7.1 Green turtles

A total of 182 green turtle nests were marked during the 2014 Green Turtle Program; 126 in Tortuguero and 56 in Jalova. From these it was possible to determine the fate for 167 (91.8%), which is a higher percentage than in other years. Only four nests could not be found at the time of excavation, showing that there was a high level of precision while marking nests during the night patrols. There was an increase in the percentage of nests that were poached, which is a little worrying; there was also an increase in the number of nests that were predated. During training with the RAs the FRC focused on the importance of the daily monitoring of the marked nests and this effort was reflected in the improvement in the data collected.

During 2014 the majority (around 77%) of marked nests remained undisturbed and hatched successfully; the major cause of loss of nests was due to disturbance or destruction by other females nesting close to the location of the marked nest, or poaching (See Table 8).

The emphasis on nest marking and monitoring during training with RAs in 2014 was also shown by the fact that evidence of emergence was reported for a lot more nests than in 2013 (81 compared to 10, respectively). Incubation period ranged from 40 – 80 days; 40 days is very short for this species, while 80 days is very long. These two extremes might have been caused by the very hot and very cold periods (due to high rainfall) during the nesting season. The incubation period of the last nests to be laid were a lot longer than those laid at the start of the season.

Overall hatching success of marked nests was lower in 2014 than in 2013, 68.7% compared to 75.9%, respectively. For undisturbed nests (n = 127) emerging and hatching success were very high, 87.8% and 85.5%, respectively (See Table 8). The estimations of overall hatching and emerging success were affected by nests that were destroyed by other nesting females, poached, predated or partially predated, eroded or inundated, since such nests had a hatching and emerging success of 0% or very close to 0%. Very few deformed or albino embryos were recorded; as in previous years.

4.7.2 Hawksbill turtles

It was possible to mark and monitor 15 hawksbill nests during 2014. Hatching and emerging success of undisturbed nests were high (77.3% and 63.2%, respectively), though lower than the values reported in 2013, but within the normal range observe at Tortuguero for this species. Overall hatching and emerging success was affected by nests that were destroyed by other turtles, predated, eroded or poached, which all had 0% success. It was disturbing that one hawksbill nest was poached, despite the attempts made by STC researchers to all erase the tracks of hawksbills after they have returned to the sea, so that the nest location is not as obvious to would be poachers.

It is hoped that the policy to not show hawksbill turtles to tour groups will allow STC 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 2014 can be found in the 2014 Leatherback Program Report.

4.8 Physical Data Collection

4.8.1 Rainfall and air temperature

The pattern of precipitation observed in 2014 was similar to that seen in 2013; July was very wet and September was very dry, but the amount of rain registered (a total of 4,794.4mm from March – November) was a lot higher in 2014, almost double that recorded in 2013. This may have been one of the reasons for the change in the temporality of the nesting season observed in 2014. This high level of precipitation also affected air temperatures; mean monthly temperatures were lower in 2014 than in 2013, and the maximum temperatures recorded were lower. It is important that these data are recorded daily, to continue to monitor rainfall and air temperature patterns at Tortuguero.

4.8.2 Sand temperature

During 2014 we saw a similar pattern for sand temperature as that observed in other seasons, which was measured using ‘data loggers’ located in three different beach zones; ‘vegetation’ (100% shade during the day), ‘border’ (shade and sun) and ‘open’ (100% sun during the day). Temperature in the vegetation zone was less than that in border, which in turn was less than the open zone. The temperatures registered in the different zones were all within the range previously observed, though they were lower than in 2013, possibly as a result of the high level of rainfall reported during the season. There were still days when sand temperatures reached above 31°C. Temperatures above 30°C can start to negatively affect embryo development, and temperatures above 34°C can result in embryonic death. Minimum temperatures were also lower in 2014 than in other seasons, which might have had the effect to increase the proportion of male hatchlings produced this year.

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

There was a significant decline in the number of tourists to the STC Visitor Center; more than 9.000 fewer people in 2014 than in 2013 (See Table 14), which was very discouraging. However, one reason may have been that the level of tourism in Tortuguero in general was much lower in 2014 than in recent years. It will be interesting to watch the trend over the next few years. One suggestion would be to try to improve the exhibits in the Center to enrich the visitor experience, as well as updating the information about the programs STC runs in the region.

4.9.2 Artificial Lights

The problem of artificial lights visible on the beach continued throughout 2014 and there was an increase in the number of lights in front of the village. The pattern of lights was the same as that observed in other years, and public street lights remained the biggest problem. However, STC worked very closely with ICE personnel to try to solve the issue of artificial lights on the beach; there were several joint activities conducted with STC, ICE and TNP personnel to reforest the area directly behind the beach, cover problem lights or change their orientation away from the beach, and also inform village residents and tourists about the problem of artificial lights for sea turtles. We hope to continue this close collaboration in the future to continue to address this issue.

4.9.3 Hatchling disorientation

It was very encouraging that there were no reports of incidents of hatchling disorientation during 2014. However, this does not necessarily mean that there were no disorientated hatchlings, but that they were not observed during monitoring activities.

4.10 Satellite Tracking Project

The three turtles fitted with satellite transmitters during the 2014 Green Turtle Program will provide valuable information about the migratory behavior of green turtles and hawksbills nesting at Tortuguero. It was interesting to observe that the two green turtles went to foraging grounds other than Nicaragua (Belize and Cuba), and to have an opportunity to track a hawksbill again, after many year,s, was also very special.

Satellite telemetry is a very useful tool for researchers to use to study migration behavior of sea turtles once they leave the nesting beach, and to determine the location of foraging sites, and the potential threats they may face on route to the feeding area, or once they arrive there. Also, it can be a powerful educative tool, providing a means to reach the public and teach them in an entertaining way about science and conservation initiatives. Two of the three turtles tracked in 2014 participated in the Tour de Turtles on-line event, organized by STC, which allows the general public an opportunity to follow the turtles during their migrations, and at the same time, raise awareness about a variety of different threats to sea turtles and their habitats, through each turtle's campaign in the 'competition'. At Tortuguero, hundreds of people, local residents and visitors, could observe the attachment of the transmitter and the subsequent release of the turtle back to the ocean. The project, therefore, was very successful, both from a scientific perspective as well as the public outreach opportunity it provided.

5. References

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6. Appendices

Appendix 1. Turtles killed by jaguars, June – November 2014

Date	Mile	Species	Comments
7-Jun	9 4/8	Cm	Fresh kill, no tags
	9 4/8	Cm	Fresh kill, no tags
14-Jun	5 4/8	Cm	Fresh kill, no tags
	9 4/8	Cm	Fresh kill, no tags
21-Jun	8	Cm	Fresh kill, no tags
	11	Cm	Fresh kill, no tags
	15	Ei	Fresh kill, tags #123506 / 131943
28-Jun	7 4/8	Cm	Fresh kill, no tags
5-Jul	9 4/8	Cm	Fresh kill, no tags
	10	Cm	Fresh kill, no tags
	11	Cm	Fresh kill, no tags
19-Jul	7	Cm	Fresh kill, no tags
26-Jul	7 4/8	Cm	Fresh kill, tag #122336
	15 1/8	Cm	Fresh kill, tag #118087
	9	Cm	Fresh kill, no tags
2-Aug	10	Cm	Fresh kill, no tags
9-Aug	7	Cm	Fresh kill, no tags
	10	Cm	Fresh kill, no tags
16-Aug	7 4/8	Cm	Fresh kill, no tags
	10 4/8	Cm	Fresh kill, no tags
	8 4/8	Cm	Fresh kill, no tags
	11	Cm	Fresh kill, no tags
	14	Cm	Fresh kill, no tags
20-Aug	4 3/8	Cm	Fresh kill, no tags
23-Aug	6 4/8	Cm	Fresh kill, no tags
	7	Cm	Fresh kill, no tags
	12	Cm	Fresh kill, no tags
	12	Cm	Fresh kill, no tags
30-Aug	6 4/8	Cm	Fresh kill, no tags
	8	Cm	Fresh kill, no tags
	16 4/8	Cm	Fresh kill, no tags
6-Sep	5	Cm	Fresh kill, no tags
	5	Cm	Fresh kill, no tags
	8 4/8	Cm	Fresh kill, no tags
	9	Cm	Fresh kill, no tags
	12	Cm	Fresh kill, no tags
13-Sep	16 4/8	Cm	Fresh kill, no tags

Appendix 1. Continued

Date	Mile	Species	Comments
18-Sep	4 3/8	Cm	Fresh kill, no tags
19-Sep	14 4/8	Cm	Fresh kill, no tags
	15	Cm	Fresh kill, no tags
	15 4/8	Cm	Fresh kill, no tags
	16	Cm	Fresh kill, no tags
26-Sep	4 7/8	Cm	Fresh kill, tag #90131
	4 5/8	Cm	Fresh kill, no tags
1-Oct	10 4/8	Cm	Fresh kill, tag #90004, found by park rangers
	10 4/8	Cm	Fresh kill, tag #109990, found by park rangers
4-Oct	14 4/8	Cm	Fresh kill, no tags
11-Oct	7	Cm	Fresh kill, no tags
	9 4/8	Cm	Fresh kill, no tags
	12 4/8	Cm	Fresh kill, tag #134490
	15 4/8	Cm	Fresh kill, no tags
	16 4/8	Cm	Fresh kill, no tags
18-Oct	16	Cm	Fresh kill, no tags
	13	Cm	Fresh kill, no tags
	8	Cm	Fresh kill, no tags
21-oct	4 3/8	Cm	Fresh kill, tags #125130 / 125131
25-Oct	5 4/8	Cm	Fresh kill, no tags
	6	Cm	Fresh kill, no tags
	10 4/8	Cm	Fresh kill, no tags
2-Nov	9 4/8	Cm	Fresh kill, no tags
	9 4/8	Cm	Fresh kill, no tags
	11	Cm	Fresh kill, no tags
	11	Cm	Fresh kill, tags #94851 / 94852
	12 4/8	Cm	Fresh kill, no tags
3-Nov	14	Cm	Fresh kill, no tags
7-Nov	4 5/8	Cm	Fresh kill, tags #135318 / 135319
15-Nov	6 4/8	Cm	Fresh kill, no tags
	7	Cm	Fresh kill, no tags
	10	Cm	Fresh kill, no tags
	14	Cm	Fresh kill, no tags
	15	Cm	Fresh kill, no tags
22-Nov	17	Cm	Fresh kill, no tags

Cm = *Chelonia mydas* – Green turtle; Ei = *Eretmochelys imbricata* – Hawksbill

Appendix 2. Nightly sea turtle encounters for the 2014 Green 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
4-Jun				0				0				0
5-Jun		1		1				0				0
6-Jun				1				0				0
7-Jun			1	2				0				0
8-Jun				2				0				0
9-Jun				2	1			1				0
10-Jun				2				1				0
11-Jun				2				1				0
12-Jun				2				1	1			1
13-Jun				2	1			2				1
14-Jun				2				2				1
15-Jun				2				2				1
16-Jun				2	1			3				1
17-Jun				2				3				1
18-Jun				2				3	1			2
19-Jun				2				3	1			3
20-Jun				2	1			4				3
21-Jun				2				4				3
22-Jun				2				4	1			4
23-Jun				2				4				4
24-Jun				2	1			5				4
25-Jun				2	1			6		1		5
26-Jun				2	1			7				5
27-Jun				2		1		8				5
28-Jun				2				8	1			6
29-Jun				2				8			1	7
30-Jun				2				8				7
1-Jul				2	1			9				7
2-Jul				2	2	1		12				7
3-Jul				2		1	1	14	1			8
4-Jul				2				14				8
5-Jul				2	1	1		16				8
6-Jul				2	3	2		21				8
7-Jul				2	5	5		31				8
8-Jul				2	2		1	34	1			9
9-Jul				2				34				9
10-Jul				2	3	1		38				9

Appendix 2a. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
11-Jul				2	3	2		43				9
12-Jul				2	3	3		49				9
13-Jul				2	1	7		57				9
14-Jul				2	2	1		60	1			10
15-Jul				2		3		63				10
16-Jul				2	3	3	1	70				10
17-Jul				2	2	4	1	77				10
18-Jul				2		1		78				10
19-Jul				2	4	1		83				10
20-Jul				2	2	4	1	90				10
21-Jul				2	1	4	1	96				10
22-Jul				2	2	3	1	102				10
23-Jul				2		1	1	104				10
24-Jul				2	1	4	1	110	1			11
25-Jul				2	5	2		117				11
26-Jul				2	4	4	1	126				11
27-Jul				2	3	1		130	1			12
28-Jul				2	6	6	1	143				12
29-Jul				2	3	8	3	157				12
30-Jul				2	8	5		170				12
31-Jul				2	9	2		181				12
1-Aug				2	5	4		190				12
2-Aug				2	4	6		200				12
3-Aug				2	10	10		220				12
4-Aug				2	3	7		230				12
5-Aug				2	5	13	1	249			1	13
6-Aug				2	10	13	3	275				13
7-Aug				2	21	9	2	307				13
8-Aug				2	8	12	3	330				13
9-Aug				2	11	17	2	360				13
10-Aug				2	6	8		374				13
11-Aug				2	10	13	5	402				13
12-Aug				2	17	12		431				13
13-Aug				2	15	11	1	458				13
14-Aug				2	15	15	2	490				13
15-Aug				2	7	7		504				13
16-Aug				2				504				13
17-Aug				2	2	3		509				13

Appendix 2a. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
18-Aug				2	1	4	3	517				13
19-Aug				2	2	4	1	524				13
20-Aug				2	3	3	2	532				13
21-Aug				2	6	2	2	542				13
22-Aug				2	1	1	1	545				13
23-Aug				2	4	9	4	562				13
24-Aug				2	7	2	3	574				13
25-Aug				2	5	5	2	586				13
26-Aug				2	7	7	1	601				13
27-Aug				2	7	7		615				13
28-Aug				2	9	2	3	629				13
29-Aug				2	4	7	3	643				13
30-Aug				2	6	7	1	657				13
31-Aug				2	5	6	2	670				13
1-Sep				2	9	4	1	684				13
2-Sep				2	9	3	3	699				13
3-Sep				2				699				13
4-Sep				2	9	3	3	714				13
5-Sep				2	7	5	3	729				13
6-Sep				2	9	8	3	749				13
7-Sep				2	8	2	2	761				13
8-Sep				2	21	4	8	794				13
9-Sep				2	10	3	2	809				13
10-Sep				2	6	5	2	822				13
11-Sep				2	10	4	2	838				13
12-Sep				2	8	2	1	849				13
13-Sep				2	13	6		868				13
14-Sep				2	3	6	6	883				13
15-Sep				2	19	0	3	905				13
16-Sep				2	8	5	3	921				13
17-Sep				2	11	8	1	941				13
18-Sep				2	7	2	7	957				13
19-Sep				2	16	4	11	988				13
20-Sep				2	9	5	2	1004				13
21-Sep				2	7	6	3	1020				13
22-Sep				2	9	8	2	1039				13
23-Sep				2	12	1	6	1058				13
24-Sep				2	6	4	2	1070				13

Appendix 2a. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
25-Sep				2	9	6	2	1087				13
26-Sep				2	8	6	3	1104				13
27-Sep				2	14	7	5	1130				13
28-Sep				2	6	8	8	1152				13
29-Sep				2	8	8	3	1171				13
30-Sep				2	14	7	5	1197				13
1-Oct				2	11	4	6	1218				13
2-Oct				2	13	3	2	1236				13
3-Oct				2	16	7	3	1262				13
4-Oct				2	16	4	5	1287				13
5-Oct				2	15	10	7	1319				13
6-Oct				2	17	7	4	1347				13
7-Oct				2	17	8	5	1377				13
8-Oct				2	23	12	1	1413				13
9-Oct				2	14	9	6	1442				13
10-Oct				2	12	5	5	1464				13
11-Oct				2	17	5	3	1489				13
12-Oct				2	9	2	2	1502				13
13-Oct				2	7	6	3	1518				13
14-Oct				2	13	3	2	1536				13
15-Oct				2	14	7	8	1565				13
16-Oct				2	9	2	3	1579				13
17-Oct				2	6	4	5	1594				13
18-Oct				2	6	2	2	1604				13
19-Oct				2	7	2	9	1622				13
20-Oct				2	5	4	3	1634				13
21-Oct				2	7	1	1	1643				13
22-Oct				2	4	1	2	1650				13
23-Oct				2	6		4	1660				13
24-Oct				2	3	2	4	1669				13
25-Oct				2	4	1		1674				13
26-Oct				2	6	2	2	1684				13
27-Oct				2	2	2	3	1691				13
28-Oct				2		1	2	1694				13
29-Oct				2			1	1695				13
30-Oct				2				1695				13
STT	**0**	**1**	**1**	**2**	**866**	**563**	**266**	**1695**	**10**	**1**	**2**	**13**

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
4-Jun				0				0				0
5-Jun				0				0		1		1
6-Jun				0				0				1
7-Jun				0				0	1			2
8-Jun				0				0	1			3
9-Jun			1	1				0				3
10-Jun				1				0	1			4
11-Jun				1	2			2				4
12-Jun				1				2				4
13-Jun				1				2				4
14-Jun		1		2				2				4
15-Jun			1	3				2				4
16-Jun				3	1			3				4
17-Jun				3				3				4
18-Jun				3				3				4
19-Jun				3				3				4
20-Jun				3			2	5				4
21-Jun				3	2		1	8				4
22-Jun		1		4				8				4
23-Jun				4	1			9				4
24-Jun				4				9				4
25-Jun				4	1			10				4
26-Jun				4	1			11				4
27-Jun				4				11				4
28-Jun				4				11		1		5
29-Jun				4	2			13	1			6
30-Jun				4				13				6
1-Jul				4	1			14				6
2-Jul				4	1	2	2	19	1			7
3-Jul				4	1	1	1	22				7
4-Jul				4				22				7
5-Jul				4	1		1	24				7
6-Jul				4	2			26				7
7-Jul				4			1	27	1			8
8-Jul				4	1			28				8
9-Jul				4				28				8
10-Jul				4				28	1			9
11-Jun				4				28				9

Appendix 2b. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
12-Jul				4	2		1	31				9
13-Jul				4	3	1		35				9
14-Jul				4	5	2		42				9
15-Jul				4	3			45				9
16-Jul				4	2		1	48				9
17-Jul				4	3	1		52			1	10
18-Jul				4				52				10
19-Jul				4	3			55				10
20-Jul				4	3		2	60				10
21-Jul				4	2			62	1			11
22-Jul				4				62				11
23-Jul				4	4		1	67				11
24-Jul				4	5	2		74				11
25-Jul				4				74				11
26-Jul				4	3		1	78				11
27-Jul				4	2		2	82	1			12
28-Jul				4	6			88				12
29-Jul				4	6	2		96				12
30-Jul				4	3			99				12
31-Jul				4	4	2		105				12
1-Aug				4				105				12
2-Aug				4	6		1	112				12
3-Aug				4	5	1	1	119				12
4-Aug				4	4	1		124				12
5-Aug				4	5		2	131				12
6-Aug				4	6	1	1	139				12
7-Aug				4	6			145				12
8-Aug				4				145				12
9-Aug				4	6	3	1	155				12
10-Aug				4	11	1	1	168				12
11-Aug				4	4	3		175				12
12-Aug				4	6	2		183				12
13-Aug				4	6	1	3	193				12
14-Aug				4	10	3	1	207				12
15-Aug				4				207				12
16-Aug				4	2	1		210				12
17-Aug				4	3		1	214				12
18-Aug				4	9	2		225				12
19-Aug				4	4	1	1	231				12

Appendix 2b. Continued

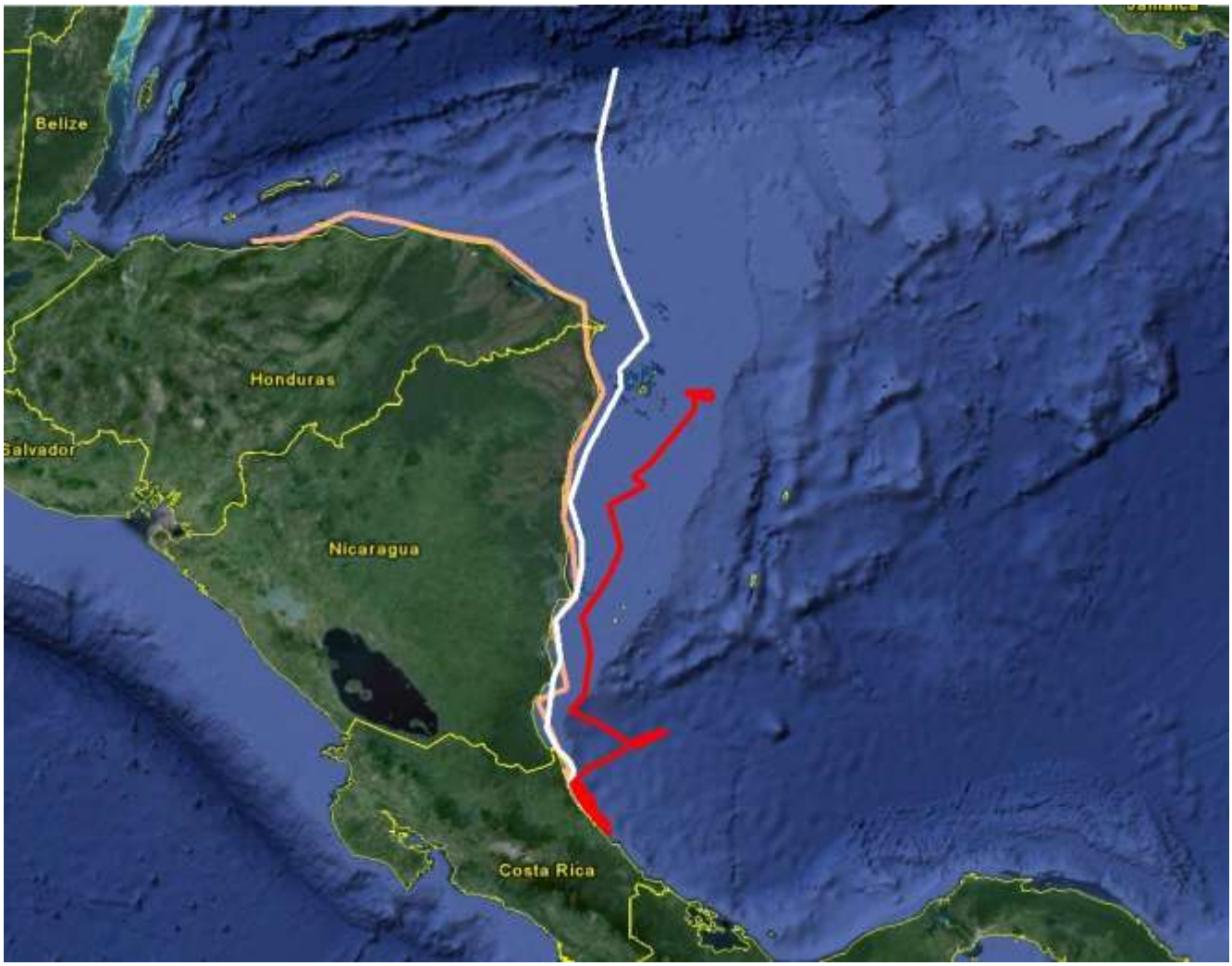
Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
20-Aug				4	3	3		237				12
21-Aug				4	5			242	1			13
22-Aug				4				242				13
23-Aug				4	8	3	1	254				13
24-Aug				4	7	2	1	264				13
25-Aug				4	3			267				13
26-Aug				4	3	2		272				13
27-Aug				4	3			275				13
28-Aug				4	1			276				13
29-Aug				4				276				13
30-Aug				4	1			277				13
31-Aug				4	4			281				13
1-Sep				4	3	2	1	287				13
2-Sep				4	7	1		295				13
3-Sep				4	9		2	306		1		14
4-Sep				4	3	1		310				14
5-Sep				4				310				14
6-Sep				4	8	4	1	323				14
7-Sep				4	10	2	1	336				14
8-Sep				4	5	1	2	344				14
9-Sep				4	3			347				14
10-Sep				4	1			348				14
11-Sep				4	6	2	2	358				14
12-Sep				4				358				14
13-Sep				4	3			361				14
14-Sep				4	6	1		368				14
15-Sep				4			2	370				14
16-Sep				4	5		2	377				14
17-Sep				4	2	1	1	381				14
18-Sep				4				381				14
19-Sep				4				381				14
20-Sep				4	3	1		385				14
21-Sep				4	2			387				14
22-Sep				4	2	4	4	397				14
23-Sep				4	1	1		399				14
24-Sep				4	1		1	401				14
25-Sep				4	3		1	405				14
26-Sep				4				405				14
27-Sep				4	6		1	412				14

Appendix 2b. Continued

Date	Leatherback				Green				Hawksbill			
	New	REM	REN	Total	New	REM	REN	Total	New	REM	REN	Total
28-Sep				4	3		1	416				14
29-Sep				4	4		1	421				14
30-Sep				4	3	2	2	428				14
1-Oct				4	2	1		431				14
2-Oct				4	4	1	3	439				14
3-Oct				4	2			441				14
4-Oct				4			1	442				14
5-Oct				4	7	4	1	454				14
6-Oct				4	5		1	460				14
7-Oct				4	6	2		468				14
8-Oct				4	8	1	2	479				14
9-Oct				4	8		2	489				14
10-Oct				4				489				14
11-Oct				4	8	3	1	501				14
12-Oct				4	3		1	505				14
13-Oct				4	2		4	511				14
14-Oct				4	5	3	2	521				14
15-Oct				4	3		1	525				14
16-Oct				4	2		1	528				14
17-Oct				4				528				14
18-Oct				4	6	1	2	537				14
19-Oct				4	3	1	4	545				14
20-Oct				4	7			552				14
21-Oct				4	5		1	558				14
22-Oct				4	3			561				14
23-Oct				4	4		2	567				14
24-Oct				4	1			568				14
25-Oct				4	2			570				14
26-Oct				4	2	1	2	575				14
27-Oct				4	3		1	579				14
28-Oct				4	2		1	582				14
29-Oct				4			1	583				14
30-Oct				4	1	2	3	589				14
STJ	**0**	**2**	**2**	**4**	**410**	**86**	**93**	**589**	**10**	**3**	**1**	**14**
Total	**0**	**3**	**3**	**6**	**1276**	**649**	**359**	**2284**	**20**	**4**	**3**	**27**

New – Turtles that had no tags on first encounter in 2014; **REM** – Remigrant turtles that had tags from previous years/other projects on first encounter in 2014; **REN** – Renester turtles that were encountered on more than one occasion during 2014; **STJ** – Sub-total of encounters for Jalova; **Total** – Combined total of encounters from Tortuguero and Jalova.

Appendix 3. Migration map of the turtles tracked using satellite telemetry (until September 2014)



The red line is the hawksbill, the white and pink lines are the green turtles