Playa Norte Marine Turtle Conservation & Monitoring Programme

Green and Hawksbill Season Report 2009

Stephanny Arroyo Arce
David Aneurin Jones

Playa Norte Marine Turtle Monitoring and Conservation Programme

Barra del Colorado Wildlife Refuge, Costa Rica

Green and Hawksbill Season Report 2009

Submitted to

MINAET (Costa Rican Ministry of Environment, Energy and Telecommunications)

COTERC (Canadian Organization for Tropical Research and Rainforest Conservation)

GVI (Global Vision International)

By

Stephanny Arroyo Arce, GVI Costa Rica Programme Manager
David Aneurin Jones, GVI Costa Rica Country Director

February 2010

Programme managed by Global Vision International (GVI) Costa Rica for the Canadian Organization for Tropical and Rainforest Conservation (COTERC)

GVI Costa Rica

Email: costarica@gviworld.com & tortuguero@gvi.co.uk
Web page: http://www.gvi.co.uk
Blog: http://gvicostaricablogspot.com

COTERC

Address: Estación Biológica Caño Palma, Tortuguero, Costa Rica
Tel: (+506) 2709 8052
Web page: http://coterc.org/

Playa Norte Marine Turtle Monitoring and Conservation Programme

Green and Hawksbill Season Report 2009

Rebeca Chaverri & David Aneurin Jones
GVI Costa Rica Country Director

Sara Calçada
GVI Costa Rica Field Coordinator

Wing Tsui & Stephanny Arroyo Arce
GVI Costa Rica Programme Managers

PATROL LEADERS for 2009

David Aneurin Jones	Sara Calçada	Diogo Verissimo	Wing Tsui	Stephanny Arroyo Arce	Josh Feltham
Jonathan Willans	Richard Bull	Sarah Durose	Cody Glasbrenner	Jack Roper	Richard Phillips
Jessica Greenland	Sarah Shotwell	Haley Nedderman	Mike Dunn	April Stevens	Tom Bregman

VOLUNTEERS for 2009

Marjolein Groot	Robert Nichols	Peter Strand	Holly Hansen	Tara O'Sullivan	Noelle Diaz
Lisa Spencer	Ariane Chif	Jennifer Fucci	Jasmine McKenzie	Rachel Stevenson	Kelsey Boultbee
Tom Parsons	Nicholas Louis	Megan Lieb	Lizzie McCready	Kate Tucker	Caroline Holderfied
Jennifer Archer	Jonathan Murphy	Adam Hejnowicz	Elizabeth Lynch	Victoria Copeland	Laura Prideaux-Brune
Rachael Bohnen	Nava Fedaeff	Brian Lami	Phillip Chapman	Hannah Dudley	William Brideaux-Brune
Karen Dykxhoorn	Lara Dixon	Felisa Macaspac	Megan Cronkite	Nicholas Walenda	Rhiannon Harrington
Desiree Fleck	Brandi Bechard	Louise Bloxham	Thea Sida-Murray	Katie May	Emily Credit
Tracy Farrell	Alvaro Alfaro Gomez	Leonie Wilson	Russell Pepper	Sam Hopes	Susann Brunner
Andres Vargas	Marcia Chambers	Molly Clifford	Helen Wain	Allie Coad	Susann Brunner
Laura Oliver	Brandon Alford	Tucker Smith	Adam Schifter	Juan De La Fuente	Gabrielle Busch
Jennifer Morris	Allison Antonson	Charlotte Hemsley	Stuart Mott	Katheryn Maschovich	Madeline Busch
Anja Dullaghan	David Thomas	Morgan Early	Melanie Simpson	Linn Holm	Thomas Proctor
Michael Larson	Haley Forbes	Amanda Meehan	Sho Murphy-Shigematsu	Bill Valaika	Molly Swailes

with financial support from

with institutional support from

1. ACKNOWLEDGMENTS

This programme is the result of the hard work of GVI and COTERC employees and volunteers. Their time and dedication is invaluable and the programme would not be possible without them. Thank you for your hard work and dedication.

- To the volunteers and patrol leaders that made data collection possible throughout the season.
- To GVI, COTERC, Turtle Beach Lodge and the Toronto Zoo and other contributors for their generous financial support.
- To Cabinas Vista al Mar Lodge for the use of their property to access the study area.
- To Turtle Beach Lodge and Cabinas Vista al Mar for cover (and occasional coffee and cookies) during thunderstorms.
- To MINAET and especially Carlos Calvo, for granting the permits not only for turtle research but also for the leatherback and hawksbill nest relocations.
- To Jonathan Willans, Josh Feltham, Charlotte Foale, Mike Dunn (EBCP Station Managers) and COTERC volunteers for ensuring the day-to-day running of the station and assisting with the programme at times through the year.

2. TABLE OF CONTENTS

3. LIST OF FIGURES

4. LIST OF TABLES

5. INTRODUCTION

Tortuguero and the surrounding area have a long history of marine turtle research and conservation. The area was, from 1954, the target of Archie Carr's pioneering efforts in sea turtle conservation which lead, in 1975, to the creation of Tortuguero National Park (TNP).

The Playa Norte Marine Turtle Monitoring and Conservation Programme was initiated in 2004, in the form of a feasibility study, by the Canadian Organization for Tropical Education and Rainforest Conservation (COTERC), after an initial approach by the Caribbean Conservation Corporation (CCC) (Greg Mayne, pers. comm. 2008). During this and the 2005 season the programme had the objective of collecting baseline data on the nesting marine turtle population of Playa Norte, as to determine if it warranted a long term conservation effort.

The findings of the assessment did indeed establish the importance of a long term effort and a partnership was initiated between COTERC and Global Vision International (GVI) Costa Rica to support data collection and analysis. This substantially increased the human resources available and in 2006 the project started to conduct night surveys and nest excavations in addition to the ongoing morning surveys. Since 2007, GVI Costa Rica has been responsible for the management of the project. Prior to the beginning of the 2007 seasons the programme managers and director revised the protocol, shifting the focus to a more conservation based approach and it's current incarnation as the Playa Norte Marine Turtle Monitoring and Conservation Programme. This programme will contribute to an informed approach to the management plan of Playa Norte, the Barra del Colorado Wildlife Refuge (REBACO) and the larger Tortuguero area by increasing our understanding of the dynamics of Playa Norte and its associated marine turtle populations.

This report aims at assessing the accomplishments and limitations of the 2009 Leatherback Programme and providing appropriate recommendations for future conservation and research efforts on leatherback turtles on Playa Norte. Furthermore, it is hoped that through the National Network for the Conservation of Marine Turtles *(Red Nacional de Conservación de las Tortugas Marinas)* and the Caribbean Leatherback Alliance *(Alianza para las Baulas del Caribe)*, the collected information can be used to enhance the knowledge on the nesting marine turtle populations of Costa Rica and the wider Caribbean.

6. METHODS

The research protocols used for the duration of the leatherback 2009 season follow the guidelines set out by the IUCN/SSC Marine Turtle Specialist Group and the official "Manual para el manejo y la conservación de las tortugas marinas en Costa Rica: con énfasis en la operación de proyectos en playa y viveros" (Chacón *et al.* 2007). For further details, please refer to the 2007 Marine Turtle Monitoring and Conservation Programme Night and Day Protocols (http://www.gvicostarica.blogspot.com & http://coterc.org).

6.1. Study site

The 3.125 mile (around 5 Km) long study area is located within Playa Norte and extends from the Tortuguero river mouth (10º35'34.4"N - 83º31'28.6"W) to the north end of Laguna Cuatro (10º38'06.9"N - 83º32'31.7"W). The area is located within the BCWR, which is managed by the Tortuguero Conservation Area (ACTo), under the Costa Rican Ministry of Environment, Energy and Telecommunications (MINAET). The study area is marked with mile-markers at every 1/8 of a mile (approximately 201meters) to allow for the documentation of spatial distribution along the beach. These run from 0 at the Tortuguero river mouth to mile $3^{1/8}$ just north of Laguna Cuatro.

The study area encompasses two hotels, Turtle Beach Lodge and Vista al Mar Lodge, several houses and, at the southern end, the northern extent of the village of San Francisco, a growing community of approximately 300 residents (Campos & Schoereder 2008). Additionally, a path used by those on foot, bicycle, horseback or car, runs parallel to the beach, connecting all the previously mentioned landmarks (Figure 1).

Botanically, the dominant plants on the study area are morning glory (*Ipomoea pes-caprae*), Rea-purslane (*Sesuvium portulacastrum*) and rush grass (*Sporobolus virginicus*). The berm is bordered by a hedgerow of cocoplum (*Chrysobalanus icaco*) and sea grapes (*Coccoloba uvifera*) along with a mixture of coconut palms (*Cocos nucifera*) and various tree species such as the beach almond (*Terminalia catappa*) and guava (*Psidium guajava*) amongst others.

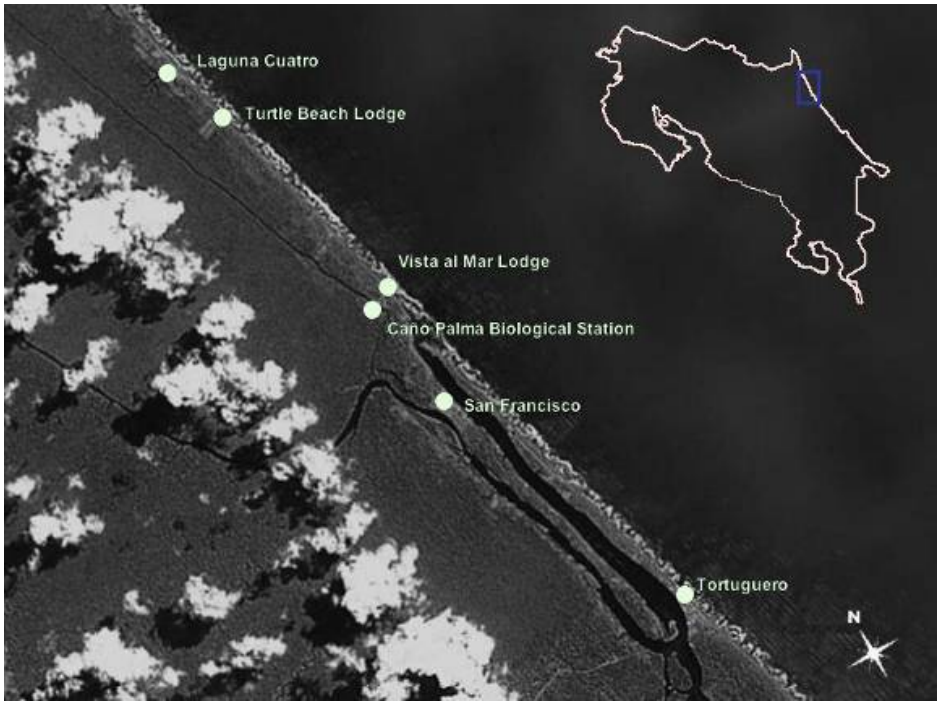

Figure 1. Study area for the Playa Norte Marine Turtle Monitoring and Conservation Programme, REBACO, Costa Rica.

6.2. Staff and volunteer training

Patrol leaders (PLs) and volunteers were trained throughout the season, with a greater emphasis on the periods of arrival of GVI volunteers on the 14th February - 19th February, 12th April - 16th April, 17th May – 21st May, 12th July – 17th July, 16th August – 21st August, 11th October – 16th October, and 15th November – 20th November. Each PL and volunteer was trained both in the classroom and in the field in order to ensure proficient data collection and ethical behaviour on the beach.

Classroom training consisted of lectures on marine turtle biology, marine turtle conservation and the discussion of possible beach scenarios. In addition, extensive workshops were held on the contents of both the morning and night protocol. Patrol leaders received practical tagging training using dummy cardboard flippers and practical relocation training, digging egg chambers appropriate for hawksbills. All personnel completed practical triangulation training, both in the day and at night, together with mimicking the night protocol procedures with dummy sand turtles. Furthermore, four PLs received training in flipper tagging and egg relocation at the CCC and two PLs participated in a night patrol with the CCC to gain additional experience.

All PLs and volunteers were tested on the night and day protocols. Tests consisted of 80 questions for PLs and about 40 questions for volunteers, which encompassed all aspects of the protocols, as well as turtle species identification, health and safety and survey kit. Pass rates were set at 100% for PLs and 95% for volunteers. All personnel were tested on triangulation technique by triangulating (at night) and reverse triangulating (by day) buried coconuts on the beach.

Finally, all potential PLs were accompanied by more experienced personnel on both morning and night patrols until they were considered able to lead patrols independently.

6.3. Beach habitat management

Preparations for the 2009 Green and Hawksbill Season began on the 17th January and continued until the official beginning of the season on the 12th March. These consisted mainly of a complete check of all beach mile markers along the study area, replacing the damaged or absent markers with new ones and verifying their spatial position using a Garmin eTrex Venture HC GPS unit.

Beach cleans were undertaken throughout the nesting season in order to improve the habitat for nesting turtles. These concentrated in areas where poaching and erosion probability was low. Additionally, a system of hatchling watches took place for all nests, beginning 10 days before their theoretical hatching date, at which time any debris that could affect the normal emergence and movement of hatchlings to sea were removed.

6.4. Morning track census and nest status

Track surveys were conducted daily between the Tortuguero river mouth and Laguna Cuatro ($3^{1/8}$ miles), by a team of one PL and one to three volunteers. Surveys started at day break (generally between 05:00 and 06:00) and lasted for up to four hours depending on the volume of data to collect and number of tracks to erase.

During the track surveys all tracks and nests since the previous survey were recorded and all nests from the previous two nights were monitored for signs of poaching. When all data were recorded, nests and tracks were disguised to decrease the likelihood of poaching and ensure against double counting on future surveys.

During the morning track census tracks were identified as **Nests**, **Half-moons** (non-nesting emergences), or a **Lifted** turtle (turtle was captured before returning to sea). After this initial step, the following information was collected:

- Date
- Global Positioning System (GPS) location and GPS accuracy
- Species
- Closest northern mile marker
- For nests, vertical position on the beach was identified either as **Open** (area of beach which receives 100% sunlight), **Border** (area where nest is partially shaded by vegetation) or **Vegetation** (area where nest is constantly shaded by vegetation) (Figure 2). Nests were then identified as **Natural** (if it appeared in its original state), **Poached** (when egg shells or a cavity were found), **Eroded** or **Predated** by an animal. Nests could also be marked as **Unknown** if the nest had signs of poaching such as flies, stick holes, disturbed sand and human and/or dog prints, and it was suspected to be poached but no conclusive evidence (egg shells or cavity) were present.

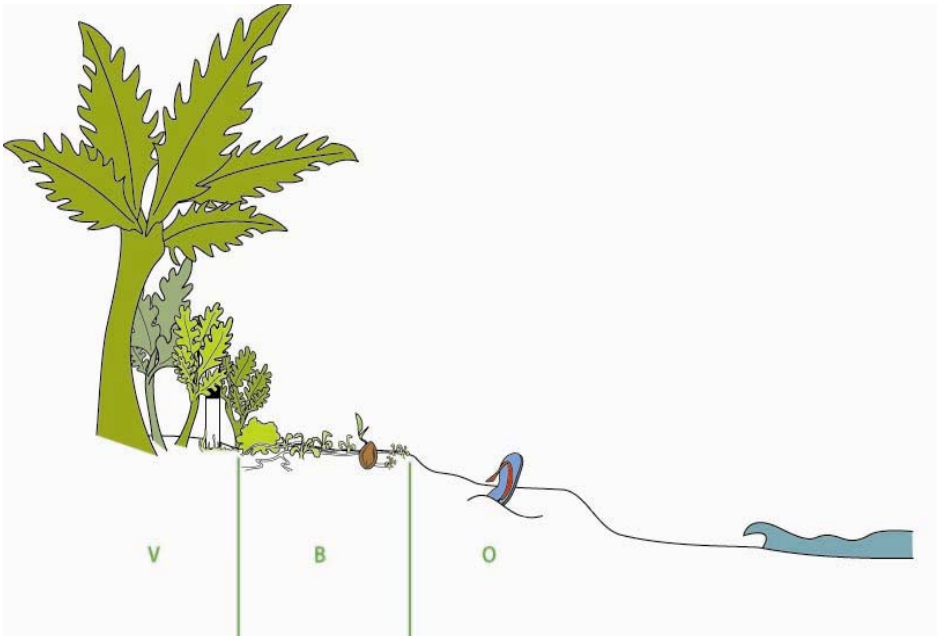

Figure 2. Nest vertical position on the beach, Playa Norte, Costa Rica.

Additionally, a weekly track survey one mile north of the study site was also conducted. This survey counted all tracks since last survey and had the objective of estimating the

number of nests and the incidence of poaching in a non-patrolled area adjacent to the study site.

6.5. Hatchling orientation

For all first encounters of hatched nests for which hatchling tracks were present the following information was recorded:

- Date
- Geographical Positioning System (GPS) location and GPS accuracy
- Species
- Closest northern mile marker
- Nest number
- Number of tracks observed
- Number of alive hatchlings
- Number of dead hatchlings
- Number of circles counted in the tracks (indicating hatchlings might have been confused by light sources other than the waves)
- Number of outliers (tracks found outside of where the majority of hatchlings approach the sea)
- Number lost (tracks heading towards the vegetation)
- Distance to HTL

Four sticks were placed at the distance of 10 metres from the nest to mark the dispersal pattern of hatchlings. Sticks 1 and 4 were placed on the boundaries of the main body of tracks (excluding outliers) and sticks 2 and 3 were placed to demark the highest density of tracks with the main body. Tracks outside the main body of tracks were denominated **outliers** and tracks going in a direction opposite to the sea were called **lost**. Both these types of tracks were excluded from further analysis.

After the sticks were in place, the angle formed between each stick and north was measured from directly above the egg chamber at waist height using a compass. These measures were used to establish, through trigonometry, the average extra distance travelled to reach sea by a group of hatchlings from a particular nest. This demanded the estimation of the optimum angle that a hatchling should keep as to cover the smallest

distance possible between its nest and the sea. By measuring, every half mile, the angle that a straight line to sea would make to north the optimum angle to sea was determined to be 70º.

It is important to clarify that this methodology assumes for the sake of simplicity that hatchlings travel in straight lines and only calculates the extra distance travelled for the first ten meters; nonetheless, as this should be a linear relationship, any other distances can be easily accounted for.

6.6. Night patrols

The night patrols began on March 12th and continued daily until the end of the green season on the November 5th. Each night a minimum of one patrol team, of three to four members walked the beach between mile 0 and $3^{1/8}$ for a minimum of four hours. On nights when only one team was on the beach, the patrols were scheduled from 22:00 to 02:00 since these were the hours of greater emergence. When two teams were scheduled, the first team was scheduled from 20:30 to 00:30 and the second team from 23:00 to 03:00.

When a turtle track was found, the patrol leader determined whether or not the turtle was still on the beach. If the turtle was not on the beach, the patrol leader determined if the track was a half moon, nest, or lifted turtle. The team then proceeded to collect the following information:

- Date
- Geographical Positioning System (GPS) location and GPS accuracy
- Species
- Northern mile marker
- Time of encounter
- For nests vertical position on the beach was identified either as **Open, Border** or **Vegetation**. Nests were then identified as **Natural**, **Poached**, **Eroded**, **Predated** by an animal or **Unknown** *(see section 0 for details)*.
- If evidence of a **Lifted** turtle was encountered any useful additional information was also collected.

When a female turtle was encountered on the beach, the patrol would collect additional information depending on the nesting stage of the individual. The PL established what stage of nesting she was in (**Emerging** from the sea, **Selecting** nest site, **Digging** body pit, **Digging** egg chamber, **Oviposition**, **Covering** egg chamber, **Disguising** and **Returning** to the sea).

For females encountered prior to oviposition, egg counting was done by touch and/or sight as eggs were laid into the egg chamber (fertile and infertile eggs counted separately). Egg depth was recorded immediately after the completion of oviposition and a small aluminium tag placed near the surface of the egg chamber to facilitate location of nests during excavation.

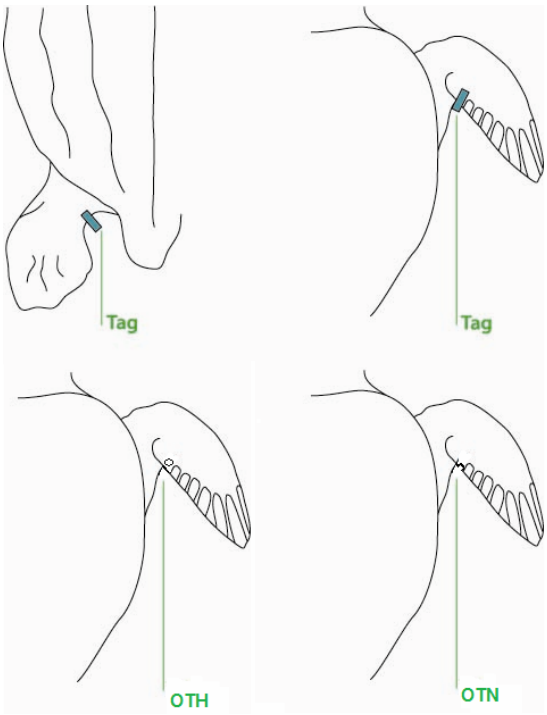

Figure 3. Above: proper position of tags for greens and others species. **Below:** old tag notches (OTNs), old tag holes (OTHs).

Triangulation was only conducted during ovipostion, directly over and in clear view of the egg chamber. The distance to the most recent high tide line (HTL) was also recorded.

When the turtle completed oviposition and began to cover her egg chamber, she was then checked for tags, **Old Tag Notches** (OTNs), **Old Tag Holes** (OTHs), and tagged if no tags were present. Green and Hawksbill turtles were tagged in the membrane between the front flippers and the body just before the primary scale using Iconel #681 tags (Series CP0222 to CP0986, National Band & Tag Co; Newport, USA) (Figure 3). All turtles were double tagged and only nesting individuals that were covering the egg chamber or disguising their nest were considered suitable for tagging.

For tagged females, the **CCLmin** and **CCWmax** were measured to the nearest millimetre, using a flexible fibreglass measuring tape. Three measurements within 3mm were

recorded for both CCLmin and CCWmax. For green and hawksbill turtles, CCLmin was measured from the nuchal scute where the skin touches the carapace, along the centre of the carapace until the notch at the posterior end. The CCWmax was measured along the widest part of the carapace to where the carapace meets the skin (Figure 4).

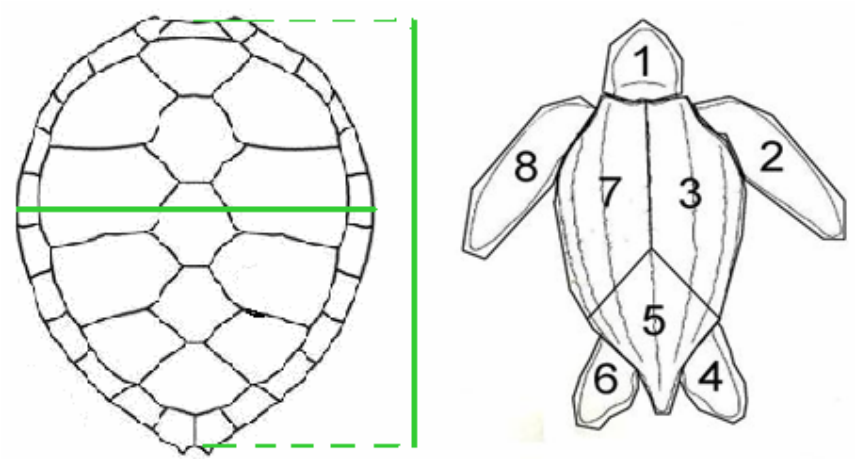

Figure 4. Left: proper position of the minimum curved carapace length (CCLmin) and the maximum curved carapace width (CCWmax). **Right:** external body exam of turtles.

Once measuring was completed, nesting turtles with tag information were examined for their external condition. Small abnormalities being defined as a mutilation that affects less than 25% of the limb, and large abnormalities being defined as more than 25% of the limb; and damaged carapace includes incomplete caudal projection and missing parts on carapace. Abnormalities were recorded as occurring in the sections shown in Figure 4. Only nesting turtles with tag information were examined for their external condition

6.6.1. Relocations

For all hawksbill nests that where at risk of erosion, in areas of high poaching incidence (determined for this season as the areas from mile marker 6/8 to 1 and from 3 to $3^{1/8}$) or laid below the HTL were relocated to safer areas of the beach. The eggs were carried by the patrol leader alone to the relocation site to dig a new egg chamber and deposit the eggs. The new egg chamber would utilise the depth and width measurements of the old egg chamber and ideally be located at minimums of four metres from the HTL and one metre from the vegetation.

Triangulation was conducted after all eggs were transferred to the new egg chamber as to assure the nest could be located for excavation. Patrols leaders have the option of not

measuring HTL as to avoid footprints that could lead potential poachers to the new egg chamber.

6.6.2. Disguising nests

For all hawksbill tracks, a considerable effort was put into **disguising** (i.e. erasing all signs of presence from the sand). For nests, this was done to diminish the possibility of poachers finding the egg chambers with half moons being disguised to increase the number of disturbed areas as to confound potential poachers.

All green nests and tracks were disguised by the first patrol that found them on either morning or night survey after data collection. Teams employed different strategies such as flattening out and disturbing a large area of sand, digging false body pits and egg chambers, (confirming through a GPS map that no other nests were in proximity), and/or dusting the area with a small layer dry sand to hide the tracks and nest.

6.7. Nest fate, hatching success and emergence success

All nests determined by the presence of hatchling tracks to have hatched, were excavated two days after the first hatchling tracks were encountered. Triangulated leatherback nests that were not seen to have hatched were excavated 75 days after laid.

For each excavated nest the following information was recorded:

- **Number of hatched eggs** – Only shells corresponding to more than 50% of the egg were counted
- **Number of hatchlings** – alive and dead
- **Number of un-hatched eggs** - These were categorized as:
    - Without embryo
    - With embryo – These were further divided into (Figure 5):
        - **Stage 1** (embryo occupies less than 25% of the egg)
        - **Stage 2** (embryo occupies between 25% and 50% of the egg)
        - **Stage 3** (embryo occupies between 50% and 75% of the egg)
        - **Stage 4** (embryo occupies between 75% and 100% of the egg)
        - **Unknown** – Embryo has been predated and it is impossible to determine at what stage development stopped

- **Number of pipped eggs** – embryo had broken the shell but failed to hatch

- **Number of eggs predated** by larvae, bacteria/fungi, ants, crabs or other unknown species
- **Number of yolkless eggs**
- **Number of deformed embryos** – including albinism or multiple embryos in a single egg

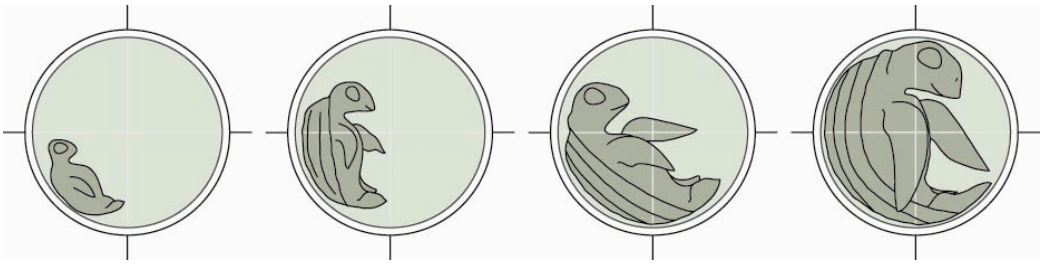

Figure 5. Embryonic development stages used during nest excavations.

For all excavated nests a nest fate was determined. Nests which were not excavated were excluded from the analysis. The following nest fate categories were applied: **natural and hatched**, **natural and un-hatched**, **relocated and hatched**, **relocated and un-hatched**, **poached**, **partially poached**, **predated**, **eroded** and **unknown**. Empty egg chambers were classified as poached nests if the aluminium tag deposited at the time of egg counting was found or if only infertile eggs remained. If there was any doubt about the fate of a nest, it was categorized as unknown. In addition, on all excavations the distance from the surface to the first egg encountered (egg depth) and the distance between the surface and the bottom of the egg chamber (nest depth) were measured to the nearest centimetre.

Also, for all excavated nests a hatching success and emergence success was determined (Eckert *et al.* 1999). Hatching success refers to the number of hatchlings that hatch out of their egg shell; emergence success refers to the number of hatchlings that reach the beach surface (Table 1).

Table 1. Formulas and definitions to estimated hatching success and emergence success.

Shells = Number of hatched eggs
UD = Un-hatched egg without embryo
UH = Un-hatched egg with embryo (stage 1 to 4)
UHT = Pipped eggs
P = Unknown
L = Live hatchlings
D = Dead hatchlings

Hatching success	#shells / #shells + #UD + #UH + #UHT + #P
Emergence success	#shells – (#L + #D) / #shells + #UD + #UH + #UHT + #P

6.8. Poaching of adult turtles

Whenever dead turtles were encountered during surveys, the following information was recorded in order to determine the cause of death:

- Date
- Geographical Positioning System (GPS) location and GPS accuracy
- Species
- Closest northern mile marker
- CCLmin and CCWmax
- Tag numbers (if present)
- Relevant comments including: signs of wounds or missing body parts, estimated time since death and condition of the carcass when first found
- Photographs

6.9. Human impact data

During each night survey, the number of red and white mobile lights, fires, locals and tourists on the beach were recorded. Tourists were defined as people on the beach to observe nesting turtles and locals as people with any other purpose. Additionally, each month during the new moon, the number of stationary white and stationary red lights was also recorded.

6.10. Environmental education

The project developed communication platforms with the two key stakeholders around the study area. On one side, the local community of San Francisco and on the other, the tourists visiting Playa Norte to see nesting marine turtles. In order to improve communication with the community of San Francisco there was an effort to improve the

environmental message transmitted during five-weekly community events and to keep up the work developed during environmental education classes.

7. RESULTS

The data presented refer only to nesting green and hawksbill turtles. Nonetheless, during the period encompassed by this report other species were recorded nesting on Playa Norte. Please see the relevant species report for this information (Playa Norte Leatherback Season Report 2009).

7.1. Beach habitat management

Prior the start of the 2009 Green and Hawksbill Season, the beach was prepared by replacing the mile markers that were washed away or destroyed since the end of the 2008 nesting season. Also, each mile marker was re-painted in white with black numbers.

Nesting habitat was managed through a series of beach cleans, which mainly involved the clearing of big logs and plastic on the beach, with an estimated total of 352 hours of work put into this endeavour.

7.2. Morning track census and nests status

The daily morning track census was conducted from 18th January to 10th December - which represents a total of 293 surveys.

7.2.1. Green temporal distribution

Green nesting activity was recorded from the 15th March to the 06th December. A total of 540 tracks were recorded, of which 168 were nests and 372 were half-moons. The peak of the activity corresponded to the third week of August (from 16th August to 29th August) (Figure 6).

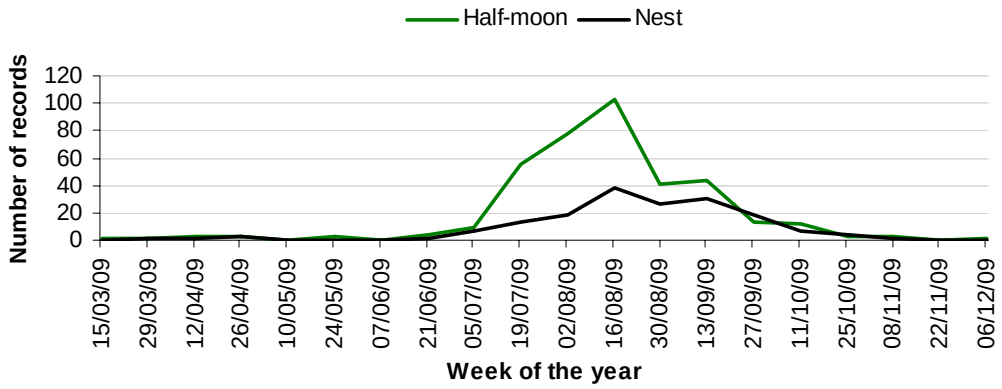

Figure 6. Temporal distribution of green nesting activity during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

7.2.2. Hawksbill temporal distribution

Hawksbill nesting activity was recorded from the 03rd May to the 10th October. A total of 39 tracks were recorded, of which 19 were nests and 21 were half-moons (Figure 7).

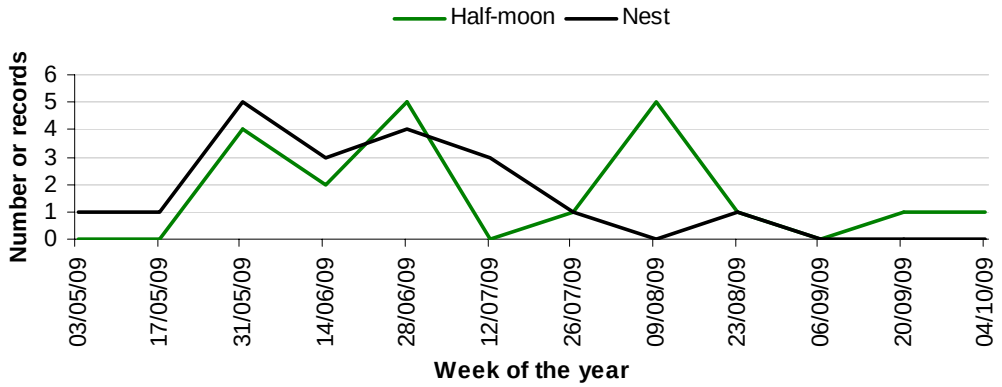

Figure 7. Temporal distribution of hawksbill nesting activity during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

7.2.3. Green spatial distribution

Green nesting activity concentrated at miles 3/8 and 3/4. The lower numbers of nests were reported at mile $1^{3/8}$ (where one house is located), mile $2^{4/8}$ (where one lodge is located) and at the end of the beach (Figure 8). According with the vertical position, 67 nests were located in the open, 82 nests in the border and 17 nests in the vegetation.

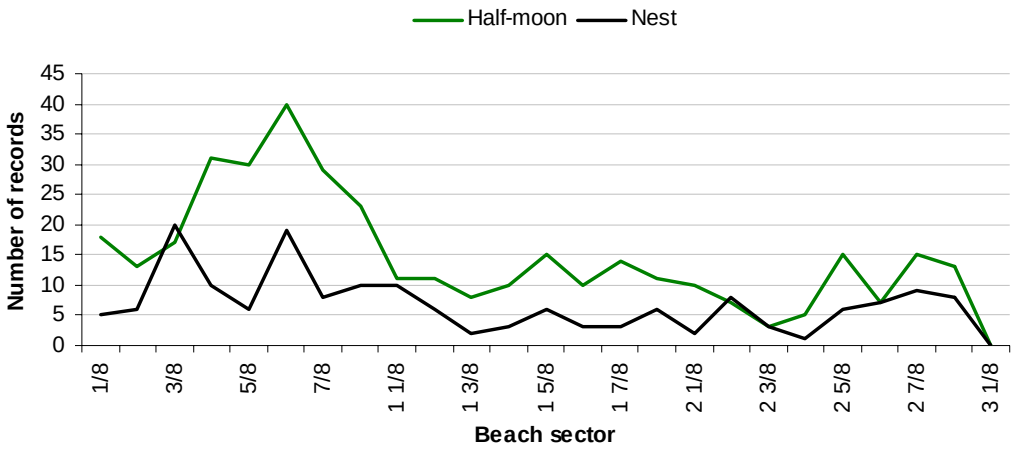

Figure 8. Spatial distribution of green nesting activity during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

7.2.4. Hawksbill spatial distribution

Hawksbill nesting activity concentrated at miles 3/8 and 5/8 (Figure 9). According with the vertical position, 14 nests were located in the open, 14 nests in the border and 12 in the vegetation.

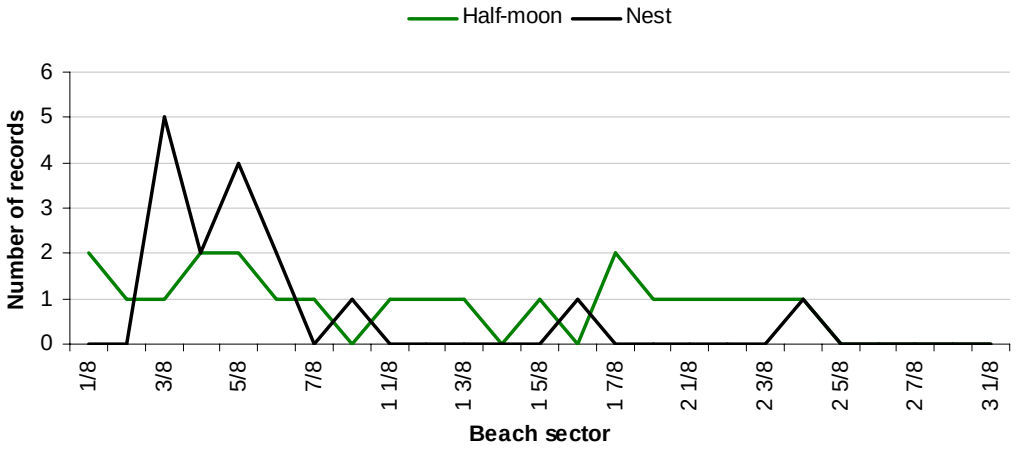

Figure 9. Spatial distribution of hawksbill nesting activity during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

7.2.5. Nest status based on morning census

Of the 167 green nests monitored during morning census, 97 nests were found to be natural on the first two days after being laid, 39 nests were poached, six were determined as unknown. Regarding to the hawksbill nests, a total of 19 nests were monitored; 11 nests were found to be natural, five nests were poached and three were determined as unknown. None of the nests had signs to prove to be subject to erosion or predation.

7.3. Hatchling orientation

It was not possible to assess if there was a relationship between the distance travelled by the hatchlings and artificial lights or other potential anthropogenic disturbance.

7.4. Night patrols

Night patrols began on 12th March and ended on 08th November - the last recorded hawksbill activity was on 05th October and the last recorded green activity was on 08th December. Patrols were usually composed of two teams on the beach, with occasionally a single team due to shortage of personnel. There were 463 night patrols in total throughout the Green and Hawksbill Season. Patrols normally lasted for four hours and were occasionally cancelled or cut short due to environmental conditions.

7.4.1. Encountered turtles

For green and hawksbill turtles the peak encounter time for nesting was from 23:00 to 23:59.

Throughout all the patrols, 172 green turtles were encountered; of which 93 nested and 79 were half-moons. Most turtles were encounter digging body pit (Table 2).

Table 2. Encountered nesting activities of green turtles by patrol teams on Playa Norte, Tortuguero, Costa Rica.

Encounter occurrence		%
Emerging from the sea	23	13.4
Selecting a nest site	20	11.6
Digging body pit	44	25.6
Digging egg chamber	24	14.0
Oviposition	11	6.4
Covering egg chamber	2	1.2
Disguising nest	28	16.3
Returning to sea	20	11.6

A total of 20 hawksbill turtles were encountered; of which 16 nested and four were half-moons. Most turtles were encounter selecting a nest site or digging body pit (Table 3), and their direction of nesting was found to be mainly towards the West (Table 4).

Table 3. Encountered nesting activities of hawksbill turtles by patrol teams on Playa Norte, Tortuguero, Costa Rica.

Encounter occurrence		%
Emerging from the sea	0	0.0
Selecting a nest site	5	25
Digging body pit	5	25
Digging egg chamber	5	25
Oviposition	3	15
Covering egg chamber	0	0
Disguising nest	2	10
Returning to sea	0	0

Table 4. Direction of nesting of hawksbill turtles during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

Direction of nesting	Number of individuals
East	2
North	3
South	2
South East	1
South West	3
West	3

7.4.2. Tagging

Of all the green turtles encountered by patrols teams, 79 individuals were identified. Forty four turtles came up without tags and were tagged by patrol teams; 35 came up with tags and were previously tagged either on Playa Norte (previous nesting season) or other regions nearby.

Out of all the identified nesting turtles, 11 individuals were recorded re-nesting within the season in Playa Norte. Nine individuals were recorded nesting two times and only one individual three times. The re-nesting intervals varied from ten to 59 days, with an average re-nesting interval of 22 days.

Of all the hawksbill turtles encountered by patrols teams, 11 individuals were identified. Six turtles came up without tags and were tagged by patrol teams; five came up with tags and were previously tagged either on Playa Norte (previous nesting season) or other regions nearby.

Out of all the identified nesting turtles, three individuals were recorded re-nesting within the season in Playa Norte. Two individuals were recorded nesting two times and only one individual three times. The re-nesting intervals varied from 15 to 30 days, with an average re-nesting interval of 23 days.

7.4.3. Biometric Data

A total of 56 green turtles were measured. The mean carapace length was 103.80 cm (n=56, S.D=11.0) and the mean carapace width was 92.49 cm (n=56, S.D=11.0). A total of five hawksbill turtles were measured. The mean carapace length was 90.12 cm and the mean carapace width was 81.63 cm.

7.4.4. External condition of nesting females

Abnormalities were detected in 48 green turtles and 10 hawksbill turtles. The most common abnormality was small mutilations such as scars and scratches.

7.5. Nest fate, hatching success and emergence success

7.5.1. Green nests

A total of 168 green nests were laid, of which 42 nests were successfully excavated; 15 were excavated two days after signs of hatchlings were recorded and 23 nests that were triangulated by night teams but with no signs of hatching before due date were excavated 70 days after being laid.

The incubation time of green nests was determined by referring to hatched nests with original nest date, and those seen with hatchling tracks. It ranged from 44 to 65 days, with an average of 54 days.

7.5.2. Hawksbill nests

A total of 19 hawksbill nests were laid, of which eight nests were successfully excavated; three were excavated two days after signs of hatchlings were recorded and five nests that were triangulated by night teams but with no signs of hatching before due date were excavated 80 days after being laid. Also, only one nest was relocated – however, it was recorded has eroded by morning census.

The incubation time of green nests was determined by referring to hatched nests with original nest date, and those seen with hatchling tracks. It ranged from 58 to 62 days, with an average of 59 days.

7.5.3. Summary of green excavations

A total of 1,887 fertile eggs were excavated, 1,534 of which had hatched. A summary of hatching success and emerging success rates of all triangulated nests is illustrated in Table 5.

Table 5. Summary of hatching success and emerging success of natural nests of green turtles on Playa Norte, Tortuguero, Costa Rica.

	N	Hatching success %	Emerging success %
Natural & hatched	19	83	78
Poached	9	67	67
Partially poached	8	31	25
Eroded	4	-	-
Predated	2	93	93

A breakdown of the excavation result for natural nests is presented in Table 6 and 7. Internal predation was found in all nests with eggs present, with bacteria and fungi as the main cause of egg failure.

Table 6. Summary of excavated nests of green turtles on Playa Norte, Tortuguero, Costa Rica.

	Total yolked eggs	Total yolkless eggs	Mean clutch size	Hatched (Shells >50%)	Alive hatchlings	Dead hatchlings	No embryo	Stage 1	Stage 2	Stage 3	Stage 4	Pipped	Unknown
Natural & hatched	1806	1	100	1499	15	67	168	19	7	10	6	2	95
Poached	3	1	-	2	0	0	1	0	0	0	0	0	0
Partially poached	64	0	-	20	1	3	15	1	0	0	4	0	24
Eroded	0	0	-	-	-	-	-	-	-	-	-	-	-
Predated	14	0	-	13	0	0	1	0	0	0	0	0	0

Table 6. Summary of predation of eggs in triangulated and excavated nests of green turtles on Playa Norte, Tortuguero, Costa Rica.

	Ants	Larvae	Bacteria/Fungi	Crabs	Unknown
Natural & hatched	60	12	168	2	26
Poached	0	0	1	0	0
Partially poached	18	5	15	0	2
Eroded	-	-	-	-	-
Predated	0	0	1	0	0

7.5.4. Summary of hawksbill excavations

A total of 1,887 fertile eggs were excavated, 1,534 of which had hatched. A summary of hatching success and emerging success rates of all triangulated nests is illustrated in Table 8.

Table 7. Summary of hatching success and emerging success of natural nests of hawksbill turtles on Playa Norte, Tortuguero, Costa Rica.

	N	Hatching success %	Emerging success %
Natural & hatched	4	93	92
Partially poached	2	60	60
Poached	2	10	10

A breakdown of the excavation result for natural nests is presented in Table 9 and 10. Internal predation was found in all nests with eggs present, with bacteria and fungi as the main cause of egg failure.

Table 8. Summary of excavated nests of hawksbill turtles on Playa Norte, Tortuguero, Costa Rica.

	Total yolked eggs	Total yolkless eggs	Mean clutch size	Hatched (Shells >50%)	Alive hatchlings	Dead hatchlings	No embryo	Stage 1	Stage 2	Stage 3	Stage 4	Pipped	Unknown
Natural & hatched	647	0	162	604	1	1	30	6	4	1	1	0	1
Partially poached	4	0	0	3	0	0	0	0	0	0	0	0	1
Poached	1	0	0	1	0	0	0	0	0	0	0	0	0

Table 9. Summary of predation of eggs in triangulated and excavated nests of hawksbill turtles on Playa Norte, Tortuguero, Costa Rica.

	Ants	Larvae	Bacteria/Fungi	Crabs	Unknown
Natural & hatched	0	1	34	1	1
Partially poached	1	0	0	0	0
Poached	0	0	0	0	0

7.6. Poaching of adult turtles

Throughout the season four green turtles were poached (only one successfully nested; the nest was recorded as eroded during morning census) and six green turtles were lifted, of which one was tagged on Playa Norte (Tags CP0899 – CP0900; Date tagged: 06 September 2009).

7.7. Human impact data

Playa Norte received a higher number of tourists during March and July, and a higher number of locals during March, April and August. However, the number of visitors decreased at the end of the green nesting season (Figure 11).

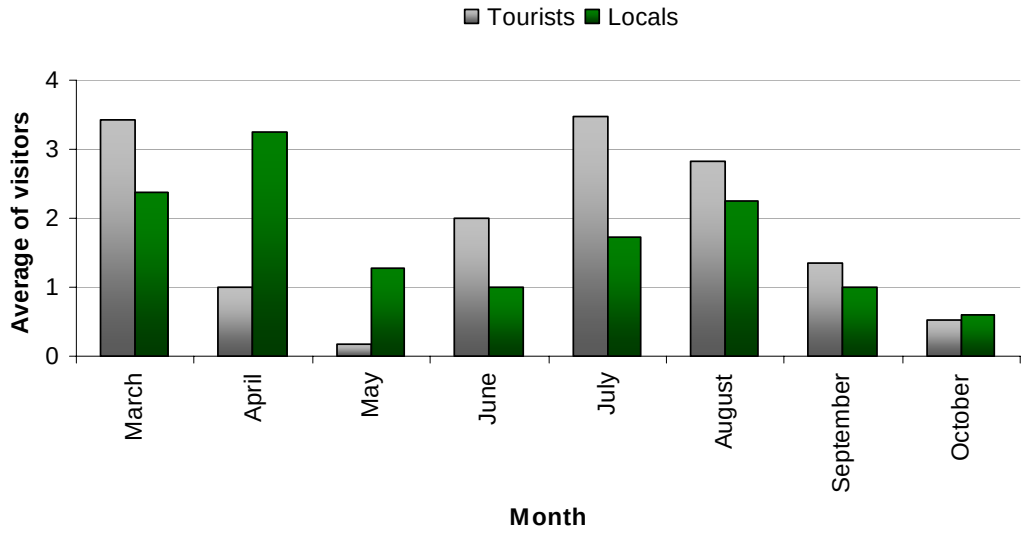

Figure 100. Monthly variations of the total number of tourists and locals recorded during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

Regarding the mobile lights, there are a higher number of white lights during March, July and August, and the number decreased at the end of the green nesting season. The number of red lights followed the same trend during the nesting season (Figure 12). Concerning the stationary lights, the number of red and white lights increased steadily has the season progress.

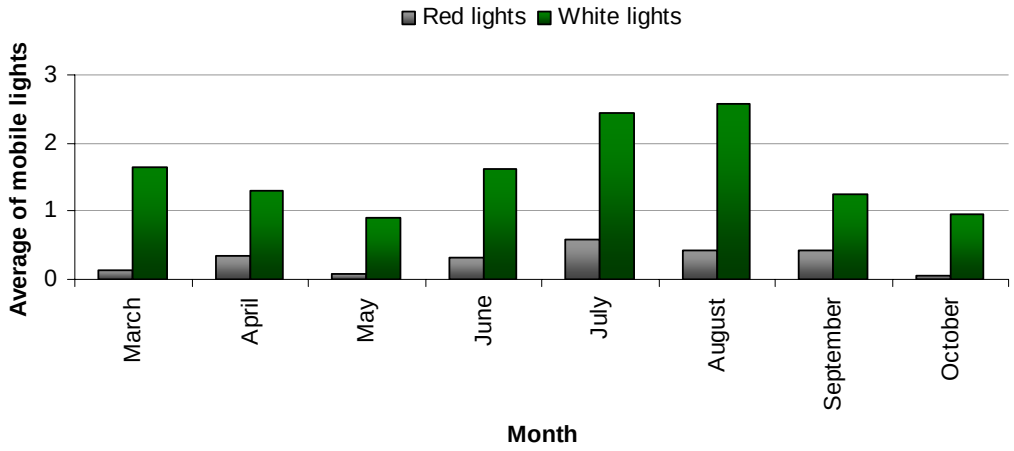

Figure 111. Monthly variations of the total number of mobile red lights and white lights recorded during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

7.8. Environmental education

Throughout the season, staff and volunteers organized classes with the community of San Francisco for both English language and environmental education. Several events were also organized and attended in the local area. These consisted of conducting environmentally themed educational community events in San Francisco and attending events both locally and nationally.

8. DISCUSSION

8.1. Beach habitat management

The use of two mile markers per eighth of a mile has proved effective, as some eighths of mile lost one of the mile markers but no beach sections lost two. This ensured a more durable spatial division of the study area.

Beach cleans should be carried out before the nesting season starts and throughout the nesting season. The cleaning of debris help to improve the nesting habitat, ensure sea turtles easier access to nesting sites and hatchlings easier access to the sea.

8.2. Morning track census and nest status

8.2.1. Temporal distribution

The total number of green nests this season (n=168) was lower than previous seasons, showing the fluctuations of green turtle nesting populations throughout years. The number of hawksbill nests followed the same trend than previous years. Further study is necessary to determine any population pattern or trend.

8.2.2. Spatial distribution

Nesting activity was found on most eighths-of-mile on the beach. The absence of nesting activity at mile 1/8 could be related to the lack of beach due to debris washed up from the Tortuguero river mouth. In addition, some sectors had a higher number of half-moons than others; this could be the result of human disturbance, such as tourist activity, presence of dogs or light pollution. Also, the lower number of nests reported between miles $2^{3/8}$ and $2^{4/8}$ could be due to the large amount of human traffic and light pollution coming from Turtle Beach Lodge.

8.2.3. Nest status based on morning census

The number of poached nests was lower than previous seasons, which could be due our constant presence on the beach, which lowers the risk of nests to be poached. Regarding

to hawksbill natural nests, only 26% were poached – we recommend further study to determine whether or not the relocation of nests is necessary in following seasons.

8.3. Hatchling orientation

As the sample size was small it was impossible to assess if there was any relationship between the extra distance travelled by the hatchlings and artificial lights or other potential anthropogenic disturbance. Nonetheless, the establishment of this methodology coupled with a larger dataset from previous and following seasons may allow for a better understanding of the influence of human settlements (e.g. artificial lights), presence of debris on the beach (e.g. logs) and the dynamic of the beach (e.g. erosion) on hatchling orientation.

8.4. Night patrol

8.4.1. Encountered turtles

The encounter rate of nesting turtles had decreased compared to previous seasons. Given the similar amount of patrol time, the lower encounter rate could be explained by the higher nesting occurrence, for example, that patrol teams spent more time working a turtle while other turtles were nesting on other parts of the beach. The peak encountered time was 23:00 to 23:59, which was the time when both patrol teams were out on the beach and gave the most coverage. However, the encountered time ranging widely from 21:00 to 03:59 indicated nesting turtles may come up to Playa Norte throughout the night, hence the importance of having two teams patrolling on the beach each night to give the full coverage.

Turtles were found to nest mainly facing towards the sea, with the fewest facing towards the vegetation. Although turtles might prefer the darker vegetation line than the brighter ocean, others could have been affected while nesting which may explain the nesting direction.

8.4.2. Tagging

There was a slight decrease in the number of turtles newly tagged compared to previous seasons – for both hawksbills and green turtles. However, our dataset and sample is too

small to draw any conclusion at this stage. The previously tagged turtles were tagged along the Caribbean coast, illustrating the migratory nature of green and hawksbill turtles and the sharing of nesting population with the Caribbean beaches of the country. This also showed the importance of joint effort in turtle conservation projects along the Caribbean coast.

For green turtles the registered re-nesting interval of ten to 59 days matched with the estimates for the most common re-nesting interval of ten to 17 days – this also applies for hawksbill turtles, where the registered re-nesting interval of 15 to 30 days matches with the estimate of 11 to 28 days (Lutz *et al.* 1996). *T*he upper end of the re-nesting interval is likely due to turtles either returning to nest on another beach (most likely Tortuguero), or them simply not being encountered while nesting on Playa Norte.

8.4.3. Biometric data

The mean CCLmin and CCWmax measurements were similar to those obtained from previous seasons. Results from re-measuring the same individuals showed that there was a higher precision in measuring CCWmax than CCLmin. Improvement in training and field assistance is needed to help minimizing discrepancies.

8.4.4. External condition of nesting females

Small abnormalities like scratches and scars could be caused by either natural wear-and-tears as turtles grow older or by natural predators. Large mutilations could be caused by natural predators or could be marks from dragging by poachers/fishermen.

8.5. Nest fate and hatching success

Poaching and human disturbance were recorded the most at places where there were human settlements nearby, combined with easy access to the trail along the beach. Nonetheless, the poaching rate has dropped by almost 10% through the years – proving the success of the conservation programme and the importance of environmental education in the community.

The spatial distribution of poaching events may be explained by the configuration of the study area and the distribution of the human population around it. During most of the leatherback season, direct access from the path along the beach was only possible from

the mile marker 3/8 onwards, which restricted access to the southern part of the beach. On the other hand, and given that the village of San Francisco is situated to the south of the study area and that local residents with a history of egg collecting inhabit the houses along the first one and a half miles of the study, these results are not unexpected.

8.5.1. Summary of all excavations

The majority of un-hatched eggs did not present an embryo, suggesting unusual events had happened in nests during the early stage of development. The close proximity of nests to high tide line and the possible rising of ground water/saturation due to heavy precipitation are possible reasons.

The overall poaching rate of nests was slightly lower than previous seasons. However, continuous conservation education in the community is believed to be the ultimate solution to continue to reduce poaching.

The overall hatching success rate followed the same trend than previous seasons – however a higher rate should be pursued for the following seasons.

8.6. Poaching of adult turtles

It was encouraging that no poaching or lifting of hawksbill turtles was found on Playa Norte, this contrasted with four green turtles being poached and six being lifted throughout the season, reflecting the preference of consuming green turtles in the Caribbean culture.

8.7. Human impact data

The number of tourists was generally higher than locals, however during April and May the number of locals was higher, which coincides with national holidays. A capacity study should be conducted on Playa Norte to evaluate the impact of human presence on turtle nesting activities.

Mobile white lights were higher in number than red lights, however, there has been an increased in mobile red lights and a decreased in mobile white lights since the nesting season 2007. This is a positive trend and might reflect a higher level of awareness amongst tour guides and locals.

8.9 Environmental education

The presence of a monitoring and conservation program on Playa Norte does much to prevent the poaching of eggs and adult turtles; however, it is not sufficient to stop this and other threats completely. It is necessary to involve the local community of San Francisco – so they can be more aware of the effects of their actions on the local environment.

In order to achieve this goal, it is necessary to conduct a long-term environmental education – which is a long term endeavour that directly addresses the conservation needs of Playa Norte, with the participation of international volunteers and the different sectors of the community such as the local school, developers and tourist.

Working closely with the community of San Francisco will allow creating a holistic picture of the populations nesting on Playa Norte, their threats and possible solutions within the local context, which will have implications on management and conservation for decades to come.

9. REFERENCES

Campos, D. and V. Schoereder. 2008. Census 2009 – San Francisco, Tortuguero, Costa Rica. Unpublished Report. Global Vision International. Costa Rica.

Chacón, D; Sánchez, J; Calvo, J y J. Ash. 2007. Manual para el manejo y la conservación de las tortugas marinas en Costa Rica: con énfasis en la operación de proyectos en playa y viveros. Sistema Nacional de Áreas de Conservación (SINAC), Ministerio de Ambiente y Energía (MINAE). Gobierno de Costa Rica. San José. 103 p.

Eckert, K. L; K. A. Bjorndal, F. A. Abreu-Grobois and M. Donnelly (Editors) 1999. Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

Lutz, P. L; J. A. Musick, J. Wyneken (Editors) 1996. The biology of sea turtles. Volume II. CRC Press.