Playa Norte Marine Turtle Conservation & Monitoring Programme

Leatherback Season Report 2009

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Final Editions/ Corrections by: April Stevens

COTERC Marine Turtle Project Coordinator

Playa Norte Marine Turtle Monitoring and Conservation Programme

Barra del Colorado Wildlife Refuge, Costa Rica

Leatherback 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

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

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Playa Norte Marine Turtle Monitoring and Conservation Programme

Leatherback Season Report 2009

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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 on-site management of the project. Prior to the beginning of the 2007 season the programme managers and director revised the protocol, shifting the focus to a more conservation based approach and its 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 2009 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 (10°35'34.4"N - 83°31'28.6"W) to the north end of Laguna Cuatro (10°38'06.9"N - 83°32'31.7"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.

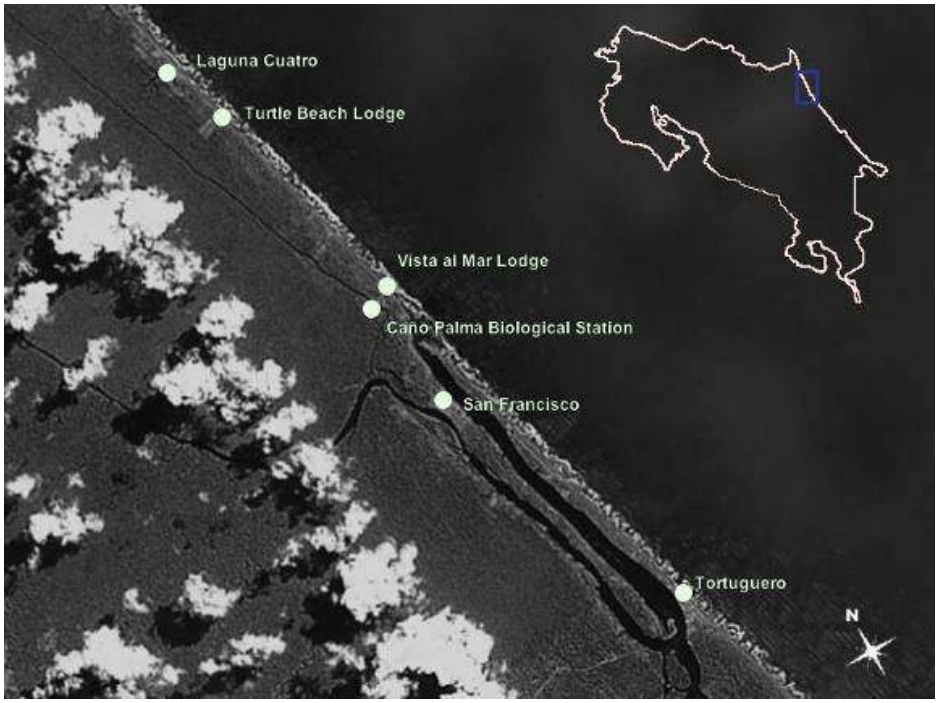

Figure 1 Study area for the Playa Norte Marine Turtle Monitoring and Conservation Programme, REBACO, Costa Rica. © Google Earth

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 13th – 20th February; 3rd – 10th April and 8th – 15th May. 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, 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 leatherbacks and 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.

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 Leatherback Season began on the 17th of January and continued until the official beginning of the season on the 16th of 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 from north.

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 two 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 leatherback emergence for the previous seasons in the main leatherback nesting beaches in Costa Rica (Chacón & Lopez 2007; Chacón & Senechal 2007). When two teams were scheduled, the first team were 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 6.4 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 (yolked and yolkless 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.

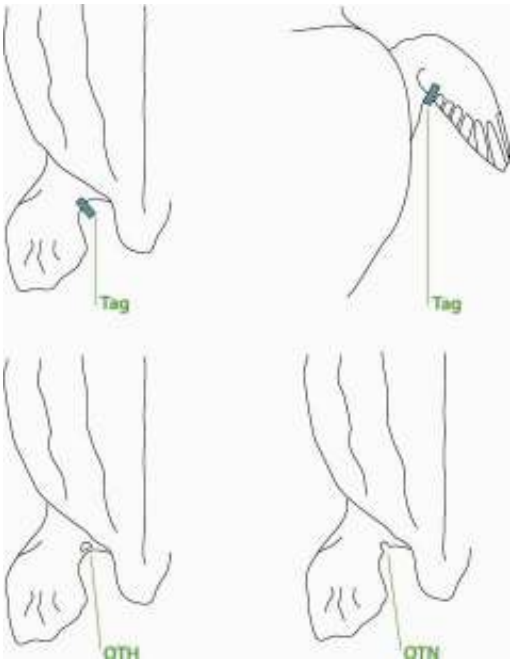

Figure 3. Above: proper position of tags for leatherbacks and others species. **Below:** old tag notches (OTNs), old tag holes (OTHs) (Barragán 1998).

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. Leatherback turtles were tagged in the membrane between the rear flippers and the tail using National Band & Tag Co., Newport, USA Monel #49 tags (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 leatherbacks, CCLmin was measured from where the skin meets the carapace at the neck, along the right of the central ridge to the end of the caudal projection (Figure 4). Additionally the caudal projection was classified as **complete** if no abnormalities occurred and **incomplete** if part of it was missing. The

CCWmax was measured along the widest part of the carapace to where the carapace meets the skin

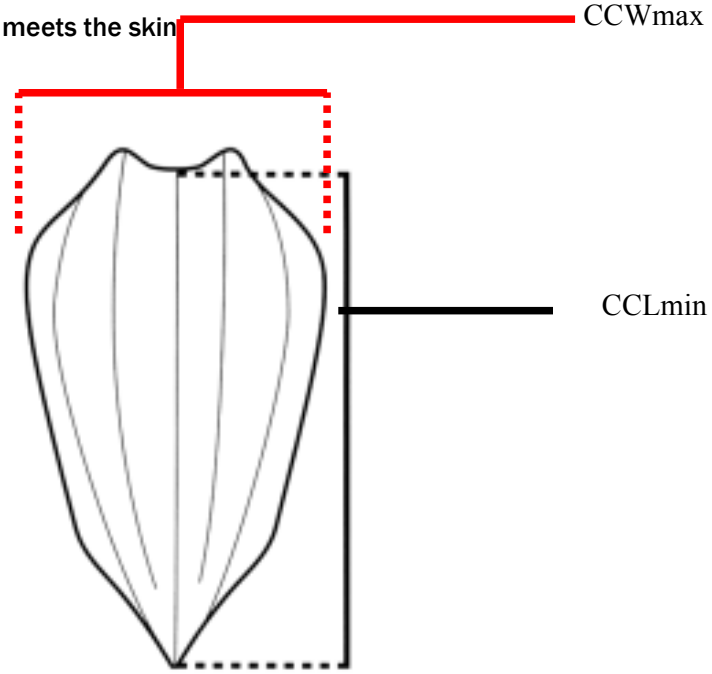

Figure 4. Left: proper position of the minimum curved carapace length (CCLmin, black) and the maximum curved carapace width (CCWmax, red)(taken and modified from Bolten (1999)).

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

Nests 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 a minimum 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 leatherback 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.

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

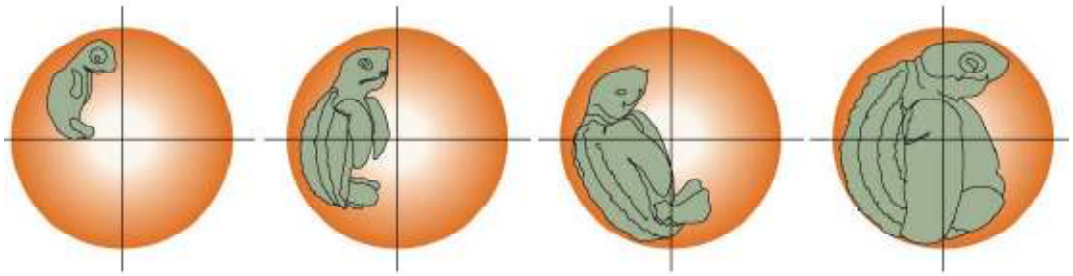

Figure 5. Embryonic development stages used during nest excavations (Chacón et al. 2007).

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** and **eroded**. Empty egg chambers were classified as poached nests if the aluminium tag deposited at the time of egg counting was found or if only yolkless eggs remained. 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 (Miller 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. Definitions and formulas used to determine hatching & emergence success rates as described by Miller (1999).

Classification	Description
Shells (S)	Number of empty shells
Live in Nest (L)	Live hatchlings remaining in nest
Dead in Nest (D)	Dead hatchlings outside of shells
Undeveloped (UD)	Unhatched eggs with no obvious embryo
Unhatched (UH)	Unhatched eggs with obvious embryo (excluding UHT, S1-S4)
Unhatched Term (UHT)	Unhatched apparently full term embryo in egg shell or pipped (with a small amount of external yolk material)
Emerged (E)	Hatchling departed from nest
Depredated (P)	Nearly complete shells containing egg residue. Includes shells predated by animals, fungi and vegetation.

$$\text{Hatching Success (\%)} = \frac{\#\text{shells}}{\#\text{shells} + \#\text{UD} + \#\text{UH} + \#\text{UHT} + \#\text{P}} \times 100$$

$$\text{Emergence Success (\%)} = \frac{\#\text{shells} - (\#\text{L} + \#\text{D})}{\#\text{shells} + \#\text{UD} + \#\text{UH} + \#\text{UHT} + \#\text{P}} \times 100$$

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 (next day, as night photography is not permitted)

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 leatherback 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 Green Season Report 2009 and the Playa Norte Hawksbill Season Report 2009).

7.1. Beach habitat management

Prior the start of the 2009 Leatherback 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. Temporal distribution

Leatherback nesting activity was recorded from the 16th March to the 14th July. A total of 155 tracks were recorded, of which 70 were nests and 85 were half moons. The peak of the activity corresponded to the third week of April to the first week of May (from 12th April to 9th May) (Figure 6).

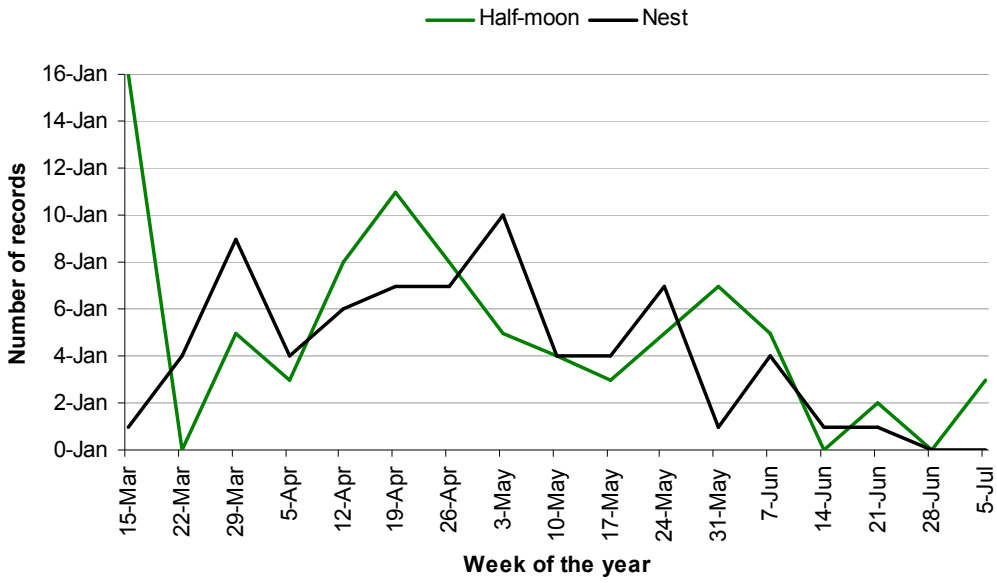

Figure 6. Temporal distribution of leatherback nesting activity during the 2009 nesting season on Playa Norte, Tortuguero, Costa Rica.

7.2.2. Spatial distribution

Nesting activity concentrated between the miles 1 and $1^{7/8}$ (with higher number of nests at mile $1^{2/8}$) and at the end of the beach, between the mile 3 and mile $3^{1/8}$. The lower numbers of nests were reported at mile 1/8 (where the beach can get very narrow), mile 4/8, mile $1^{3/8}$, mile $1^{4/8}$ and mile $2^{3/8}$ (where two houses and one lodge are located respectively) (Figure 7). According with the vertical position, 68 nests were located in the open and only two were located in the border.

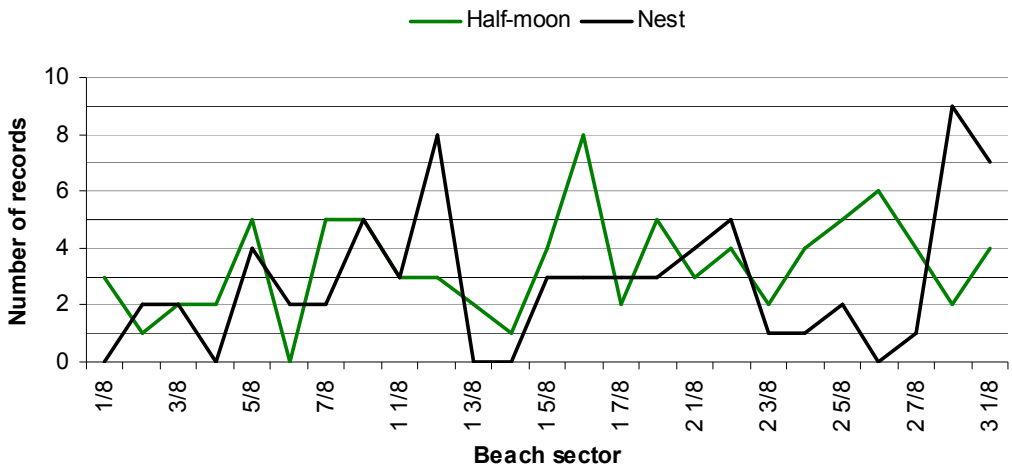

Figure 7. Spatial distribution of leatherback nesting activity during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

7.2.3. Nest status based on morning census

Of the 70 leatherback nests monitored during morning census, 65 nests were found to be natural on the first two days after being laid (including all relocated nests) and five were determined as unknown. One nest had signs of inundation; however, none of the nests had signs of predation or erosion.

7.3. Hatchling orientation

It is not possible at present 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 5th November for the end of green season - the last recorded leatherback activity was on 14th July. Patrols were usually composed of two teams on the beach, with occasionally a single team due to shortage of personnel. There were 141 night patrols in total throughout the Leatherback Season. Patrols normally lasted for four hours and were occasionally cancelled or cut short due to unsafe environmental conditions.

7.4.1. Encountered turtles

Throughout all the patrols, 79 turtles were encountered; of which 53 nested and 26 were half moons. The peak encounter time for nesting turtles was 23:00 to 23:59. Most turtles were encountered digging egg chamber and digging body pit (Table 2), and their direction of nesting was found to be mainly towards the East (Figure 8).

Table 1. Encountered nesting activities of leatherback turtles by patrol teams on Playa Norte, Tortuguero, Costa Rica.

Encounter occurrence		%
Emerging from the sea	12	15.2
Selecting a nest site	8	10.1
Digging body pit	13	16.5
Digging egg chamber	18	22.8
Oviposition	6	7.6
Covering egg chamber	2	2.5
Disguising nest	11	13.9
Returning to sea	9	11.4

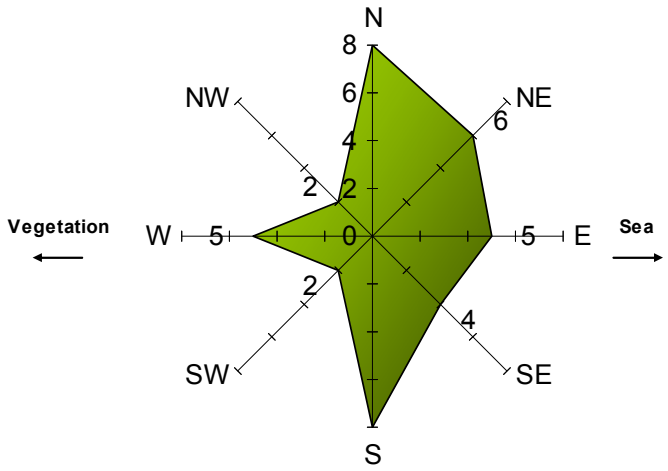

Figure 8. Direction of nesting of leatherbacks turtles during the nesting season 2009 on

7.4.2. Tagging

Of all the turtles encountered by patrols teams, 36 individuals were identified. Thirteen turtles came up without tags and were tagged by patrol teams; 23 came up with tags and were previously tagged either on Playa Norte (previous or current nesting season) or other regions.

Out of all the identified nesting turtles, 11 individuals were recorded re-nesting within the season in Playa Norte. Two individuals were recorded nesting four times, two were recorded three times, and seven recorded twice. The intervals between seeing these individuals varied from nine to forty days.

7.4.3. Biometric Data

Only nesting turtles with tag information were measured. CCLmin and CCWmax were measured a total of 48 times. Thus, those individuals observed more than once were measured repeatedly over the nesting season to ensure greatest accuracy. The mean carapace length for all observations was 149.38cm (n=48, S.D=6.40) and the mean carapace width was 108.91cm (n=48, S.D=5.85).

7.4.4. External condition of nesting females

Abnormalities were detected in 32 individuals. All of them presented small mutilations such as scars and scratches. Two individuals also presented an incomplete caudal projection.

7.5. Nest fate, hatching success and emergence success

A total of 70 leatherback nests were laid, of which 39 were natural nests and 31 were relocated nests. Out of the successfully excavated nests (n=37), 14 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 were excavated 75 days after being laid.

The incubation time of leatherback nests was determined by referring to hatched nests with original nest date, and those seen with hatchling tracks. It ranged from 61 to 67 days, with an average of 65 days.

7.5.1. Relocated nests

Of all relocated nests (n=31), one was not done, and the rest were excavated successfully. Twenty two nests were found to be natural, six were un-hatched, and two were eroded.

7.5.2. Natural nests

Of all natural nests (n=39), nine were triangulated, of which five were excavated successfully. Four nests were found to be natural and one was partially poached. Also, two nests that were not triangulated were excavated two days after signs of hatchlings were recorded, both of them were found to be natural.

7.5.3. Summary of all excavations

A total of 2,416 fertile eggs were excavated, 1,100 of which had hatched. A summary of hatching success and emerging success rates of all triangulated nests is illustrated in Table 3.

Table 2. Summary of hatching success and emerging success of natural and relocated nests of leatherback turtles on Playa Norte, Tortuguero, Costa Rica.

	N	Hatching success %	Emerging success %
NATURAL			
Natural & hatched	3	73	70
Natural & un-hatched	3	0	0
Partially poached	1	33	33
RELOCATED			
Eroded	2	-	-
Natural & hatched	22	59	55
Natural & un-hatched	6	0	0

A breakdown of the excavation result for natural and relocated nests is presented in Table 4 and 5. Bacteria/fungal infections were present in the majority of nests; however, it is still unknown in the general literature whether or not infection/infestations occur post egg mortality or can be the cause of egg death. Therefore it is only possible to denote infections/infestations rather than allocate them as reasons for nest/egg failure.

Table 4. Summary of triangulated and excavated nests of leatherback 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													
Natural & hatched	222	67	74	162	2	5	36	4	2	1	10	7	0
Natural & un-hatched	232	102	77	0	0	0	49	137	0	1	35	2	8
Partially poached	3	44	3	1	0	0	2	0	0	0	0	0	0
RELOCATED													
Eroded	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural & hatched	1585	669	72	937	30	36	266	51	56	57	76	8	134
Natural & un-hatched	374	168	62	0	0	0	174	4	44	102	12	0	38

Table 5. Summary of infestations/infections and of predation (crabs) of eggs in triangulated and excavated nests of leatherback turtles on Playa Norte, Tortuguero, Costa Rica.

NATURAL	Ants	Larvae	Bacteria/Fungi	Crabs	Unknown
Natural & hatched	0	14	47	0	19
Natural & unhatched	0	0	44	0	0
Partially poached	0	0	2	0	0
RELOCATED					
Eroded	0	0	0	0	0
Natural & hatched	4	58	367	8	13
Natural & unhatched	0	1	220	0	5
Total	**4**	**73**	**680**	**8**	**37**

7.6. Poaching of adult turtles

No poaching or lifting of adult leatherback turtles was recorded throughout the season.

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 9).

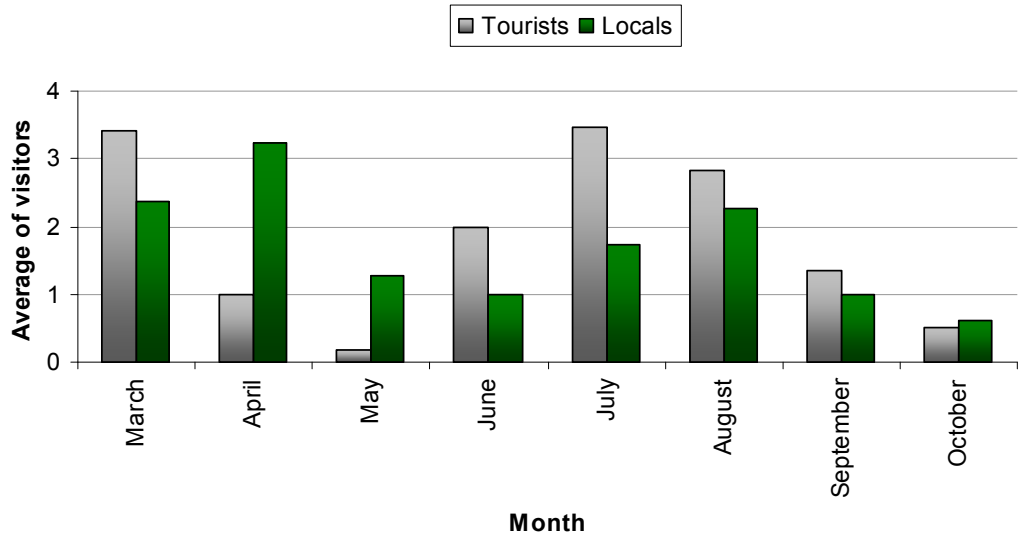

Figure 9. Monthly variations of the total number of tourists and locals recorded during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

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 10). Concerning the stationary lights, the number of red and white lights increased steadily has the season progress. However, no new structures were built therefore this was most likely due to human error and/or people turning on security lights not necessarily on at other times of year.

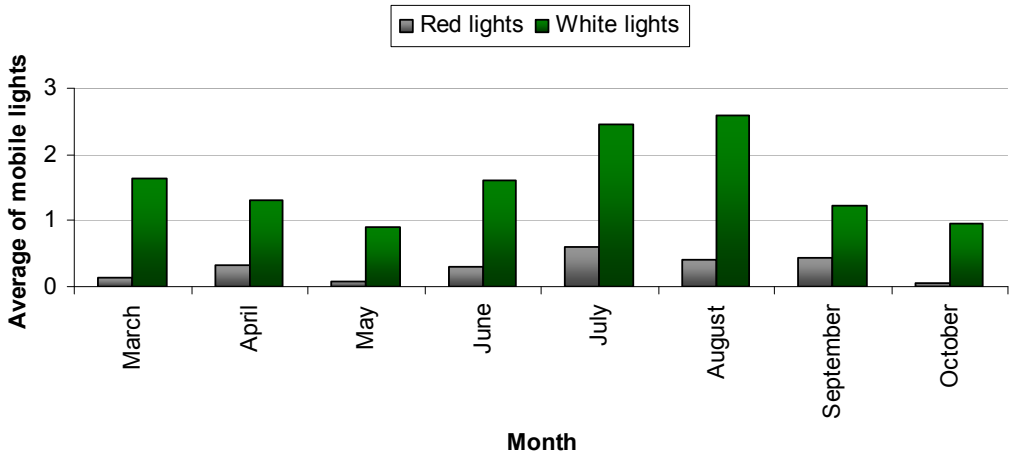

Figure 10. Monthly variations of the total number of mobile red lights and white lights recorded during the nesting season 2009 on Playa Norte, Tortuguero, Costa Rica.

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 prior to, and throughout, the nesting season. The cleaning of debris helps to improve the nesting habitat by decreasing pollution and preventing sea turtles from entanglement and injury from non-natural objects.

8.2. Morning track census and nest status

8.2.1. Temporal distribution

The total number of nests this season (n=70) was lower than seasons 2005 and 2008, but higher than seasons 2006 and 2007, showing the fluctuations of leatherback turtle nesting populations throughout years. However it is too early to determine any population pattern or trend due to the normal two to three-year remigration intervals (Chacón & Araúz 2001, Chacón 2004). As with previous seasons, April and May contained the highest nesting activity.

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. In addition, miles 4/8, $1^{3/8}$ and $1^{4/8}$ only experienced half-moons. At this point in time it is not possible to isolate one particular factor; however, human disturbances, such as activity, presence of dogs or light pollution (one small hotel, and two houses) most likely contribute. 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.

The beach was extremely dynamic this season, experiencing several flood and erosion events. In relation to the vertical position, 97% of the nests were in the open, meaning the nests were subjected to sunlight for the majority of the day. The proximity to high tide line

suggested that nests were highly vulnerable to beach erosion and explains why relocations are important on Playa Norte in order to increase the survival rate of leatherback nests.

8.2.3. Nest status based on morning census

The 93% natural rate of relocated nests showed the success of relocation, which lowers the risk of nests being poached or eroded. This reinforces the necessity of a relocation permit for the 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 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 ranged widely from 21:00 to 03:59 indicating 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. It is unknown for what reason this behaviour was observed.

8.4.2. Tagging

This season 13 turtles were newly tagged, a slight increase compared to previous seasons; however, our sample size is too small to draw any conclusions at this stage.

Some of the previously tagged turtles were tagged along the Caribbean coast from Gandoca to Tortuguero, illustrating the migratory nature of leatherback turtles and the sharing of leatherback 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.

The return of turtles tagged previously on Playa Norte suggests that the nesting/remigration pattern of our leatherback nesting population could be of a two-year interval. Once again, with a relatively small data set combined with the lengthy lifecycle and large nesting area (greater Caribbean) life history of this species, it is very difficult to say this with certainty.

The registered re-nesting interval of nine to 40 days matched with the estimates for the most common re-nesting interval of 9 to 10 days (Pritchard 1971, Witt *et al.* 2008), the upper end of the re-nesting interval is likely due to turtles either returning to nest on another beach, 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 minimize discrepancies.

8.4.4. External condition of nesting females

Small abnormalities like scratches and scars could be caused by either natural wear-and-tear as turtles grow older or by natural predators. Large mutilations could be caused by natural predators or could be marks from poachers/fishermen, interactions with fishing gear, boat motors, and other anthropogenic factors.

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 conservation efforts such as nest disguising and relocation and hopefully 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. Relocated nests

Of all relocated nests, only one nest was not excavated because of the loss of flagging tape – which represents a triangulation accuracy of 97%.

8.5.2. Natural nests

Of all triangulated nests, one nest was not excavated because of the loss of flagging tape, one because of a wrong triangulation measurement, and the other two nests were eroded.

8.5.3. 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 or lack of fertilization to begin with. The close proximity of leatherback nests to the high tide line and the possible rising of ground water/saturation due to heavy precipitation are possible reasons.

The overall poaching rate of all triangulated nests was lower from previous seasons. None of the relocated nests were poached proving the benefits of relocating nests from areas of high poaching. However, continuous conservation education in the community is believed to be the ultimate solution to continue to reduce poaching.

8.6. Poaching of adult turtles

It was encouraging that no poaching or lifting of leatherback turtles was found on Playa Norte, this contrasted with four green turtles being poached and six being lifted in the

same year. This not only reflects the shear difficulty of taking one of these rather large animals, but also 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 overall decrease in mobile lights regardless of colour since Turtle Beach Lodge began to utilize the Tortuguero Turtle Observation program.

8.8 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 program. This is to be a lengthy 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 tourists alike.

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.

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