Marine Turtle Monitoring and Tagging Program

Green Season Report

2019

Caño Palma Biological Station
Canadian Organisation for Tropical Education and Rainforest Conservation
Playa Norte, Costa Rica

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Green Turtle (*Chelonia mydas*) 2019 Season Report.

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List of Acronyms

COTERC: Canadian Organisation for Tropical Education and Rainforest Conservation.
CPBS: Caño Palma Biological Station.
STC: Sea Turtle Conservancy.
ACCSTR: Archie Carr Center for Sea Turtle Research.

MINAE: Ministry of Environment and Energy.
SINAC: National Area of Conservation.
ACTo: Tortuguero Area of Conservation.
TNP: Tortuguero National Park.
AC NWR: Archie Carr National Wildlife Reserve

CM: *Chelonia mydas*.
REC: New individual turtle record (newly tagged).
REM: Re-emerging turtle between nesting seasons (previously tagged).
REN: Re-nesting turtle within the same nesting season (previously tagged).
MC: Morning census.
NP: Night patrol.
CCLmin: Curved carapace length.
CCWmax: Curved carapace width.
HLF: Half-Moon.
NST: Nest.
OTH: Old Tag Hole.
OTN: Old Tag Notch.
TBL: Turtle Beach Lodge.
GPS: Global Positioning System.
TRI: Triangulated Nest.
NTRI: Non-Triangulated Nest.
PL: Patrol Leader.

1. Summary

The official green (*Chelonia mydas*) nesting season is 01st June until the 31st October, however we recorded the first green emergence on the 5th of June, found by night patrol the last green emergence was found by morning census on the 14th of November 2019, therefore this report will discuss all nesting events from 5th of June 2019 until 14th of November 2019. In 2019, night patrol concluded on the 26th October, and morning census concluded on the 28th December.

1.1 Survey Effort

- The average duration (hrs:mins) of night patrol during the green nesting season (01st June until 26th October) was 06:11, with a total survey (hrs:mins) time of 948:06.
- The average duration (hrs:mins) of morning census during the green nesting season (01st June until 28th December) was 03:02, with a total survey time (hrs:mins) of 622:37.

1.2 Nesting Activity

- The first successful nest of the season was on the 5th of June and was encountered by the night patrol team and the last was on the 14th November and was found by the morning census team.
- In total, there were 411 nests and 1314 half-moons recorded between the 5th of June and 14th of November, along our 3 1/8th mile study transect, Playa Norte.
- Of the emerging greens, the encounter rate by the night patrol was 12.4% (214 out of 1725) with tag data recorded on 126 occasions (57 REC, 39 REM, 15 REN, 15 NO TAG).
- The night patrol teams encountered 6.7% (88 out of 1314) of greens during a half-moon.
- Of the nesting greens, 30.7% (126 out of 411) were encountered by the night patrol with 70.6% (89 out of 126) encountered before or during oviposition and were triangulated.

1.3 Nest Success

- Average no. of yolked eggs 114 ± 21 (x̅ ± std; [7, 159], *n*=68). Sample size (*n*) is based on individuals encountered before oviposition.
- Average no. of yolkless eggs 0 ± 1 (x̅ ± std; [0, 5], *n*=68). Sample size (*n*) is based on individuals encountered before oviposition.
- Average incubation period (days) was 60 ± 6 (x̅ ± std; [51, 75], *n*=36). Incubation period is calculated based on the no. of days from the lay date, to the morning hatchling tracks were observed.
- Average hatching success was 77.1% ± 33.8 (x̅ ± std; [0, 100], *n*=50).
- Average emergence success was 76.1% ± 34.8 (x̅ ± std; [0, 100], *n*=50).

The 89 triangulated nests were checked daily during the incubation process, with the following outcome:

- 50 nests remained natural and were successfully excavated.
- 1 nest was eroded and 3 were flooded.
- 11 nests were not found during the excavation process.
- 13 nests were poached and 10 were predated
- 1 was recorded as unknown

1.4 Biometrics

- Average (cm) minimum curved carapace length (CCLmin): 104.8 ± 7.19 (x̅ ± std; [92.0, 119.6]; *n*=104).
- Average (cm) maximum curved carapace width (CCWmax): 94.7 ± 4.8 (x̅ ± std; [83.2, 108.3], *n*=103).

1.5 Body Check

- The most common observed abnormality on the green were barnacles, accounting for 56.7% of all abnormalities checked for during the body check.

2. Introduction

Four marine turtle species have been documented to nest on the Caribbean coast of Costa Rica: leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and, in significantly lower numbers, loggerhead (*Caretta caretta*) (Ernst & Barbour, 1989), all of which have been recorded on Playa Norte, our study beach.

Caño Palma Biological Station (CPBS) was founded in 1991 by Marilyn Cole and Ozzie Teichner, and the Canadian Organization for Tropical Education and Rainforest Conservation (COTERC) was established shortly afterwards. COTERC is a registered non-profit organization in Canada that owns and manages the CPBS. The CPBS invites volunteers, interns, and researchers to study different taxonomic groups and participate in a variety of long-term projects including the Marine Turtle Monitoring & Tagging Program, which has been in operation seasonally since 2006. The project aims to conduct daily morning and night patrols to fulfil the following goals:

1. Conduct research and collect data on nesting sea turtles on Playa Norte.
2. Assess the health status of nesting individual females.

3. Educate the public (local community and tourists) about sea turtle biology and conservation.
4. Deter poaching by maintaining a presence on the beach.

This report focuses exclusively on the results of the 2019 Marine Turtle Monitoring & Tagging Program during the green (*Chelonia mydas*) sea turtle nesting season. Detailed information on the standardised methods used for data collection is provided for all aspects of the project. Protocols were utilised to ensure data comparability between nesting seasons and of other projects. This enables a greater understanding of the nesting trend, and places our long-term dataset in a wider context.

2.1 Species Characteristics

All hard-carapace marine turtles belong to the family Cheloniidae. This family is believed to have branched 50 million years ago into the six-species alive today: green, hawksbill, loggerhead, Kemp's ridley, olive ridley, and flatback (Spotila, 2004). Until recently it was thought that the green turtle comprised of two evolutionary significant units; green (*Chelonia mydas*) and black (*Chelonia agassizii*), however, genetic analysis has discounted this theory and they are now widely accepted to be two subspecies of *C. mydas* (Karl and Bowen, 1999). Greens are the slowest maturing of the marine turtle species; depending on the population, the estimated age to reach sexual maturity is between 25-50 years (Mendonça 1981; Eckert & Abreu Grobois, 2001; Spotila, 2004). This may be due to their herbivorous diet of sea grass, upon which the adults almost exclusively feed (Bjorndal *et al* 1999). Greens are distributed across the tropics and sub-tropics, and migrate hundreds of miles between feeding and breeding grounds (Eckert & Abreu Grobois, 2001). It is known that females return to the natal beach in order to nest (Eckert & Abreu Grobois, 2001). It is widely accepted that they achieve this navigational feat through geomagnetic imprinting (Brothers & Lohmann, 2015). The largest green turtle rookery in the Western hemisphere is in Tortuguero, Costa Rica (approximately seven miles south of Playa Norte) (STC, 2014). It is estimated that 17,402–37,290 females nest annually at this location (Bjorndal *et al*., 1999; Troëng & Rankin, 2005).

Table 1: Nesting characteristics of the green (*Chelonia mydas*) sea turtle found throughout Costa Rica (Adapted from Chacón *et al.*, 2007).

Characteristic	**Description**
Average Length Sexually Mature Female (CCLmin) (cm)	104.6
Inter-Nesting Frequency (nests/season)	3
Re-Migration Interval (yrs.)	2-3
Inter-Nesting Interval (days)	12
Average Clutch Size (yolked eggs)	112
Average Track Width (cm)	100-130
Track Shape	Symmetrical
Average Nest Depth (cm)	55
Nesting Season on the Caribbean Coast of Costa Rica	June to October: Barra del Colorado, Tortuguero, Parismina, Pacuare, Matina, 12 millas, Negra, Cahuita, Gandoca.

Nesting Season on the Pacific Coast of Costa Rica	September to March: Cabuyal, Ostional, Caletas, Camaronal, Matapalo, Nancite, Naranjo.
Pivotal Nest Temperature (°C)	28.6
Average Incubation Period (days)	48-70
General Characteristics	Four pairs of lateral scutes and five vertebral scutes on the carapace. One pair of prefrontal scales and two pairs of postorbital scales. Its shell is greenish and black, scales do not overlap and the plastron is yellowish. It has a claw on the outside of each flipper.

2.2 Anthropogenic Threats

Aside from natural threats such as predation and tidal inundation of nests, green sea turtles, like all species of marine turtle, are under threat from humans in both the marine and terrestrial environment (Ehrenfeld *et al.*, 1990; Jackson, 2001; Campbell & Lagueux, 2005; Troëng & Rankin 2005). Pelagic long-line fisheries, entanglement in fishing gear, and propeller strikes are common causes of marine turtle mortality (Troëng, 1998; Campbell & Lagueux, 2005; James *et al.*, 2005). Ingestion of marine debris, which affects feeding behaviour, poses a significant threat to marine turtles (Bjorndal *et al*., 1999; Bugoni *et al*., 2001; Vélez-Rubio *et al.*, 2013).

It has been estimated that green turtle numbers in the Caribbean exceeded tens of millions before the arrival of Europeans in the 15th century and that harvesting has reduced the population by 93-97% (Jackson, 2001). This decline has been mirrored throughout the tropics with the species being exploited for its meat and eggs (Troëng & Rankin 2005).

All species of marine turtle are affected by domestic dog predation of nests (Choi & Eckert, 2009). Hatchlings that successfully emerge are vulnerable to disorientation caused by artificial light pollution, entanglement in marine debris, and predation (Witherington & Martin, 2003; Bourgeois *et al.*, 2009; Triessnig *et al.*, 2012; Berry *et al.*, 2013). While data are limited, currently a 1:1000 egg to adulthood ratio is estimated (Frazer, 1986).

2.3 Current Status and Conservation Efforts

Due to the rapid decline in numbers, green sea turtles are afforded international protection. All marine turtle species are listed under several international conventions, including Appendix I of the Convention on International Trade in Endangered Species (CITES). This prevents almost all of international trade in the species or their derivatives. They are also listed under Appendix I and II of the Convention on Migratory Species of Wild Animals (CMS) and the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC). The hawksbill is listed as Critically Endangered and decreasing on the IUCN Red List of Threatened Species (Seminoff, 2002; Mortimer & Donnelly, 2008).

Measures have been implemented to protect marine turtles at sea, such as the introduction of Turtle Excluder Devices (TEDs) to trawl nets, which act as a trap-door to enable the escape of turtles caught in gill nests (Safina, 2007). Other ex-situ conservation efforts for marine turtles include; the relocation of nests to hatcheries and, conservation medicine and rehabilitation, are beyond the scope of this report (see: Chacón *et al*., 2007; Phelan & Eckert, 2006). Some of the common in-situ conservation efforts include; patrolling beaches to prevent poaching, relocation of nests laid below the high tide line, and the establishment of tagging and monitoring programs to assess population trends and demographics of marine turtle populations. The increase of the nesting population in the Caribbean has been attributed to these methods, which are the methods employed by most of the sea turtle conservation projects in Costa Rica (Dutton *et al*., 2005; Gordon & Harrison, 2011).

The study site of our Marine Turtle Monitoring and Tagging Program of COTERC, is Playa Norte (fig. 1), and according to Costa Rican law N° 8586 (conservation of migratory species and wild animals) articles 1° and 3° (including endangered marine species and habitats part of the distribution of migratory species), public access to Playa Norte is prohibited between 18.00 and 05.00 during the official sea turtle nesting season. This legally corresponds to the period from March 1st until October 31st. The Marine Turtle Monitoring and Tagging Program focuses on in-situ conservation through beach patrols to protect nesting females, protection of nests, beach cleans to remove marine debris, working to reduce artificial lights on the beach, and promoting environmental education.

3. Methods

3.1 Study Site

Data collection was carried out along a 3 1/8th mile (approximately 5km) beach transect on Playa Norte (fig. 1), stretching from the river mouth of Laguna Tortuguero (Datum WGS84 552224.9E 1170322N) to Laguna Cuatro (Datum WGS84 550043.7E 1175989N). Playa Norte is located north of Tortuguero National Park (TNP) and is situated within the Barra del Colorado Wildlife Refuge. The area is managed by the Tortuguero Conservation Area (Área de Conservación Tortuguero, ACTo) and is regulated by Ministerio de Ambiente y Energía (MINAE), the Costa Rican Ministry of Environment and Energy.

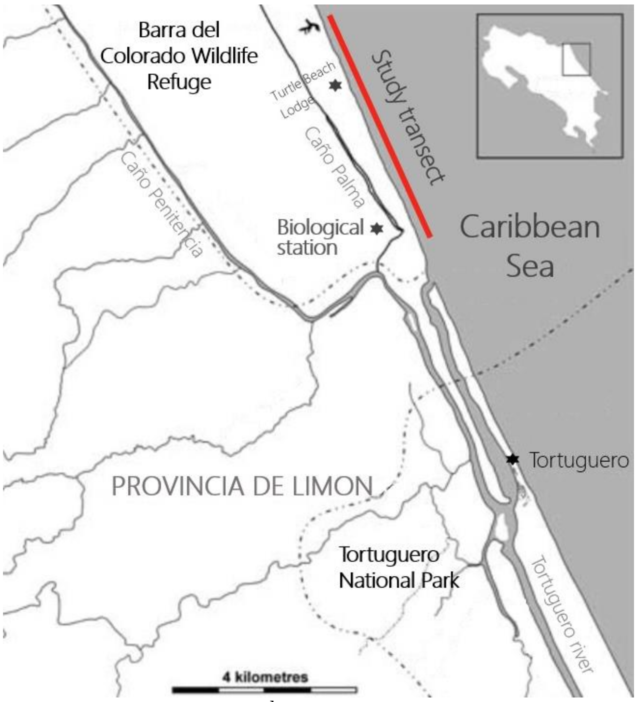

Fig 1: Descriptive map showing the 3 1/8th mile survey transect highlighted in red, and the location of Cano Palma Biological Station (CPBS) (modified from Grant & Lewis, 2010).

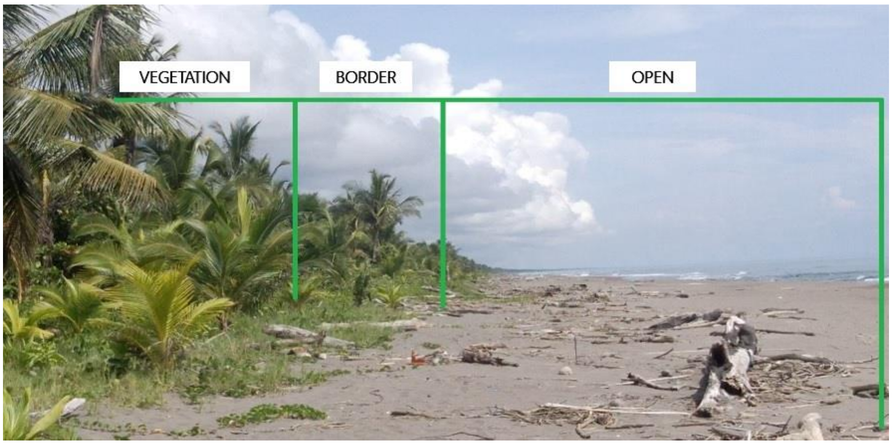

Fig 2. An illustration describing the different sectors of vertical beach zones, differentiated by the amount of shade cover each area receives.

Along the beach transect, mile markers were placed every 1/8th of a mile to facilitate the orientation and to allow spatial nest distribution analysis along the horizontal beach axis.

The GPS coordinates of the markers were recorded with a Garmin GPSMAP 62S device for the spatial analysis. These markers were replaced and painted in February, as well as every time it was necessary. The beach is divided vertically into three sections (fig. 2) differentiated by shade cover, open (0%), border (50%), and vegetation (100%). This is done in order to also analyse spatial nest distribution along the vertical beach axis.

A semi-illuminated path runs parallel to the beach. There are two hotels (Hotel Vista al Mar, not in function, and Turtle Beach Lodge), and several private residencies along the beach transect. The public lights on the path and the private lights from hotels and houses can cause artificial light pollution in the vegetation along the beach, and sometimes directly on the beach itself, which poses a threat to the orientation of nesting turtles and emerging hatchlings (Witherington & Martin, 2003; Bourgeois *et al*., 2009; Berry *et al*., 2013).

Beaches and wetlands in Costa Rica are legally protected under Resolución ACTo-Dirección-04-2013, and as such the use of motorized vehicles is prohibited in the area anywhere within 200 meters inland of the high tide line. This would include the public path parallel to Playa Norte. Nonetheless, vehicles including motorbikes, four-wheel quads, and occasional trucks are observed.

3.2 Data Collection

3.2.1 Night Patrol Protocol

During the 2019 official green sea turtle nesting season (01st June to 26th October), patrols were carried out on as many nights as were made possible given the available people. The minimum duration of night patrol was 6 hours, and consisted of a minimum of three persons. On the occasion of two night-patrol teams, they were scheduled to overlap to maximise beach coverage (table 2), with one team patrolling the north end of the beach and one team patrolling the south end.

Table 2: An example of the night patrol teams, showing the duration and the hours of overlap on the beach.

Time	**20:00**	**21:00**	**22:00**	**23:00**	**00:00**	**01:00**	**02:00**	**03:00**	**04:00**
PM1									
PM2									

In order to ensure the safety of our teams, minimize the impact on turtles, and be as discrete as possible in the beach, night patrol has the following rules:

- Dark clothing must be worn.
- No alcohol before or during Night Patrol.
- No smoking during Night Patrol.
- Limit light usage and only use red light.
- Do not apply insect repellent before or during patrol.
- Stay behind or next to patrol leader (PL) at all times.
- If you see poachers tell the PL, never approach poachers.
- Walk on or below the most recent high tide line when possible.
- Keep quiet when walking the beach and when encountering a turtle.
- Never walk in front of the turtle or shine light near its head.
- Taking pictures or video is not allowed in night patrol.
- Patrol is cancelled or delayed if there is a lack of appropriate personnel or during extreme lightning storms when there is a risk of injury.

Night Patrol collects data on:

Tracks and nests (turtle absent): For each encounter the species and location data (northern mile marker, vertical beach zone, G.P.S. co-ordinates, and G.P.S. accuracy) are recorded. The vertical beach zone and the G.P.S. coordinates of half-moons were taken at the furthest point from the tide line that the turtle had reached. The encounter was recorded either as nest (NST) or half-moon (HLF).

Nesting sea turtles (turtle present): For all turtles encountered the following was recorded: species, encounter time, encounter activity (NST/HLF), and location data. If encountered before oviposition, it was possible to count the eggs and triangulated the nest. For all nesting turtles encountered, the flippers were checked for pre-existing tags and evidence of old tags (indicated by holes or notches in areas commonly used for tag placement). If no tags were found, new tags were applied by a trained patrol leader. Once collection of tag data/tagging occurred, morphological measurements were taken and an external health-check conducted. A turtle facing the sea and located halfway between the sea and the vegetation zone was assumed to be returning to the sea. In these circumstances, the turtle was checked for pre-existing tags if possible. If tags were present, tag data was recorded, and morphological data taken and health check performed, again, if possible. If the turtle did not have tags, administering new tags was not attempted, due to risk of injury to the turtle. An overview of the different nesting stages and appropriate action to be taken by the team is provided in table 3.

Table 3: Stages of nesting activity and corresponding actions to be taken by patrol teams if the individual is encountered at any stage.

Nesting stage	Action
1) Emerging.	Wait.
2) Selecting nest site.	Wait - Patrol Leader checks on progress.
3) Cleaning.	Wait - Patrol Leader checks on progress.
4) Digging egg chamber.	Wait - Patrol Leader checks on progress.
5) Oviposition.	Egg counting & nest triangulation.

6) Covering egg chamber.	Egg depth, tag data, CCLmin and CCWmax, and body check.
7) Disguising the nest.	Tag data, CCLmin and CCWmax, and body check.
8) Returning to sea.	Check for tags, and if present: tag data, CCLmin and CCWmax, and body check (at the patrol leader's discretion).
9) After working the turtle.	Check data and equipment, record GPS of the nest, disguise the nest and tracks.

Egg Counting and Nest Triangulation

Eggs were counted during oviposition by placing a hand below the cloaca and counting each egg as it passed over the hand into the egg chamber. While the turtle was digging the egg chamber the patrol leader created a shallow channel to the mouth of the egg chamber, allowing access to the egg chamber without touching the cloaca. A medical latex glove was worn when counting eggs. The Nest ID, the nest identification number was dropped into the nest at the beginning of oviposition, after which egg counting and triangulation of the nest began. The yolked eggs were counted using the counter, and the number of yolkless eggs were counted mentally. At the end of oviposition, when the turtle began covering the egg chamber with her rear flippers, the egg depth, distance from the uppermost egg to the top of the egg chamber, was measured (cm) with a flexible 3m measuring tape.

Egg counting and triangulation were conducted simultaneously. The end of a 50m tape measure was held directly over the egg chamber, taking care to avoid contact with the turtle. The triangulation team tied the appropriately labelled (centre, north and south) flagging tapes on three sturdy pieces of vegetation with at least 45 degree angles from one another (fig. 3), and recorded the distance from the egg chamber to the three fixed points, and then to the high tide line. For accuracy purposes the knot was tied to face the direction of the nest and care was taken to ensure the tape was tight and not caught on anything between the turtle and triangulation point.

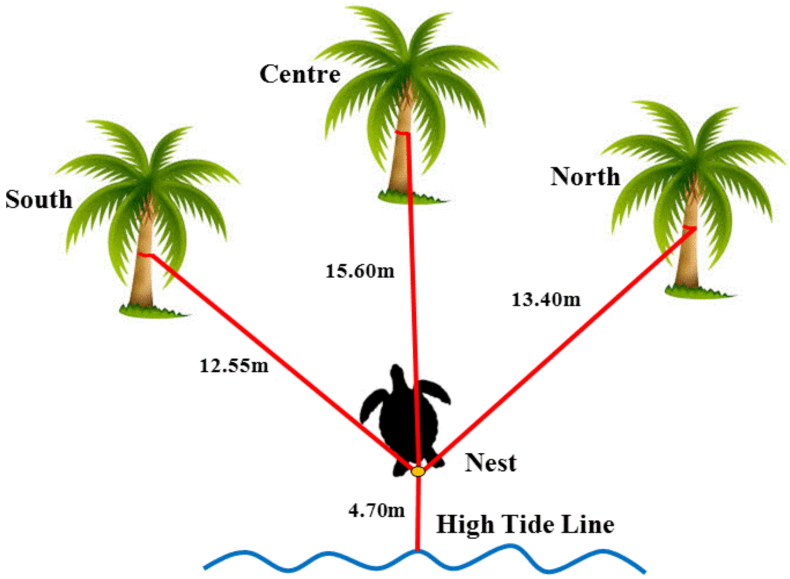

Fig 3: An example of the nest triangulation, to mark the nest location. The red lines indicate the measurements taken from the egg chamber to the three fixed points in the vegetation.

Tag Information

Tagging enables the identification of individual turtles, which in turn allows us to build up an historical record of that individual based on morphometric data, nesting events, and health status. Green sea turtles are tagged on the front flipper, on the skin before the primary scale (fig. 4). If tagging in this location is not possible due to an injury, scar tissue or other abnormalities, the tag should be placed between the primary and the secondary scale or through the primary scale (fig. 4). After oviposition, the patrol leader (PL) checks for previous tags, first the right flipper and then the left, and if present the numbers are recorded after being repeated by the PL and volunteer to avoid misinterpretations. Old tag evidence was recorded as either an old tag hole (OTH) or an old tag notch (OTN) (fig. 4). If no tags were present, the PL administered new ones. A correctly placed tag is positioned so that one third (or two numbers) of the tag is off of the flipper and two thirds (or four digits) are over the flipper. This prevents friction and allows space for possible swelling. Unreadable tags, tags causing damage (e.g. ingrown) or tags that were likely to cause damage or fall out in the near future (e.g. tag placed too far in with a risk of becoming ingrown, or tag placed too far out with the risk of catching on something and ripping out) were removed and replaced. Two tags are never placed in one flipper; an old tag would always be removed before a new tag is placed in the same flipper.

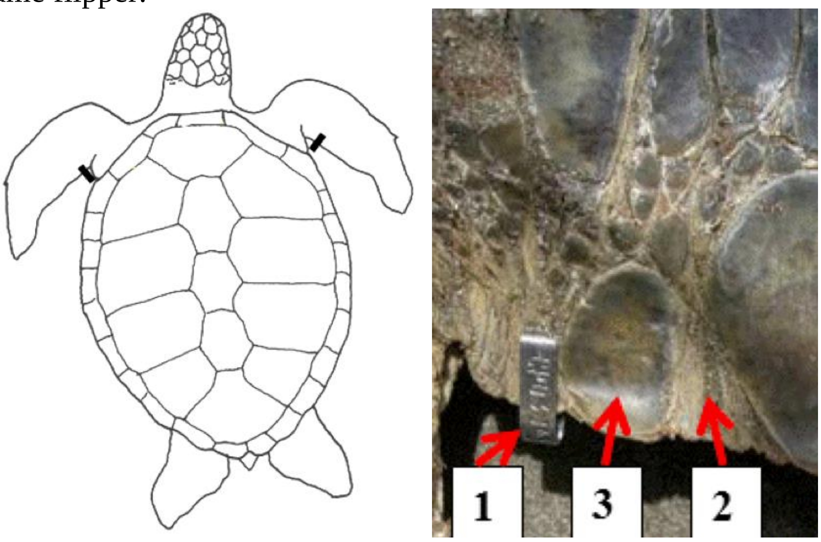

Fig 4: Tag position on hard carapace sea turtles. On the skin before the primary scale (left). Optional tag positions (right) are as follows: (1) before the primary scale on the skin, (2) in between the primary and secondary scale on the skin, (3) through the primary scale.

Biometrics

Biometrics are only taken after the turtle has been tagged or existing tag data recorded. The Curved Carapace Width maximum (CCWmax) and Curved Carapace Length minimum (CCLmin) are measured using a 150cm flexible measuring tape. The CCLmin starts at the point where the skin meets the carapace at the neck and ends along the line between the two marginal scutes on the edge of the carapace (fig. 5). The CCWmax is taken at the widest point of the carapace, usually around the middle (fig. 5). For quality control purposes, each measurement was taken at least three times, within a 1cm range. If something affected the measurements for example, barnacles, it was recorded in the body check.

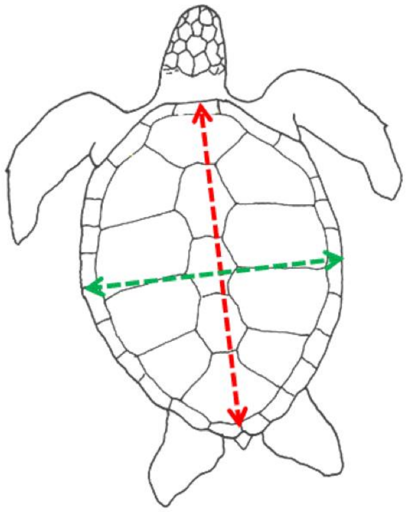

Fig 5: Diagram showing the dimensions of the biometrics taken from hard carapace sea turtles. CCWmax (green) and CCLmin (red).

Body Check

A general health assessment was performed after the measurements are recorded. Injuries such as scars, holes, notches, missing parts of flippers, bite marks, barnacles, tumours, parasites and any other abnormalities are recorded. The body check was carried out following a standardised protocol in which each predefined body zone is given a number from one to eight (fig. 6). The person performing the body check started with zone two (right front flipper) and moved around the body in a clockwise direction. Since zone one (the neck and head) is the most sensitive part of the turtle, and checking it bears the greatest risk of disturbing the turtle, it was done last and with great care. During the body check the light was orientated away from the turtle's head and turned off at any break in the assessment in order to minimise potential disturbance. If no abnormalities were found 'BODY CHECK: COMPLETE' was recorded to confirm the body check has been completed.

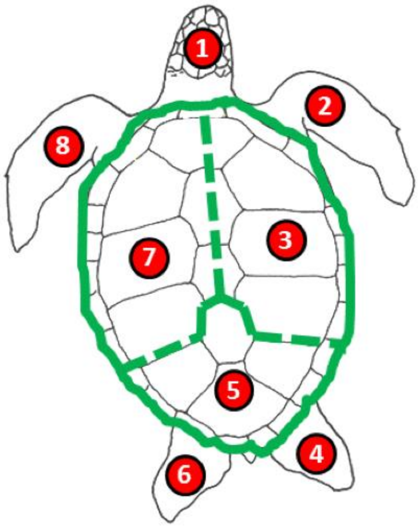

Fig 6: Body check zones. The zones are clockwise starting at zone 2, and ending on zone 1.

3.2.2 Morning Census Protocol

Morning Census (MC) was carried out daily from 1st June to 28th December during the official green nesting season. MC began at 05:15 hrs and the full beach transect was surveyed to collect data on the following:

Nest and track information: MC records and disguises any additional tracks and nests on the beach that had not been encountered by the PM teams. To prevent double counting, a copy of the activity data from the previous night was recorded in the morning census book for reference during the survey.

Nest check: All triangulated nests were checked daily from the day after they were laid to the day of their excavation. The accuracy of the nest's triangulation was checked by morning census immediately after the nest was triangulated. In the event that the lines of the triangle were over 50cm, or the lines did not make a triangle, the night patrol team returned to the nest to correct the triangulation. The status of the nest itself was assessed and any signs of disturbance recorded. Condition classifications were as follows:

- Natural (NAT): nest has no signs of disturbance.
- Wet (WET): nest is below the most recent high tide line.
- Flooded (FLO): nest is completely inundated by the tide.
- Poached (POA): nest shows signs of human disturbance.
- Predated (PRE): nest shows signs of animal disturbance.
- Eroded (ERO): the nest is below a cliff created by the tide, and may be lost.
- Hatching (HAT): signs of hatching activity, hatchlings, tracks or a hatchling hole.
- Depression (DEP): Yes/No, is there a soft depression on the surface of the nest?
- Unknown (UNK): status undetermined or it is impossible to access the nest.

Assessments of the nest status each day allows for detailed conclusions of nest fate, as well as temporal analyses of any disturbance. Daily assessments of the triangulation flagging tapes were essential in order to avoid data loss, as termites, ants or people regularly destroyed tapes.

Nest Protection: Nest protection barriers, hand-made from bamboo are placed, when possible, on green nests to minimise predation by dogs. The average nest depth of a green nest is 55cm (Chacon *et al*., 2007), therefore mesh is placed at a depth of 20cm to avoid disturbance to the egg chamber, consistent with the standardised protocol initiated on Playa Norte in 2014 (Pheasey *et al*., 2018).

Depression Check: The green sea turtle is estimated to have an average incubation period of 55 days, with a range of 48-70 days (Chacon *et al*., 2007). In 2017 on Playa Norte the average incubation period was 56 days (Gutiérrez, 2017). At day 50 of incubation, the nests were re-triangulated and depression sticks (fig. 7) erected to check for signs of hatching. Indications of hatching activity include depression in the sand around the centre of the nest caused by hatchlings ascending to the surface (fig. 7), a small cave-like hole where hatchlings have emerged (fig. 7), and hatchling tracks leading away from the nest (fig. 7). A depression is confirmed by gently pushing a small stick into the depression area, to which the sand underneath will cave.

Fig 7: Examples of depression sticks with active depression (left), hatchling hole (centre), and hatchling tracks after emergence (right).

3.2.3 Excavation Protocol

Nest excavations are conducted to determine the nest success, by calculating hatching and emergence success. Hatching success is the total number of hatchlings that emerge from the egg. Emergence success is the total number of hatchlings that emerge from the nest. Both are calculated as follows:

Hatching Success = (empty shells/ (empty shells + no embryo + stage1 + stage2 + stage3 + stage4 + deformed embryos + predated eggs)) * 100

Emerging Success = ((empty shells – (live hatchlings + dead hatchlings))/ (empty shells + no embryo + stage1 + stage2 + stage3 + stage4 + deformed embryos + predated eggs)) * 100

All triangulated nests were checked daily and were excavated under the following circumstances:

- Hatchling tracks present – excavate two days later.
- Five consecutive days of depression – excavate on the following (sixth) day.
- No signs of hatching by day 65 of incubation – excavate on 65^{th} day.

Non-triangulated nests were excavated if located by the presence of hatchling activity, and showed no signs of dog predation.

The first stage of excavations is to locate the egg chamber by re-triangulating the nest. Sand was then carefully removed using a cupped hand until the first signs of the nest appeared (e.g. empty eggshells, un-hatched eggs or hatchlings). The egg depth was taken from the top of the first visible egg to the top of the nest, and similarly the nest depth from the bottom of the nest. The nest contents were removed and sorted into different categories and assessed (table 4, fig. 8). Eggshell samples of $2cm^2$ were taken from both triangulated and un-triangulated nests, as were embryonic tissue, from embryos with a deformity, when available (from embryos that died before hatching). Deformities were categorised as no eyes, twins, triplets, and/or any abnormal feature. These will contribute to Molly McCargar's PhD study on the population genetics of turtles nesting on Playa Norte, using non-invasive sampling methods. This season, we were permitted to compare the ecological parameters of the nests, and the success of nests between Playa Norte, the Archie Carr National Wildlife Refuge, and Tortuguero National Park. Nests, which were not triangulated by other organizations were excavated between the last week of October and the last week of December, in the same manner as described above for sampling at Playa Norte. Also, small pieces of eggshells, or sometimes embryonic tissue, were sampled from those nests. These samples can broaden our knowledge of genetic diversity in the region, and perhaps, they can allow a comparison within the region. To compare the success of these nests with those of Playa Norte, we only use data from un-triangulated nests. This is because non-triangulated nests are found by hatching signals, while triangulated nests are excavated regardless of whether there are some hatched eggs.

Excavations were stopped and postponed for seven days if more than five live hatchlings were present in the nest or if the eggs appeared to still be developing (white and firm). If fewer than five live hatchlings were present in the nest, the condition of the hatchlings was assessed using the developmental stage of the plastron and the activeness of the hatchling. If the plastron was still open and/or the hatchling was lethargic, they were reburied next to the original nest at the same depth at which they were found. If the plastron was closed and they were very active, the hatchlings were allowed to make their way to sea naturally. Assistance was only given to the hatchlings if the air or sand temperature was dangerously hot, at which point they were given shade on route to the sea or moved to an area of wet sand. Hatchlings were never put directly in the sea. If able to make their own way into the water, it can be assumed that the hatchlings are active enough to swim and keep their heads above water. Hatchlings always walk into the surf without assistance and from a reasonable distance, so they can prepare their muscles and lungs for swimming.

Table 4: The potential nest contents of an excavated nest and a definition explaining how to differentiate each stage class.

Nest Content	Definition
Pipped eggs	Egg is intact apart from a small triangular hole caused by the hatchling's egg tooth.
Hatched egg shells	Shells >50% intact are considered 1 hatched shell.
Live/Dead hatchlings	Hatchlings that emerged from the egg, and are alive or dead inside the nest.
No embryo	Yolked egg with no embryo.
Embryo stage 1	Embryo occupies <25% of the egg.
Embryo stage 2	Embryo occupies 25% - 50% of the egg.
Embryo stage 3	Embryo occupies 50% - 75% of the egg.
Embryo stage 4	Embryo occupies >75% of the egg.
Predated	Micro-predated by fungus or bacteria identified by colour and smell. Crab predation identified by small holes in the egg shell. Ant/maggot presence also recorded.
Deformities	Common deformities include abnormal numbers of scutes, no eyes, albino, twins or tumour like growths on the head.
Yolkless	Non-fertilised eggs that may be hydrated, de-hydrated or predated.

Stage 1 **Stage 2** **Stage 3** **Stage 4**

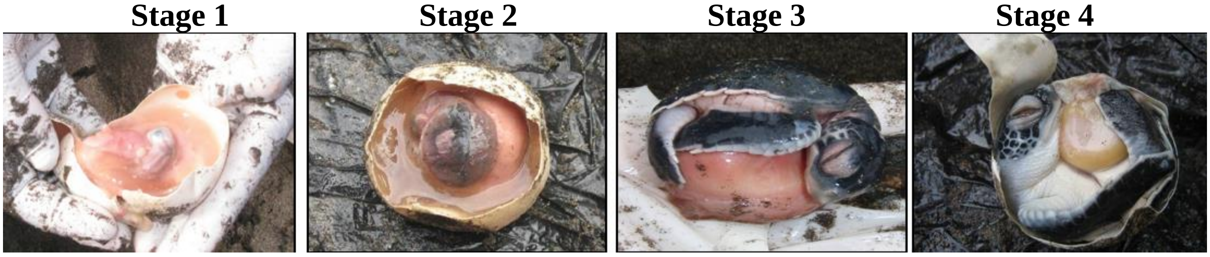

Fig 8: The different developmental stages of a sea turtle embryo.

3.2.4 Human Impact Survey

Public access to Playa Norte is prohibited between 18.00 and 05.00 hrs from March 1st to October 31st. However, due to the low level of law enforcement on Playa Norte, illegal human activity is frequently observed. In collaboration with MINAE, a standardised Human Impact Survey was carried out as part of the nightly patrols throughout the season. Human Impact was divided into six categories: white light (W), cell phone (C), red light (R), fire (F), local (L), tourist (T), and dogs (D). Temporal and spatial distribution was also recorded for each impact category.

4. Results

4.1 Survey Effort

Survey effort is given for the official dates of the green nesting season 1st of June to 26th October.

Morning census continued was carried out daily, after leatherback season, from 01st June (fig. 9) until the last triangulated nest was excavated on the 28th December, with an average survey duration of 03:02. Throughout the season, morning census was conducted on 205 occasions, with 2 teams on 7 occasions.

In 2019, night patrol began on the 15th of March, and the beach was patrolled by at least one team on as many nights as possible given the number of people available. The survey effort for the green nesting season is considered from 01st June until 26th October (fig. 10).

The minimum duration of any night patrol team was six hrs between 20:00 to 04:00, the start and end time dependent on previous nesting activity. In the event of available personnel, two or more teams would patrol the beach to maximise beach coverage. During the green nesting season, we had one team on 135 occasions, two teams on 18 occasions and three teams on 1 occasions, with an average duration of one team 06:11 hrs.

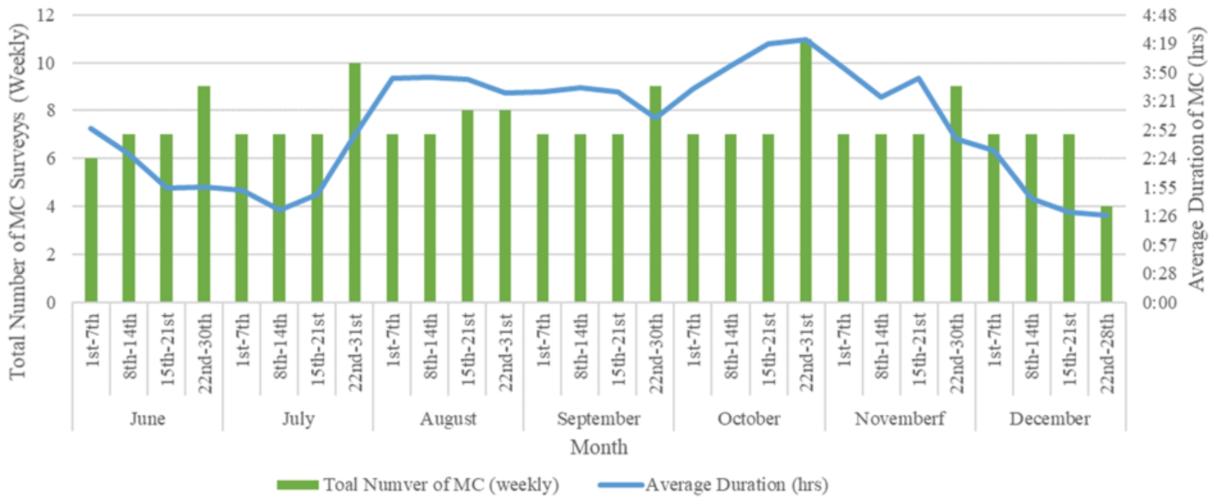

Fig 9: Morning census (MC) survey effort recorded from the 01st of June until the28th of December 2019. Effort is given as the total no. of MC surveys per week for each month and the average duration (hrs) per week.

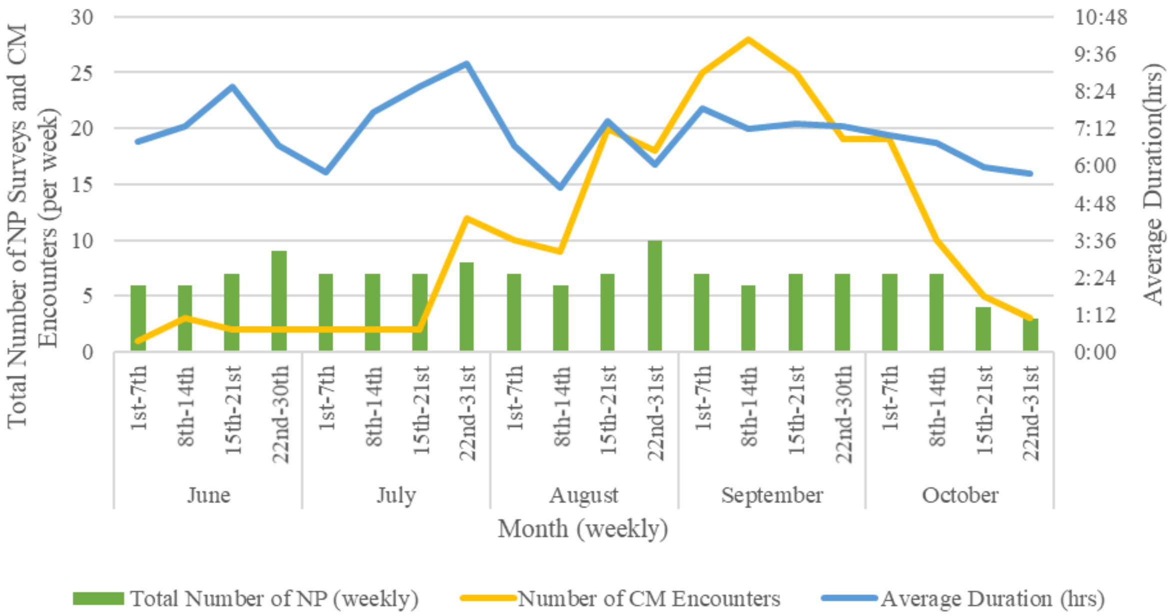

Fig 10: Night Patrol (NP) effort recorded from the 01st of June until the 26th of October 2019. Effort is given as the total no. of NP surveys per week and the average duration (hrs) per week. The no. of green (*Chelonia mydas*) encounters is given per week to highlight encounter rate relative to survey effort.

4.2 Nesting Activity

There was a total of 411 green nests recorded on Playa Norte along the 3 1/8-mile survey transect between the 5th of June and the 14th of November, which shows a 46% increase of nests compared with 2018 (*n*=221). Over the 14-year period, a fluctuation in nesting numbers is observed, and Velez-Espino *et al*, (2018) concluded that there has been a 1.79% average annual growth rate in the nesting population on Playa Norte (fig.11). In total 126 (30.4%) individuals were encountered while nesting, and 88 (6.7%) were encountered during a non-nesting emergence (table 5), with an overall encounter rate calculated as 12.3%.

In 2019, of the 126 individual's that were encountered during the nesting process, there were 57 individuals newly tagged, and 39 individuals emerged with previous tags. Of these individuals, 15 re-nested within the season, and the tagging data was not collected from 15 encounters (table 6).

The peak green nesting season on Playa Norte, when we recorded most nests, was between 15th August until 14th October, with the trend slowly decreasing until the 14th of November (fig. 12). The green sea turtle typically emerged between 22:00 and 01:00 hrs, with a majority of nests recorded within this time slot (fig. 13). Most nests were typically deposited in vegetated areas, however the spatial distribution of nests remained constant along transect (fig. 14).

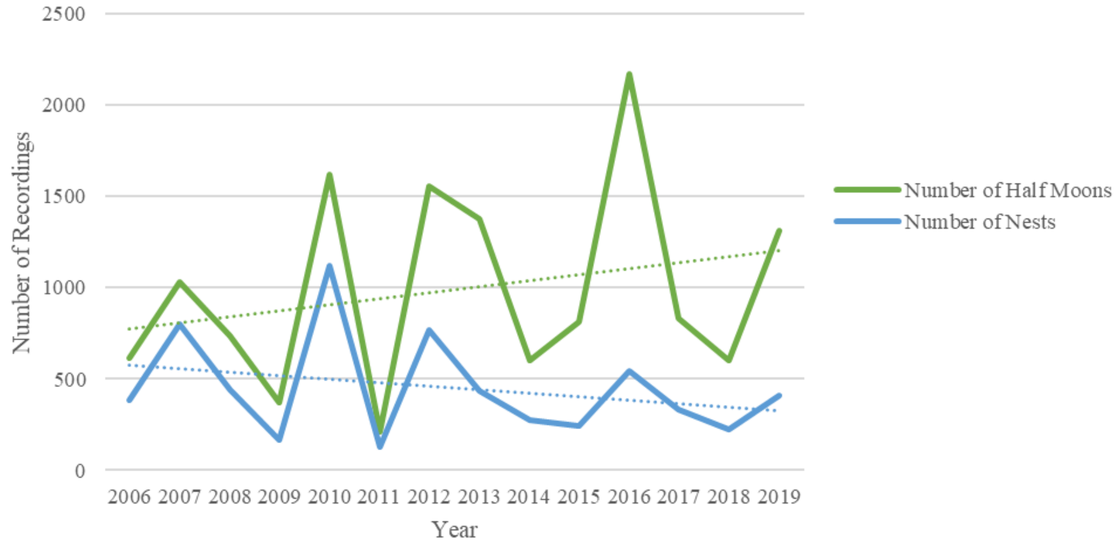

Fig 11: Temporal nesting activity of the green (*Chelonia mydas*) sea turtle during the time period 2006 to 2019 on Playa Norte.

Table 5: Descriptive data of the total green (*Chelonia mydas*) sea turtle nesting activity recorded from the 5th of June to the 14th of November 2019 and the 12th of April to the 21st of December 2018.

	2019		**2018**	
	Nest	**Half-moon**	**Nest**	**Half-moon**
Encountered	126 (30.7%)	88 (6.7%)	107 (48.4%)	123 (14.8%)
Non-Encountered	285 (69.4%)	1226 (93.3%)	114 (51.6%)	709 (85.2%)
Total	**411**	**1314**	**221**	**832**
Triangulated	89 (21.7%)	-	83 (37.6%)	-

Table 6: Tagging data of nesting green (*Chelonia mydas*) turtles encountered from the 5th of June to the 26th of October 2019 and the 18th of June to the 26th of October 2018. Included is the % of re-capture status of the encountered individuals.

	2019	**2018**
REC	57 (45.2%)	34 (31.8%)
REM	39 (30.9%)	32 (29.9%)
REN	15 (11.9%)	25 (23.4%)
No Tags	15 (11.9%)	16 (14.9%)
Total	**126**	**107**

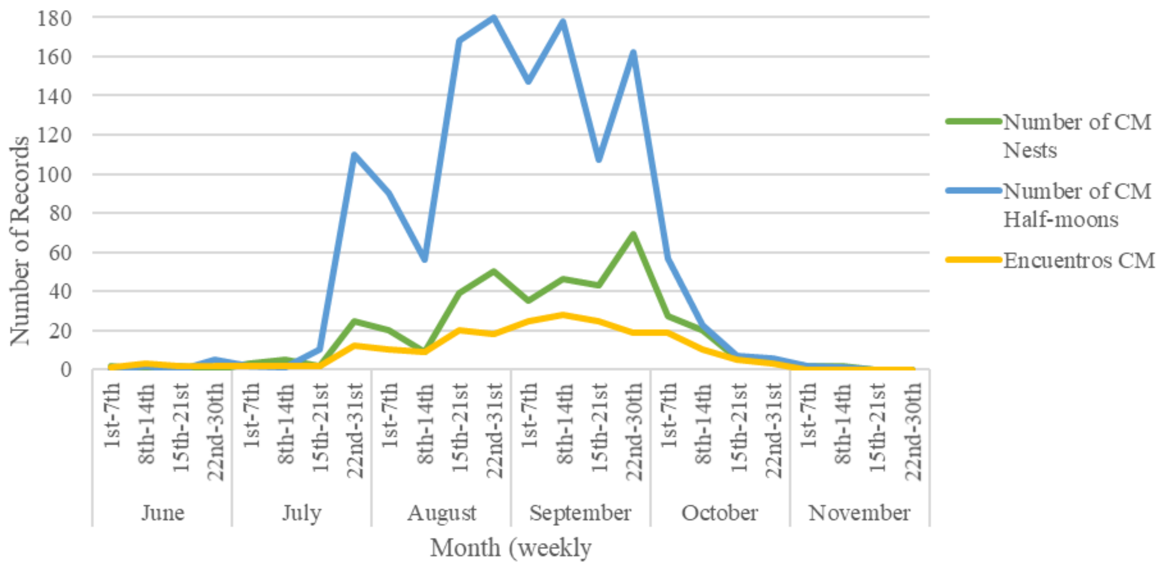

Fig 12: Temporal green (*Chelonia mydas*) nesting activity from the 01st of June until the 14th of November 2019. Nesting activity is shown per week for each month of the nesting season.

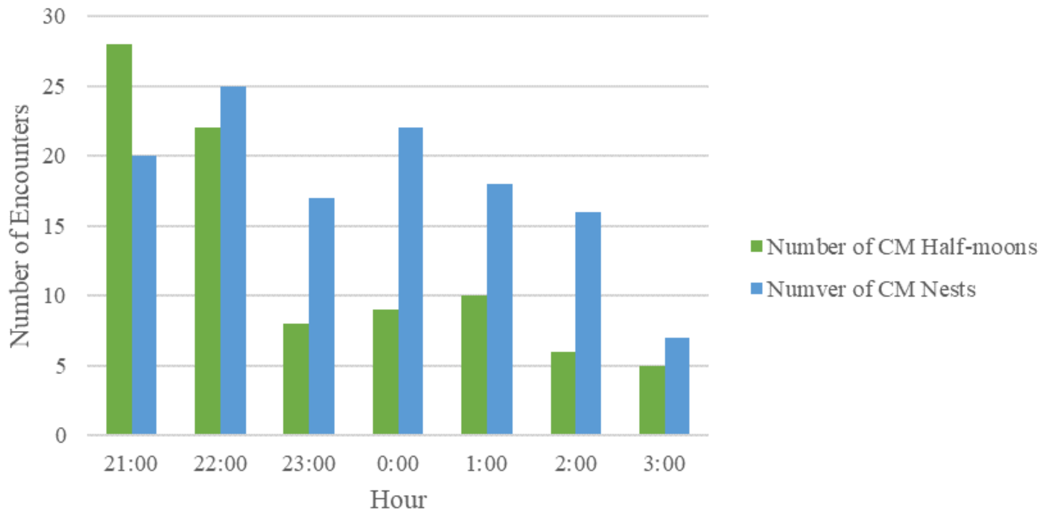

Fig 13: Temporal green (*Chelonia mydas*) nesting activity from the 5thth of June to the 14th of November 2019. Nesting activity is shown per hour intervals from 20:00 to 03:00.

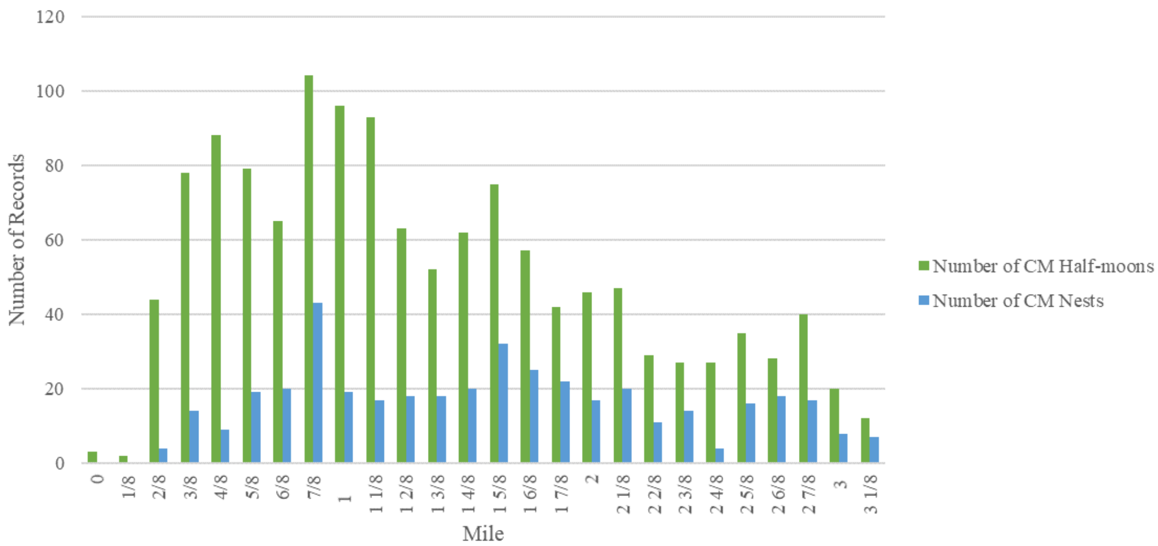

Fig 14: Spatial green (*Chelonia mydas*) nesting activity on Playa Norte from the 5th of June to the 14th of November 2019. Nesting activity is shown for the full study transect (3 1/8 miles), which is divided into sectors of 1/8th of a mile (200m).

4.3 Excavations and Nest Success

After the completed incubation period, triangulated (TRI) nests and non-triangulated (NTRI) nests are excavated when possible. In total, there were 89 TRI, of which 50 (56.2%) were successfully excavated with no signs of disturbance. Of the 322 NTRI nests,127 were excavated, with 114 successfully excavated with no signs of disturbance, 2 were partially predated and 2 were confirmed poached. Also, we were able to do complete excavations for 24 un-triangulated nests in the Archie Carr National Wildlife Refuge (AC NWR), and 74 un triangulated nests in Tortuguero National Park (TNP). Of the 24 AC NWR nests, one was poached (the nest contained only one shell of an hatched egg), and one was predated by dogs. Of the 74 TNP, one was destroyed by another turtle. The success data for the un triangulated nests are found in table 9. The final nest fate, determined at the end of the incubation period, for the 216 excavations of Playa Norte are found in table 7. The incubation period was calculated (n = 36), with an average incubation period of 60 days (table 8), a decreasing by 1-day from the 2018 average of 61 days (Allison, 2018).

During the daily nest check of 89 TRI green nests, 15 (16.1%) were recorded as wet, 49 (55.1%) displayed signs of some form of predation during the incubation process, 13 (14.6%) had signs of poaching and 12 (13.5%) remained natural throughout the full incubation period. In total 127 NTRI nests were excavated, with 115 identified by HAT tracks, with two confirmed as poached during the excavation process, 5 were identified by partial predations, with live hatchlings found inside the egg chamber, and 6 were found by predation attempts during which incubating eggs were exposed.

The 2019 average hatching success was calculated as 77.1%, and the average emergence success was calculated as 73.8% (table 8), slightly decreasing in comparison with 2018; 80.5%, 76.1%, *n*=55, respectively (Allison 2018).

Table 7: Nest fate of 216 recorded green (*Chelonia mydas*) nests, TRI (*n*=89) and NTRI (*n*=127) excavated from 24th of August to 28th December 2019 on Playa Norte.

Fate	**TRI**	**NTRI**
Excavated	50 (56.2%)	114 (89.7%)
Eroded	1 (1.1%)	-

Flooded	3 (3.4%)	4 (3.1%)
Not Found	11 (12.3%)	1 (0.7%)
Predated (Full)	4 (4.5%)	4 (3.1%)
Predation (Partial)	6 (6.7%)	2 (1.6%)
Poached	13 (14.6%)	2 (1.6%)
Unknown	1 (1.1%)	0 (0.0%)

Table 8: Hatching and emergence success (*n*=50), and the average incubation period (*n*=36) of successfully excavated triangulated green (*Chelonia mydas*) nests found from 24th August to 28th December 2019.

	Hatching success (%)	Emergence Success (%)	Incubation Period (days)
Average	77.1	76.1	60
STD	± 33.8	± 34.8	± 6
Range	0, 100	0, 100	51, 75

Table 9: Hatching success and emergence success for NTRI nests from AC NWR, and TNP.

	Hatching success AC NWR (%)	Emergence success AC NWR (%)	Hatching success TNP (%)	Emergence success TNP (%)
Average	92.6	91.2	91.3	90.4
STD	7.3	8.8	11.5	12.0
Range	69.7,100	65.5, 100	41.3, 100	39.9, 100
n=	22		73	

Turtle Mortality, Poaching and Predation

In 2019, we recorded 4 green mortalities on Playa Norte, as a result of poaching. Lifted tracks were suspected on 4 occasions, and on 10th of October, an adult turtle was found captured in the vegetation by the morning census team. This individual was successfully released back to sea by the morning census team, and all events were reported immediately to MINAE and the coastguards.

Of the 411 nests, it can be reported that 61 were predated (14.8%), with 53 receiving at least one partial predation (12.9%) throughout the incubation process. Predations were identified by dog prints and significant digging to which an egg chamber may be exposed, however no damage to the eggs.

Of the 411 nests, it can be reported at the end of the incubation process that 35 were poached (8.5%) with 22 nests confirmed poached the morning after the laying date by morning census, and 13 confirmed poached during the excavation. Poached nests were identified by an exposed empty egg chamber, flagging tape outside the egg chamber, human footprints, or stick holes. The spatial distribution of poaching and predation was analysed, and similar patterns can be observed throughout the green season as seen during hawksbill season with nest poaching most common south of mile marker 2, and nest predation most common north of mile marker 1 (fig. 15).

The nest protection project continued to be implemented on green nests, however materials were very limited and only a small number of nests were protected in 2019 (*n*=9). Of the nests that received protection by mesh, 0 were predated, 1 was poached, 2 had a partial predation and 2 received an unsuccessful predation attempt (table 11). There were 4 nests which remained with no signs of disturbance (table 11). Un-protected nests (*n*=80), also received some predation disturbance (8.3%), with 19.1%, remaining natural (table 11).

Table 10: Nest fate of triangulated (TRI) green (*Chelonia mydas*) nests that had received mesh barriers as a protection mechanism from predation (*n*=9), and those without mesh barriers (*n*=80).

Type of Disturbance	Mesh	No Mesh
None	4	17
Predated	0	11
Partial Predation	2	39
Predation Attempt	2	1
Poached	1	12

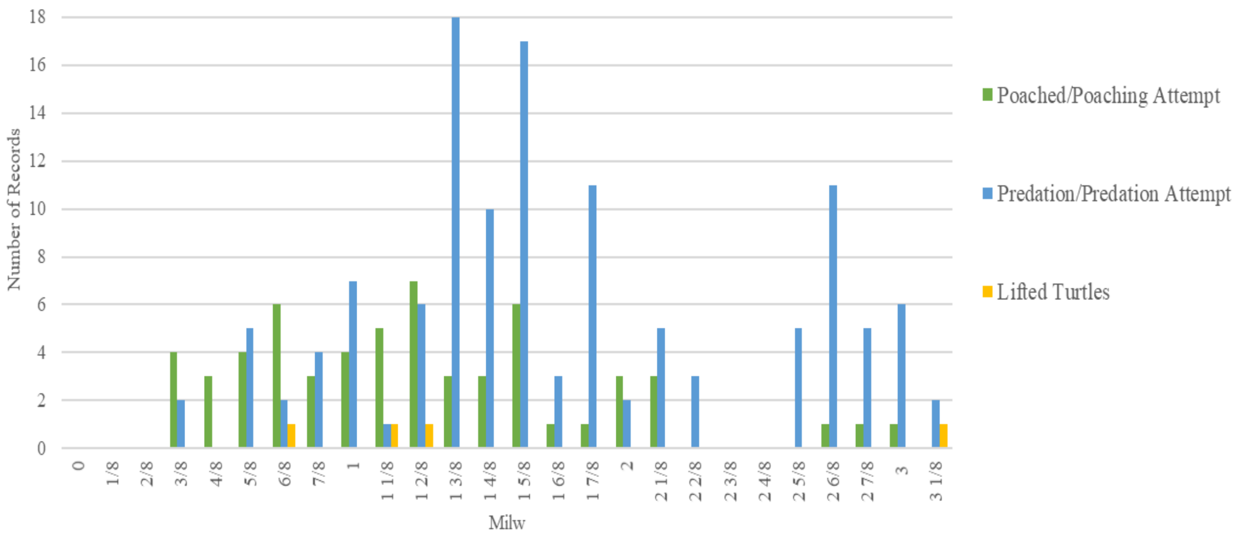

Fig 15: Spatial analysis of the poaching and predation pressure on all green (*Chelonia mydas*) nests recorded from the 5th of June to the 14th of November 2019.

4.4 Biometrics

Biometrics were taken, if possible, of encountered individual nesting females. Complete biometrics were successfully taken on 103 occasions out of the 126 occasions in which a nesting female was encountered (table 11). CCL was measured on 104 occasions and CCW was measured on 103 occasions, due to the turtle returning to the sea.

Table 11: Average biometrics, curved carapace width (CCW) and curved carapace length (CCL), taken from encountered individual nesting green (*Chelonia mydas*) females.

	Average CCWmin (cm)	Average CCLmax (cm)
Average	94.7	104.8
STD	± 4.80	± 7.19
Range	83.2, 108.3	92.0, 119.6

4.5 Body Check

The body check was successfully performed on 106 out of the 126 occasions when an individual was encountered. Of the 106 individuals, 2 (1.9%) returned to sea, and therefore was recorded as 'incomplete' and 0 were recorded as having no observed abnormalities. The most common abnormality found was barnacles (56.7%), which were distributed across all body zones. The green sea turtle also presented other abnormalities with 17.1% represented by barnacle scars, and a small percentage, >1% represented flipper notches, and damage to the carapace (fig. 16).

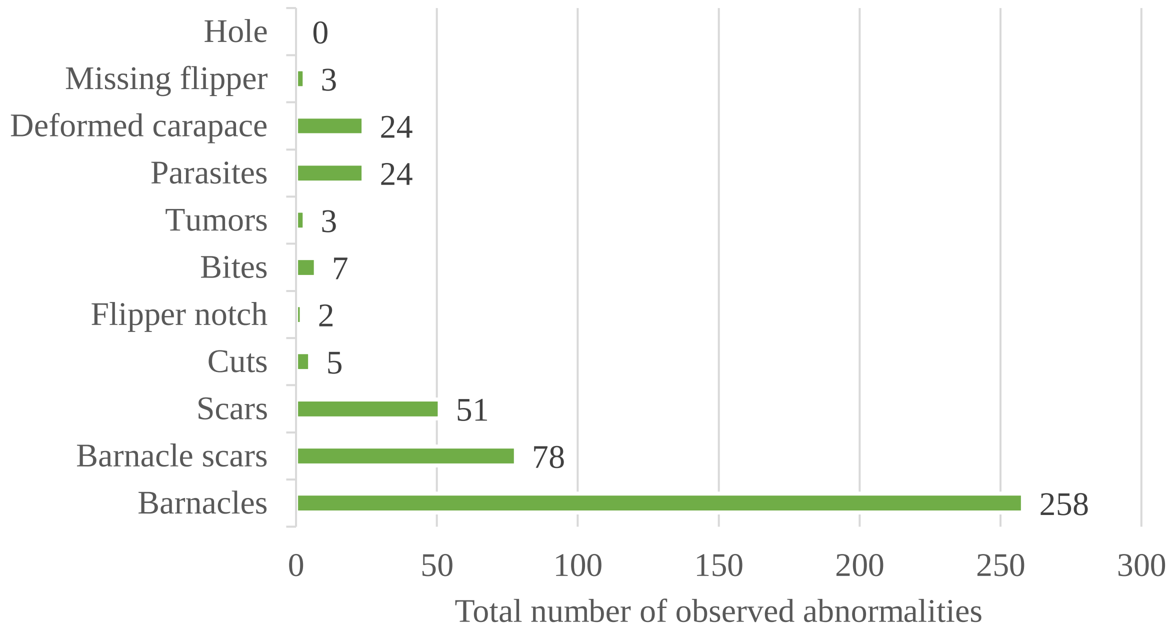

Fig 16: The no. of the most common abnormalities observed from the checked encountered (*n*=106) individual green (*Chelonia mydas)* turtles.

4.6 Human Impact Survey

Human impact observed on the beach during the hours of 18:00 to 05:00, in which it is illegal for any persons to be on the beach, is recorded during night patrol, and forwarded weekly to MINAE. This is done in order to gain a better understanding of the illegal activity present on the beach, which may have an impact upon the nesting success and nest site distribution of emerging sea turtles.

All illegal human impact recorded during the 2019 green nesting season is presented in table 12. White lights and locals were found to be the most frequent illegal impact on the beach representing 35.6% and 36.4% of all illegal activity respectively (table 12). White lights were present on the beach throughout the season, with an increase between the 15th to 21st September (fig. 17), with the majority occurring at Turtle Beach Lodge (TBL), located at mile 2 4/8 (fig. 18). From June to October, there was also an increase in local presence on Playa Norte (fig. 17). Locals were present consistently throughout the green season, with a peak from 15th to 21st September, due to Costa Rica Independence Day (fig. 17). They are mostly present from the early hours of the night, with the presence peaking between 21:00 and 22:00 (fig. 18), with most observed south of mile marker 2 (fig. 19).

Table 12: Human impact observations recorded on Playa Norte throughout the official green (*Chelonia mydas)* nesting season, 01st of June to the 26th of October 2019.

	White Lights	**Cell Phone**	**Red Lights**	**Fires**	**Locals**	**Tourists**	**Dogs**	**Total**
Total No. of Observations	240 (35.6 %)	12 (1.7%)	15 (2.2%)	13 (1.9%)	246 (36.4%)	52 (7.7%)	98 (14.5%)	**676**

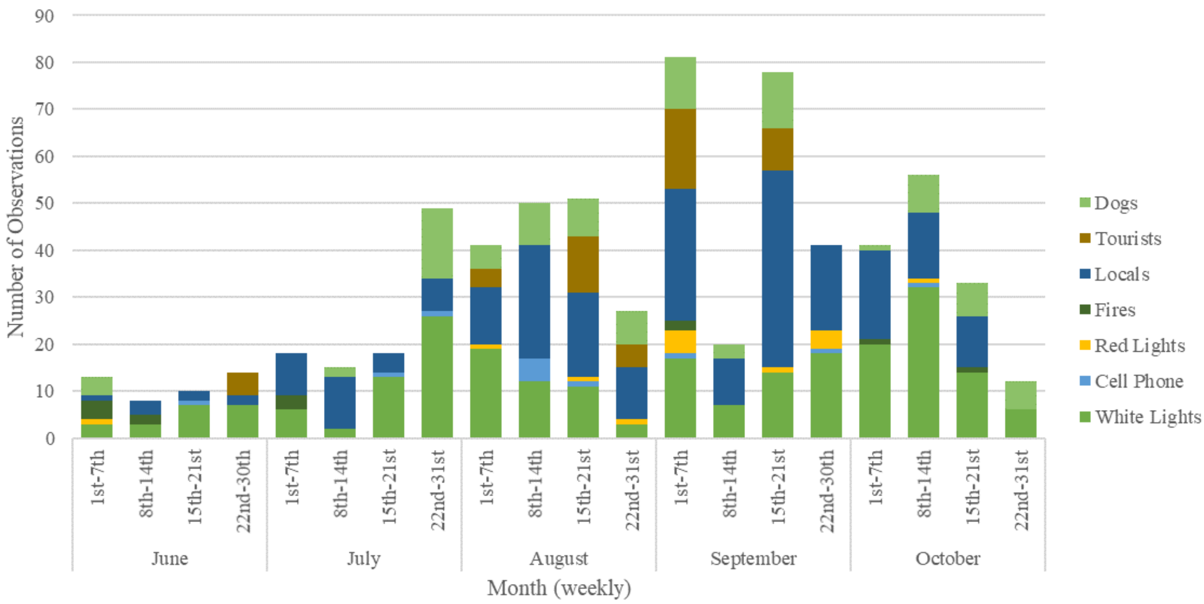

Fig 17: Temporal distribution of illegal human impact observations per week recorded along the 3 1/8-mile survey transect during green (*Chelonia mydas*) nesting season from the 01st of June until the 26th of October.

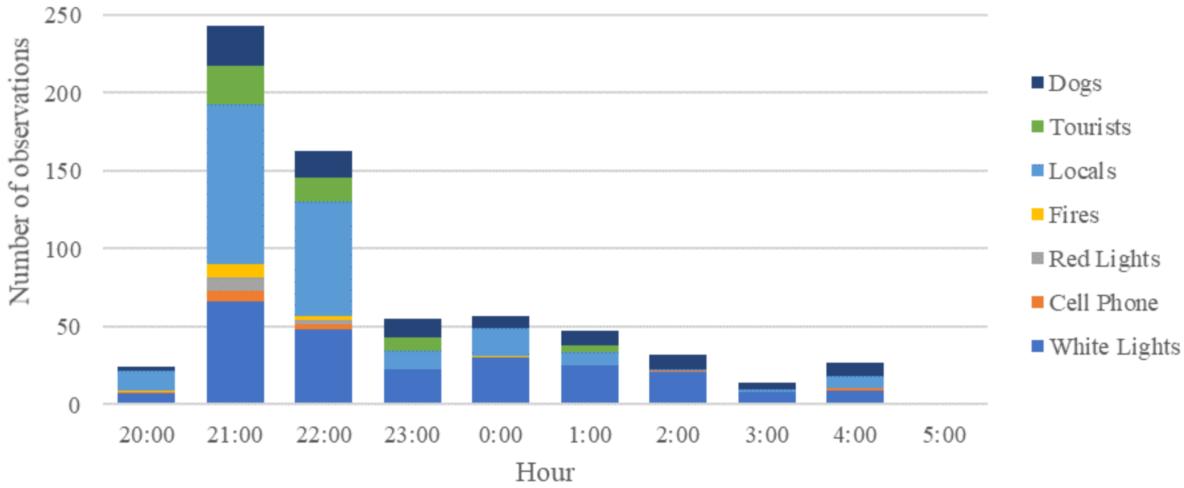

Fig 18: Temporal distribution of illegal human impact observations per hour recorded along the 3 1/8-mile survey transect during green (*Chelonia mydas*) nesting season from the 01st of June until the 26th of October.

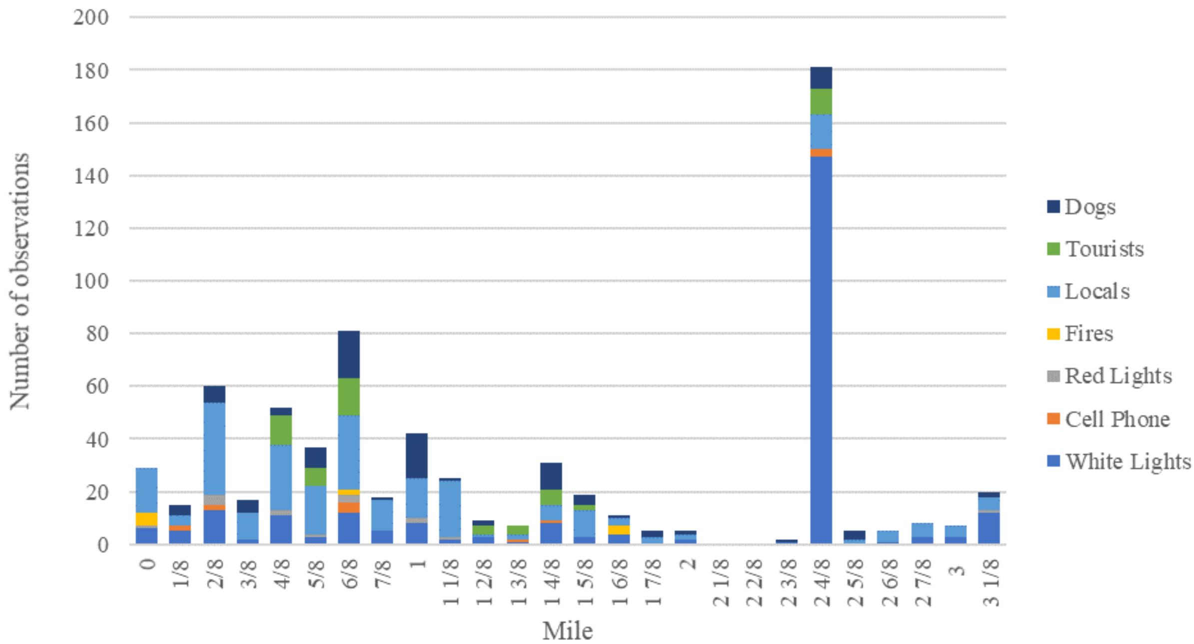

Fig 19: Spatial distribution of illegal human impact observations per mile marker (200m) recorded along the 3 1/8-mile survey transect during green (*Chelonia mydas*) nesting season from the 01st of June until the 26th of October.

4.7 Volunteers, Interns, and Training

From 01st June until 28th December, the official end of the 2019 turtle project, there was a total of 24 new arrivals at the station, including 2 long-term interns and a new project co-ordinator. 9 interns were here specifically to participate in the turtle program (table 13). 7 turtle interns and 2 mixed-taxa interns successfully demonstrated the practical skills to become independent patrol leaders.

Prior to working on the beach at night, all volunteers received standardized training in our protocols (table 14). All visitors staying longer than two weeks were required to sit an exam in which they needed to score 80%. Potential patrol leaders were required to achieve 95% in this exam, although a score of 90% would lead to an oral re-sit, to progress to patrol leader training with an experienced staff member. During this process, practice patrol leaders were taught how to apply flipper tags using cardboard to simulate the situation. In the field practice patrol leaders were supervised tagging a turtle and once they were confirmed competent, were able to manage their own team.

During weekly turtle meetings, additional training in Emergency Action Planning (EAP) was given by discussing various scenarios that require practical and critical thinking. At least five scenarios were discussed per meeting. Health and safety training and lightning safety were also given to all volunteers and interns on arrival.

Table 13: Interns who participated in the 2019 Marine Turtle Monitoring Program between the 01st of June and the 28th of December.

Name	Nationality	Association
Jasmine Joy	Canadian	York University
Tristan Williams	Canadian	University of Toronto

Elijah Dewoski	American	Independent Intern
Rachel Green	American	Independent Intern
Aidan Colligan	American	Independent Intern
Sarah Ravoth	American	Independent Intern
Fernando Lopez	Spanish	Assistant Investigator
Albert Carne	Spanish	Assistant Investigator
Aina Pons	Spanish	Assistant Investigator
Suzanne Van de Straat	Dutch	Assistant Investigator

Table 14: Participants of the turtle project training activities between the 01st of June and the 28th of December.

Training	No. of Attendees	Description
General Biology	26	Biology and nesting behaviour of the species found on Playa Norte.
Morning Census	26	Morning census protocol.
Night Patrol	25	Night patrol protocol and a simulation of working a turtle.
Triangulation	26	Triangulation practice on the beach and relocation.
Tagging Training	8	Practice tagging exercise for trainee patrol leaders only.
Turtle Exam	10	Compulsory for all interns and volunteers staying longer than 2 weeks.
Emergency Action Planning (EAP)	All	Discussion detailing emergency scenarios and solutions.
Lightning Safety Training	All	Discussion about the actions to take during a lightning storm, including scenarios.

5. Discussion

5.1 Survey Effort

The survey effort from 01st June until 28st December remained as constant as possible given the number of people present on the station. However this year we had a smaller number of volunteers and interns on the station and fielding a team was not always possible. The beach was patrolled on as many nights as possible with a minimum of one team per night, with the duration of each patrol gradually increasing as the nesting activity increased. However, the number of teams decreased toward the end of the season, due to a lack of personnel. Throughout the peak nesting months of September and October, we only had two teams once. Morning census was far more consistent into the later months since this usually only required a team of two people as opposed to the three required for night patrol. We continued to inform MINAE of any illegal activity on the beach however in 2019 they were unable to join us on the beach.

5.2 <u>Nesting Activity</u>

The 2019 recorded nesting activity of the green sea turtle (*n*=411), is much higher compared with 2018 (*n*=221, Allison, 2018), results show a 85.9% decrease, and again similar results with 2017 (*n*=333, Gutiérrez, 2018), showing a 19.0% decrease. These fluctuations in nesting numbers between seasons are typical for sea turtles due to the two to three-year migration intervals to their foraging grounds, inconsistent clutch frequencies and recruits in the adult population (Bjorndal *et al*, 1999). A recent study quantifying the demography of the green sea turtle on Playa Norte, found that over the study period of 2006 to 2015, there was a positive abundance trend in green turtle adult females, characterised by an average 1.79% annual growth rate (Velez-Espino *et al*, 2018). This is consistent with other studies of Tortuguero's population (Bjorndal *et al*, 1999, Troëng and Rankin, 2005) and highlights the importance of Playa Norte as a nest ground for Atlantic green sea turtles. Nesting activity over a 12 year period on Playa Norte (fig. 11) shows a slight decrease in the number of nests recorded but an overall increase in the number of emergences.

5.3 <u>Nest Success</u>

A number of abiotic and biotic variables can affect nest success of the green sea turtle and cause partial or complete nest failure, including: temperature, moisture, root invasion, flooding, erosion, predation and poaching (Kamel & Mrosovsky, 2004). In 2019, 3 nests were recorded flooded and one eroded, of the triangulated 89. In 2018, 2 nests were eroded and 1 flooded, of the triangulated 81 (Allison, 2018). This could be a result of the El-Nino year in 2018 and 2019, causing severe erosion of Playa Norte. In total, 24 nests were reported as 'wet' by high tides. The success of four of these nests cannot be quantified as they suffered from anthropogenic or physical pressures. However, 21 nests were successfully excavated and were found to have on average 76.0% hatching success and emergence success. The average hatching success for green turtles on Playa Norte in 2019 was 77.1%. In comparison with the leatherback sea turtle, and similarly with the hawksbill, the green sea turtle has a high average hatching and emergence success (61.5%, 72.3% respectively). This could be a result of nest-site choice and changing environmental conditions throughout the season. The green sea turtle has similar nest site selection to the hawksbill in that she typically emerges further ashore into the vegetation where the nest is less compact than non-vegetated and thus have higher emergence success (Horrocks & Scott, 1991). In contrast, the leatherback sea turtle typically nests on the open beach, where nest inundation and rising temperatures have been found to be a common cause for little or no embryonic development (Whitmore & Dutton, 1985).

On Playa Norte, the green sea turtle suffers from poaching pressure. During the peak nesting months of August through October, local presence increases mostly in the south section of the transect where local houses are located. On occasions with low personnel, survey effort is maximised within this sector. In 2019, a total of 35 nests (8.5%) were recorded as poached, 4 mortalities and 4 suspected lifted tracks. One individual was found tied in the vegetation after reports of a lifted track by the night patrol team. This individual was successfully and safely released back to the ocean by the morning census team. In an attempt to minimise egg poaching, tracks are erased and nests are disguised to puzzle an experienced poacher of the exact location of the egg chamber, and the team remains with an individual until she returns to the sea to mitigate the take of adults. The number of poached nests and the overall poaching rate recorded in 2019 is slightly less than that of 2018 and is hopefully a result of our presence on the beach.

One of the most significant threats to the hatchling success of sea turtles is non-natural predation by domestic dogs. A recent study focussing on predation on Playa Norte states that in 2013, 13% of green sea turtle nests were lost to domestic dog predation (Pheasey *et al*, 2018). This initiated a protective barrier project in 2014, where bamboo barriers were deployed to minimise predation and protect sea turtle nests. In 2019, efforts were continued to deploy bamboo barriers, however building materials were in short supply and only a limited number of bamboo meshes were able to be produced. This resulted in nests being prioritised for receiving meshes, with hawksbill nests being a higher priority than greens, and nests laid in areas with higher dog activity being a higher priority than nests laid in areas of the beach less occupied by dogs. In September, a large effort was enforced by the team to produce and deploy bamboo mesh barriers, and most were deployed at the end of the incubation period. The timing of deployment does not affect the likelihood of predation; however, predation activity was found to increase during the emergence period (Pheasey *et al*, 2018). Only 9 TRI nests received bamboo barriers, with 2 being partially predated, and 2 showing signs of a predation attempt. We are hopeful that we will be able to deploy far more bamboo meshes in the 2020 season.

In 2019 the average incubation period was 60 (±6) days, slightly longer than the average incubation period of 55 days (Chacon *et al*, 2007). The 2018 the average incubation period was 61 days (±5) and in 2017 it was 56 (±4) days (Gutiérrez, 2017). In 2019, six nests were recorded with 0% hatching success. During the excavation process, most embryos were found in stage 3 or 4 of the incubation process with evidence of over-heating, including boiled yolk-sacs, and pink colouration of the skin. All these nests were deposited in October, and therefore this is thought to be a result of soaring temperatures observed throughout November and December.

5.4 Human Impact

Illegal human activity recorded during night patrol throughout the nesting season remained relatively constant. The most common impacts that are recorded are white lights and as of June 1st, local presence also increases. These observations coincide with the inhabited areas of the transect and the sectors with an increase in nesting activity. Dogs also remain constant, however dogs present mobility throughout the full transect. The security guard from the resident hotel Turtle Beach Lodge, frequently ventures onto the beach, and is the result of constant white light observations on the north end of the transect. The increase of local activity observed on Playa Norte during the week of 15th September to 21st September is a result of Costa Rica Independence Day, to which we aim to maximise beach coverage during this period. There is also an increase in local presence between 9pm to 11pm and after 5am, a time when nest poaching is most common. MINAE and Police presence are most important around public holidays, celebrations and early morning, as it is during these time when we see an increase in human activity and illegal activity. The number of recorded white lights and locals on the beach in 2019 is lower than 2018 and could be a result of persistent presence on the beach and highlights the importance of fielding teams as frequently as possible

5.5 Collaboration, Outreach, and Public Education

Working with stakeholders and the local community is crucial to the success of the program, therefore in the CPBS, we are consistently looking to participate in activities that involve the community as well as other institutions and organizations that work in the region.

Conservation club is an extracurricular activity available to students of Escuela Laguna Tortuguero, held twice a week at the COTERC community library in the village of San Francisco, in which one of the main activities is sea turtle ecology and conservation. The goal is to encourage environmentally friendly attitudes in the youth of San Francisco. We are also getting involved with science projects for the student with the aims of sparking a passion for learning and scientific understanding.

In addition, local beach cleans have been organised in the community with the children. This would involve an afternoon spent in groups, picking up plastic debris from the river mouth. During this time, the importance of beach cleans, reduce, re-use, and recycle was explained to the children to educate them on the impact of plastics.

Continuing with the efforts realized and the goals achieve in past years, a constant cooperation is maintained with the authorities from MINAE, the police and the coast guard. Weekly reports are sent to MINAE, as well as to the coast guard, detailing nesting activity including any signs of disturbance and illegal human activity observed on Playa Norte. The presence of the authorities during the nesting season helps to minimize local presence, and therefore we continue to welcome their support.

5.6 Looking Forward

We recently received a new project coordinator, Charlie Pinson from Australia and we hope to have a good year at the beach with him. In 2020 we intend to maintain our presence on the beach and continue to reduce poaching and illegal presence. We hope to use the data of the last decade to analyse trends and anomalies and use these findings to make our work on the beach as efficient as possible. Since during the nesting season of the green turtle the main concern is poaching and predation, we will continue to work with the local community to produce solid mesh protection barriers.

Again, in 2020, we will regularly inform the MINAE and the police to obtain their support, since their presence reduced the illegal activity in Playa Norte.

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