Marine Turtle Monitoring and Tagging Program

Leatherback Season Report

2019

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

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Leatherback Turtle (*Dermochelys coriacea*) 2019 Season Report.

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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.

DC: *Dermonchelys coriacea*
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.
TNP: Tortuguero National Park.

1. Summary

The official leatherback (*Dermochelys coriacea*) nesting season is the 1st of March until the 31st May, however we recorded the last leatherback emergence on the 8th of June 2019, therefore this report will discuss all nesting events from the 1st of March 2019 until the 8th of June 2019.

1.1 Survey Effort

- The average duration (hrs:mins) of night patrol during the leatherback nesting season was 06:19, with the total survey time (hrs:mins) of 297:30.
- The average duration (hrs:mins) of morning census during the leatherback nesting season was 01:54, with the total survey time (hrs:mins) of 143:30.

1.2 Nesting Activity

- The first successful nesting event of the season was on the 20th of March and was recorded by the morning census team, the last successful nesting event was on the 8th of June and was encountered by the night patrol team.
- In total, there were 40 nests and 21 half-moons recorded between the 20th of March and the 8th of June, along our 3 1/8th mile study transect, Playa Norte.
- Of the emerging leatherbacks, the encounter rate by the night patrol was 22.3% (14 out of 61) with tag data recorded on 14 occasions (3 REC, 9 REM, 2 REN).
- The night patrol teams encountered 4.8% (1 out of 21) of leatherbacks during a half-moon.
- Of the nesting leatherbacks, 32.5% (13 out of 40) were encountered by the night patrol with 69.2% (9 out of 13) encountered before or during oviposition and were triangulated.

1.3 Nest Success

- Average no. of yolked eggs 64 ± 12 ($\bar{x}$ ± std; [49, 76], *n*=5). Sample size is based on individuals encountered before oviposition.
- Average no. of yolkless eggs 23 ± 13 ($\bar{x}$ ± std; [4, 35], *n*=5). Sample size is based on individuals encountered before oviposition.

- Average incubation period (days) was 64 ± 12 ($\bar{x}$ ± std; [59, 74], *n*=5). 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 61.1% ± 24.2 ($\bar{x}$ ± std; [26.5, 82.1], *n*=5).
- Average emergence success was 57.5% ± 23.0 ($\bar{x}$ ± std; [24.5, 74.6], *n*=5).

The 9 triangulated nests were checked daily during the incubation process, with the following outcome:

- Five nests remained natural and were successfully excavated.
- Three nests were eroded.
- One nest was not found during the excavation process.
- All nests were recorded as wet, two nests had a predation attempt, and hatchling tracks were observed from two nests.

1.4 Biometrics

- Average (cm) minimum curved carapace length (CCLmin): 155.3 ± 6.0 ($\bar{x}$ ± std; [143.3, 164.3]; *n*=13).
- Average (cm) maximum curved carapace width (CCWmax): 111.6 ± 3..3 ($\bar{x}$ ± std; [104.0, 117.5], *n*=13).

1.5 Body Check

- The most common observed injury on the leatherback were barnacles, 39% of all injuries observed, and flipper notches, also 28% of all injuries observed.

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 1991by 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 leatherback (*Dermochelys coriacea*) 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

The leatherback turtle is the largest of the marine turtle species and is the only remaining species of the Dermochelidae family (Spotila, 2004; Safina, 2007). It belongs to an ancient lineage which along with the Cheloniidae family, is estimated to have evolved from a common ancestor between 100 and 150 million years ago (Dutton *et al*., 1999). The leatherback turtle is distinct from the other 6 species by its unique phenotype. The soft-carapace is composed of 7 dorsal ridges, and is black with pink or white spots on the carapace and tissue. They also have a unique pink spot on the top of the head, which is used for navigation during large migrations. It feeds almost exclusively on jellyfish (Houghton *et al*., 2006), and to satisfy their energy requirements they migrate from the breeding zones in the tropics to feeding areas located at higher latitudes (Heaslip *et al*., 2012). Therefore, its distribution spans all the oceans in the world, and its great size and heat generation ability (Davenport *et al*., 2015), allow it to inhabit open and coastal areas from the sub polar to tropical waters (Eckert & Abreu Grobois 2001; Spotila 2004; Wallace, 2005). The nesting characteristics of the leatherback turtle are provided in table 1.

Table 1: Nesting characteristics of the leatherback (*Dermochelys coriacea*) turtle found throughout Costa Rica.

Characteristic	**Description**
Average Length Sexually Mature Female (CCLmin) (cm)	148.7 (Pacific), 152.0 (Caribbean)
Inter-Nesting Frequency (nests/season)	5
Re-Migration Interval (yrs.)	2-3
Inter-Nesting Interval (days)	9
Average Clutch Size (yolked eggs)	82
Average Track Width (cm)	152-230
Track Shape	Symmetrical
Average Nest Depth (cm)	75
Nesting Season on the Caribbean Coast of Costa Rica	February to June: Barra del Colorado, Tortuguero, Parasmina, Pacuare, Cahuita, Gandoca.
Nesting Season on the Pacific Coast of Costa Rica	September to March: Grande, Ostional, Nancite, Osa, Matapalo, Naranjo.
Pivotal Nest Temperature (°C)	29-29.5
Average Incubation Period (days)	50-70

2.2 Anthropogenic Threats

Aside from the natural threats, such as predation, nest flooding, and a naturally low hatching success [19.8%, 54.2%] (Bell *et al.*, 2004), leatherbacks, like all the other sea turtle species, are subject to anthropogenic threats in the marine and the terrestrial environment (Tröeng and Ranking, 2005, Mrosovsky *et al.*, 2009). Pelagic long-line fisheries, entanglement, marine debris and propeller strikes are common causes of leatherback mortality and injury (Troëng, 1998; James *et al.*, 2005). The ingestion of marine debris affects their diet habits, and it poses an important threat for the sea turtles (Schuyler *et al.*, 2013). Particularly, the ingestion of plastic bags mistaken for jellyfish, is one of the main causes of fatality in leatherback turtles (Bugoni *et al.*, 2001; Mrosovsky *et al.*, 2009; Vélez-Rubio *et al.*, 2013).

Historically, nesting females were vulnerable to poaching for their meat and oil, however, in many areas this problem is now in decline due to increased conservation and tagging efforts. (Eckert & Abreu Grobois, 2001). Among the numerous problems they face, illegal harvest of eggs remains a problem, poaching rates of nearly 100% have been reported outside the protected areas of Costa Rica (Eckert & Abreu Grobois, 2001). A common threat to sea turtle species, including the leatherback is domestic dog predation of nests, which also occurs within protected areas (Choi & Eckert, 2009). Hatchlings that successfully emerge are vulnerable to disorientation caused by artificial light pollution, entanglement in marine debris, and predation by many natural predators (Witherington & Martin, 2003; Bourgeois *et al.*, 2009; Triessnig *et al.*, 2012; Berry *et al.*, 2013). Though data are limited, only a 1:1000 egg to adulthood ratio is estimated (Frazer, 1986).

2.3 Current Status and Conservation Efforts

Due to the rapid decline in leatherback numbers (Tapilatu *et al.*, 2013; Spotila *et al.*, 2000; Troëng *et al.*, 2004) it has been afforded international protection. The leatherback is currently listed under several international conventions including Appendix I of the Convention on International Trade of Endangered Species (CITES). This prevents all international commercial trade in the species or its derivatives. It is 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) (Wallace *et al.*, 2013).

Undertaking accurate population assessments of a migratory marine species that comprises seven distinct sub-populations is extremely challenging. Since 1982 it has been listed as endangered (Wallace *et al.*, 2013), then critically endangered (Sarti Martinez, 2000) and most recently, downgraded to vulnerable (Wallace *et al.*, 2013) on the IUCN Red List of Threatened Species. While this may appear to be encouraging, it should be understood that this assessment is for the species as a whole, and some subpopulations are still considered to be critically endangered (Tiwari *et al.*, 2013; Wallace *et al.*, 2013). Although the Atlantic population is listed as vulnerable and in decline (Troëng *et al.*, 2004; Wallace *et al.*, 2013), the Northwest Atlantic Ocean subpopulation, the subject of this report, is listed as least concern and the population is considered to be increasing (Tiwari *et al.*, 2013).

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.

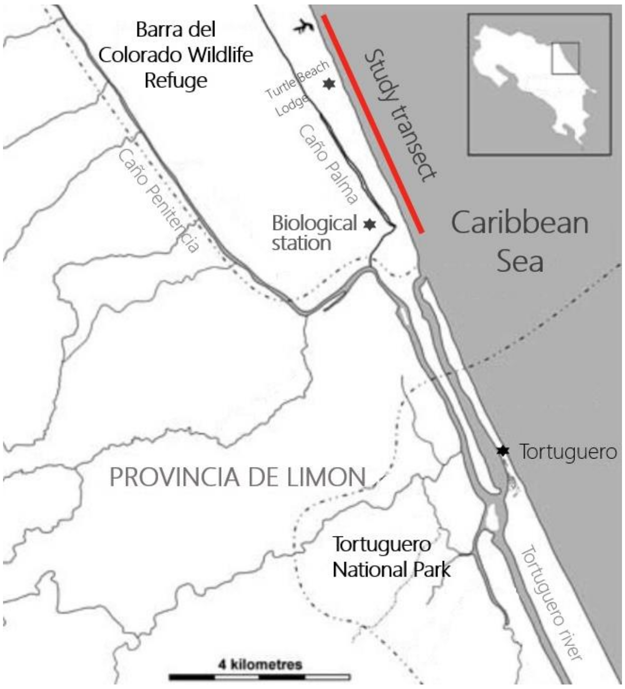
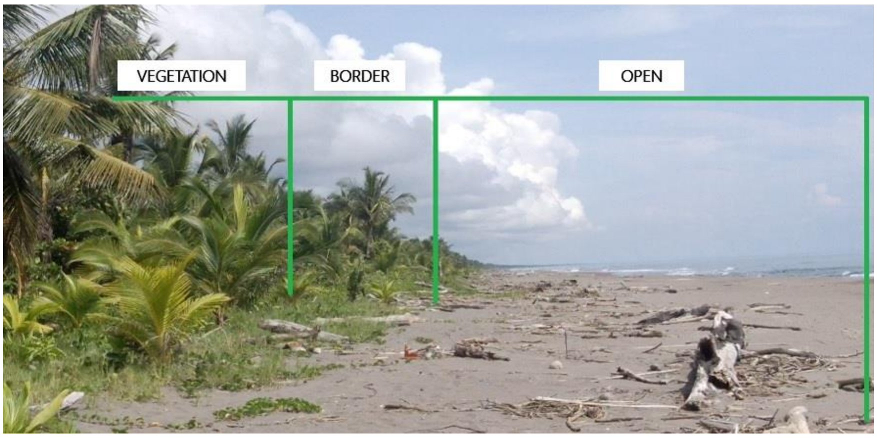


Figure 1: Descriptive map showing the 3 1/8th mile survey transect highlighted in red, and the location of Cano Palma Biological Station (CPBS) (modified from Grant & Lewis, 2010).
Fig 2. An illustration describing the different sectors of vertical beach zones, differentiated by the amount of shade cover 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 leatherback season, patrols were carried out on as many nights as possible from the 15th of March to the 31st of May. 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 on 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 Patrols collected 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 -hereafter referred to as Location Data) 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 leatherback 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.

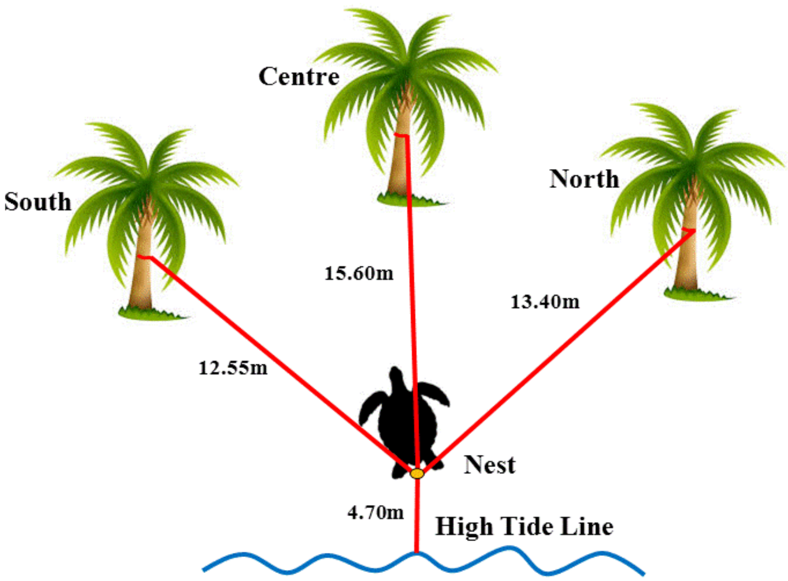


Fig 3: An example of the nest triangulation, to mark the nest location. The red lines indicate the measurements taken from the egg chamber to the three fixed points in the vegetation.

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. Leatherbacks are tagged in the membrane between the tail and the rear flipper (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.

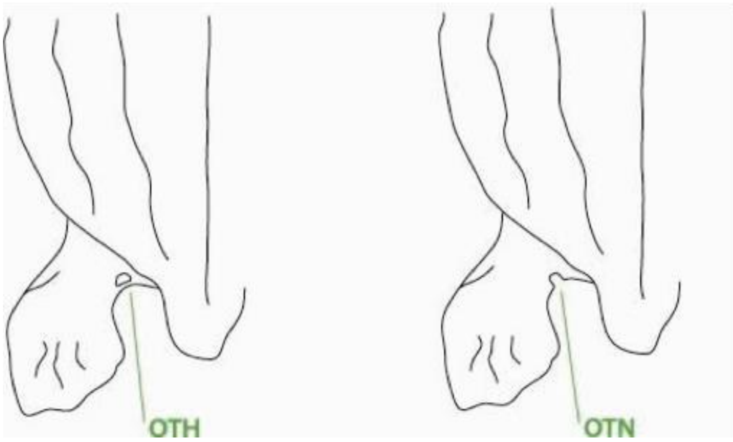


Fig 4: Leatherback tag position on the membrane between the rear flippers and the tail. OTH (left) and OTN (right) are indicated.

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 3m flexible measuring tape. The CCLmin starts at the point where the skin meets the carapace at the neck and ends at the tip of the caudal projection (fig. 5). The CCLmin is always taken on the right side of the central ridge and, for standardisation of data collection, always to the end of the caudal projection regardless of any injury or abnormality. The CCWmax is taken at the widest point of the carapace and where the carapace meets the plastron (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.

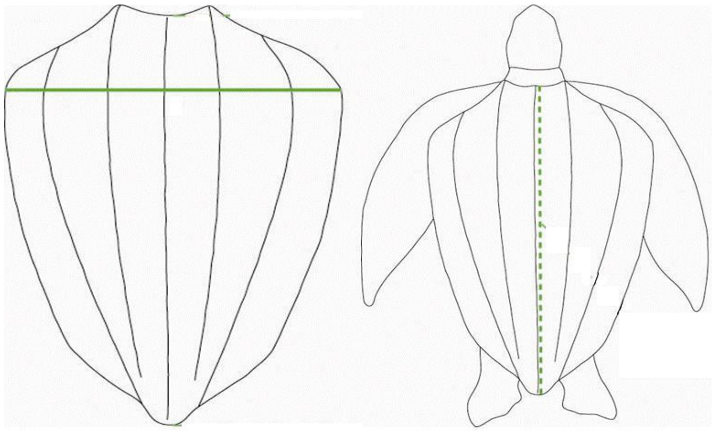


Fig 5: Diagram showing the dimensions of the biometrics taken from the leatherback (*Dermochelys coriacea*). CCWmax (left) and CCLmin (right).

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. An assessment of the caudal projection was recorded as 'complete' or 'incomplete'. Damage to the caudal projection may indicate partial injuries sustained by the turtle and affect CCLmin measurements.

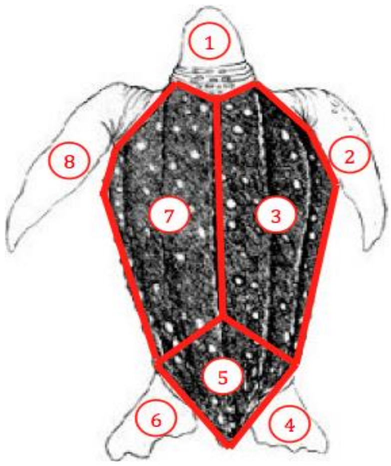


Fig 6: Body check zones of the leatherback (*Dermochelys coriacea*) sea turtle. The zones are clockwise starting at zone 2, and ending on zone 1.

3.2.2 Morning Census Protocol

Morning Census (MC) was carried out daily from 1st March to 31st May during the official leatherback 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.

Depression Check: For the leatherback, the average incubation period is 60 - 70 days (Chacon *et al.*, 2007), therefore, at day 60 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 75 of incubation – excavate on 75th 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 (table 4, fig. 8).

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.

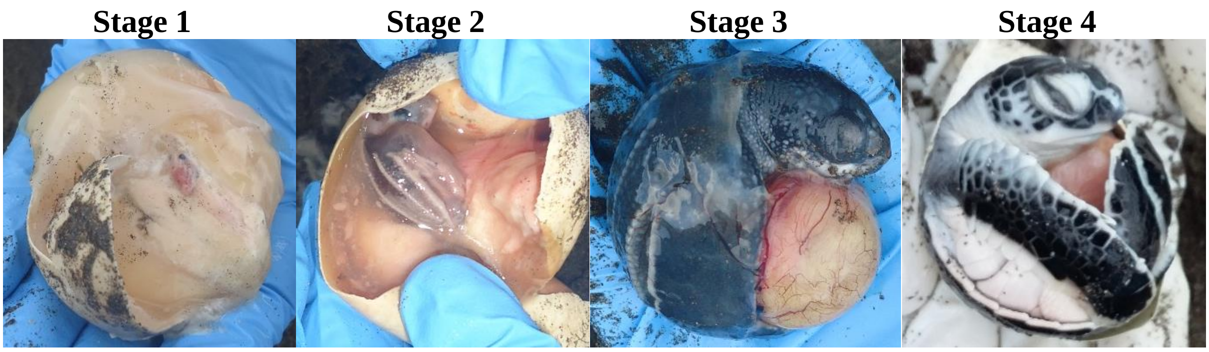


Fig 8: The different developmental stages of the leatherback (*Dermochelys coriacea*) embryo.

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 leatherback season 1st of March to 31st May. Morning census was carried out daily from 01st March (fig. 9), with the total time spent on survey 143:30 hrs, with an average of 1:54 hrs.

Night patrol began on the 15th of March, and the beach was patrolled nightly by at least one team providing people were available. The minimum duration of one night patrol team was six hrs from 20:00 to 02:00, the start and end time dependent on previous nesting activity. In the event of available personnel, two teams patrolled the beach to maximise beach coverage. The duration of the second team was 6 hrs, from 22:00 to 04:00. During leatherback season, we had two teams on 5 occasions. The total no. of hours spent on night patrol during the leatherback season was 297:30 hrs, and the average duration of one team 6:19 hrs (fig. 10).

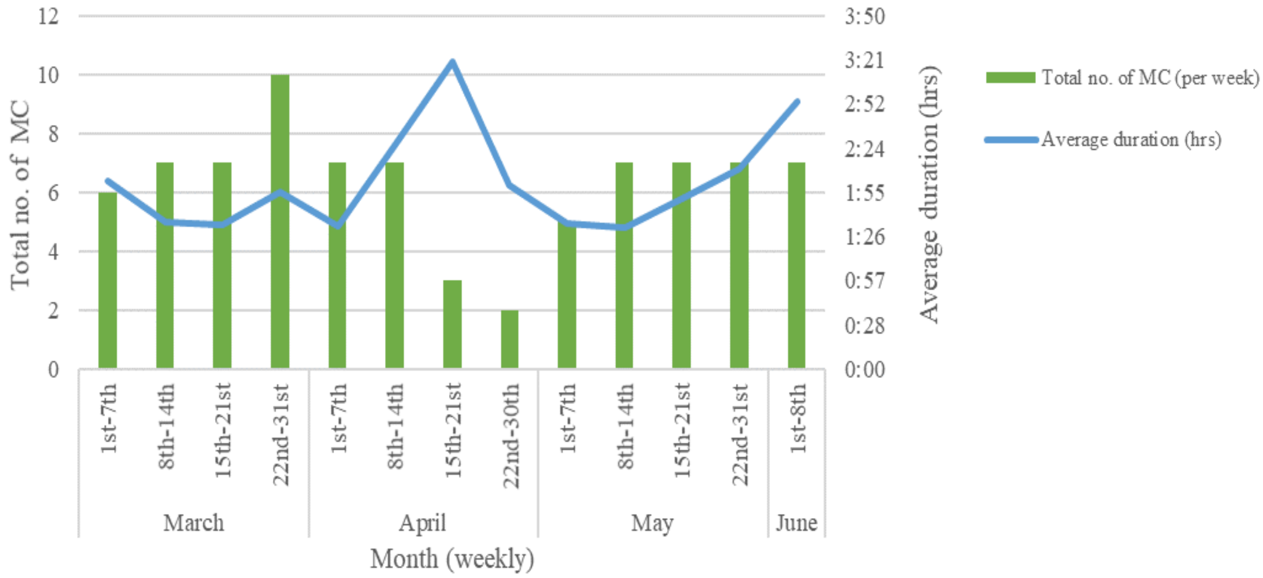


Fig 9: Morning census (MC) survey effort recorded from the 1st of March to the 8th of June 2019. Effort is given as the total no. of MC surveys per week for each month and the average duration (hrs) per week.

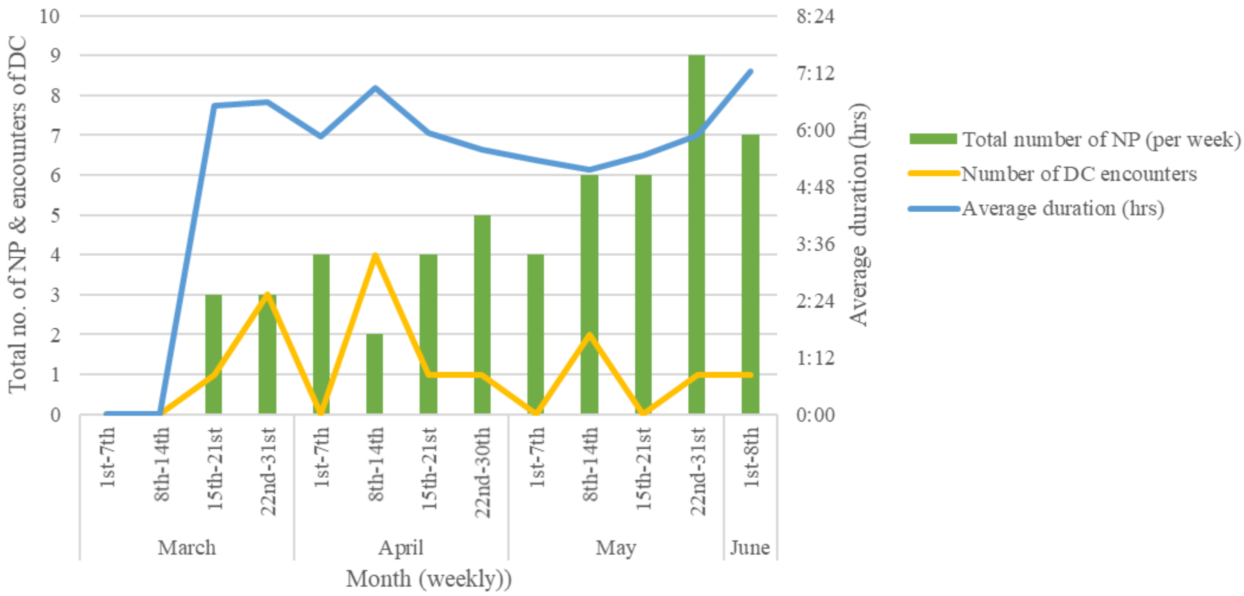


Fig 10: Night Patrol (NP) effort recorded from the 15th of March to the 8th of June 2019. Effort is given as the total no. of NP surveys per week and the average duration (hrs) per week. The no. of leatherback (*Dermochelys coriacea*) encounters is given per week to highlight encounter rate in relation to survey effort.

4.2 Nesting Activity

There was a total of 40 leatherback nests recorded on Playa Norte along the 3 1/8-mile survey transect between the 1st of March and the 8th of June, which shows a 81% increase of nests compared with 2018 (*n*=22) (Allison, 2018). However over the 14-year monitoring period there has been a decreasing trend in the number of leatherback nests on Playa Norte (fig. 11). In total 13 (20.9%) individuals were encountered while nesting, and 1 (4.8%) were encountered during a non-nesting emergence (table 5), with an overall encounter rate calculated as 22.9%, a decrease in comparison with 2018, calculated as 51.2%.

In 2019, of the 13 nesting individual's that were encountered, there were 3 RECs, 8 REMs and 2 RENs. Tag data was collected from one individual during a half-moon and was recorded as a REM (table 6).

The peak leatherback season on Playa Norte, when we recorded most nests, was between the 08th to the 30th of April, with 18 nests recorded during this period, and the nesting rate slowly decreasing until the 8th of June (fig. 12). The leatherback typically emerged between 22:00 and 00:00 hrs, with 6 nesting turtles encountered within this time slot (fig. 13). Most nests were typically deposited in wide, open areas with 10 nests recorded on the northern section of the beach between mile 2 5/8 and 3, near to Laguna Cuatro (fig. 14).

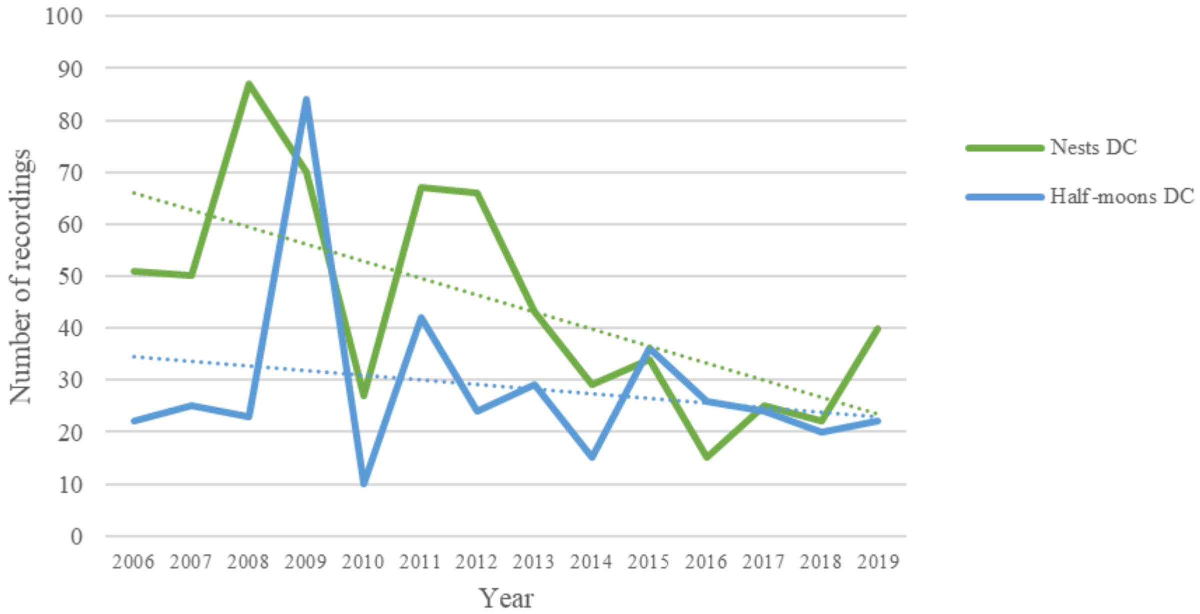


Fig 11: Temporal leatherback (*Dermochelys coriacea*) nestsing activity from 2006 to 2019 on Playa Norte. The number of nests and half-moons are given per season.

Table 5: Descriptive data of the total leatherback (*Dermochelys coriacea*) nesting activity recorded from the 15th of March to the 8th of June 2019 and the 02nd of March to the 20th of June 2018.

	2019		2018	
	Nest	**Half-moon**	**Nest**	**Half-moon**
Turtle Present	13 (32.5%)	1 (4.8%)	16(72.7%)	6 (28.6%)
Turtle Absent	27 (67.5%)	20 (95.2%)	6 (27.3%)	15 (71.4%)
Total	**40**	**21**	**22**	**21**
Triangulated	9 (22.5%)	-	11 (50.0%)	-

Table 6: Tagging data of nesting leatherback (*Dermochelys coriacea*) turtles encountered from the 15th of March to the 8th of June 2019 and the 02nd of March to the 20th of June 2018.Included is the % of re-capture status of the encountered individuals.

	2019	2018
REC	3 (21.4%)	5 (22.7%)
REM	9 (64.3%)	8 (36.4%)
REN	2 (14.2%)	6 (27.3%)
No Tags	-	3 (13.6%)

Total	**13**	**22**

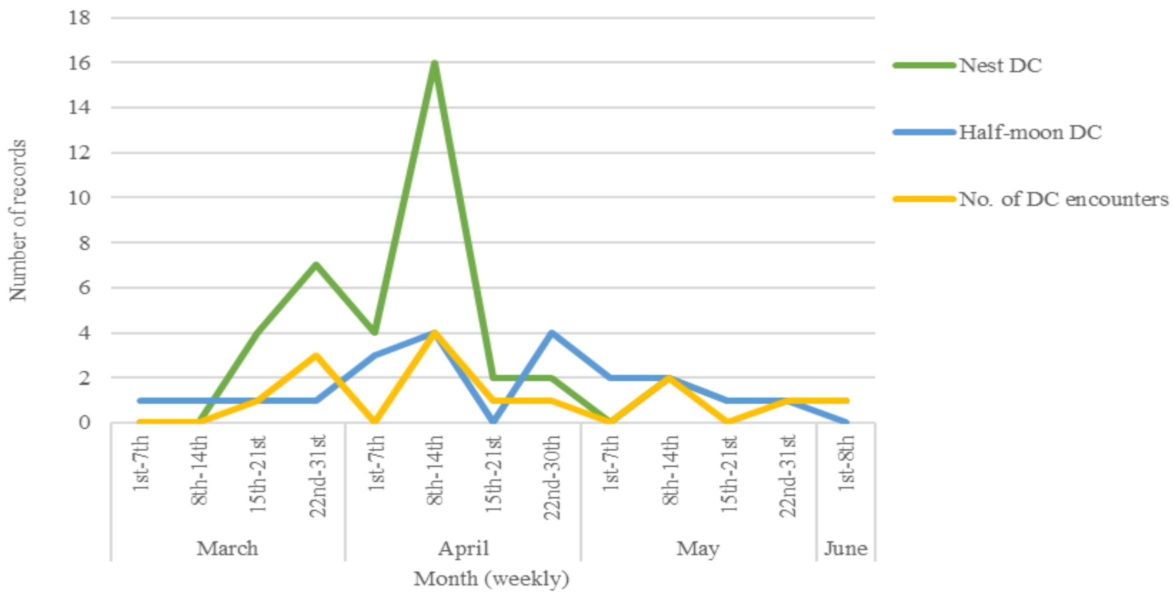


Fig 12: Temporal leatherback (*Dermochelys coriacea*) nesting activity from the 15th of March to the 8th of June 2019. Nesting activity is shown per week for each month of the nesting season.

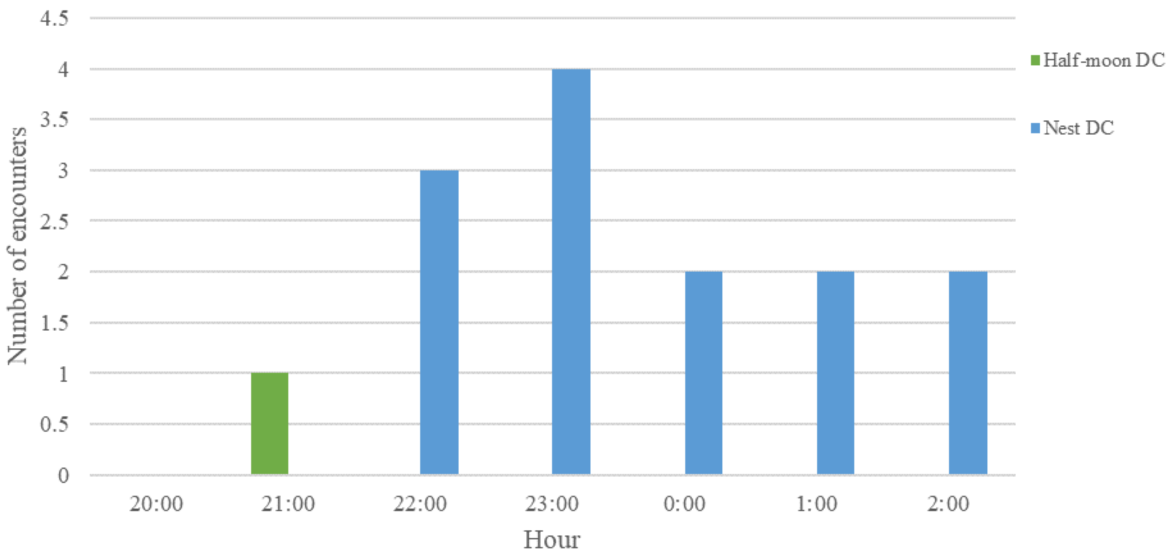


Fig 13: Temporal leatherback (*Dermochelys coriacea*) nesting activity on Playa Norte from the 15th of March to the 8th of June 2019. Nesting activity is shown per hour intervals from 20:00 to 03:00.

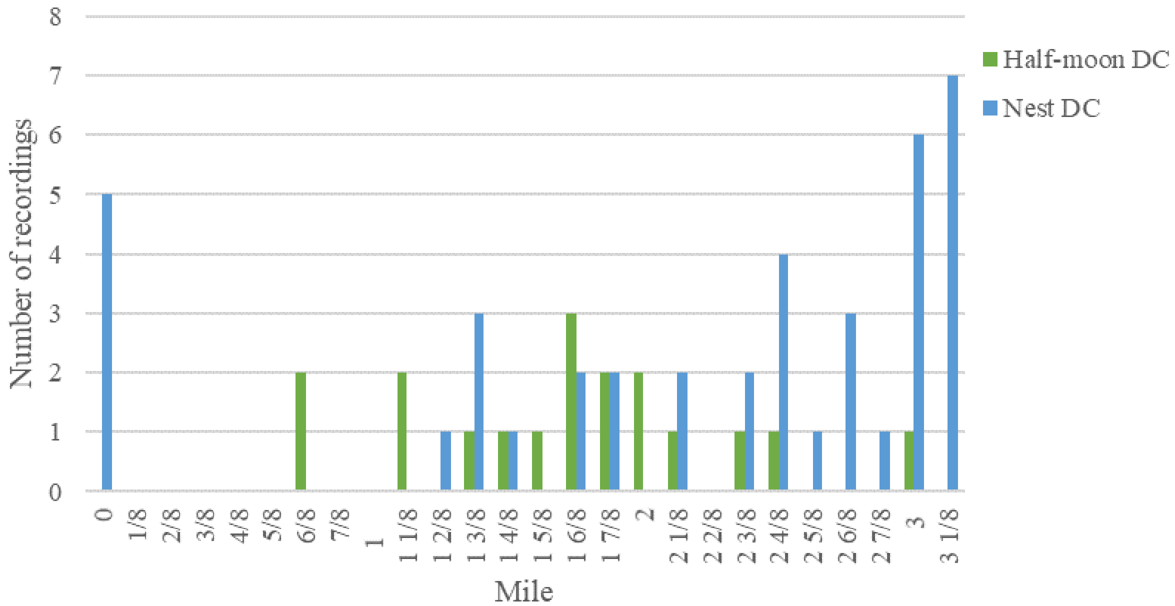


Fig 14: Spatial leatherback (*Dermochelys coriacea*) nesting activity on Playa Norte from the 15th of March to the 8th of June 2019. Nesting activity is shown for the full study transect (3 1/8 miles), which is divided into sectors of 1/8th of a mile (200m).

4.3 <u>Nest Success</u>

After the completed incubation period, triangulated (TRI) nests and non-triangulated (NTRI) nests are excavated when possible. In total, there were 9 triangulated nests, of which 5 (55.6%) were successfully excavated, 3 were eroded and 1 was unable to be located (table 7). All 5 of the excavated nests showed signs of hatching activity and the incubation duration was able to be calculated, with an average incubation time of 64 days (table 9). 7 nests were relocated during the laying process, due to inundation of the egg chamber from the high tide. There were no NTRI nests found for the leatherback, as no hatching activity was observed.

Of the excavated nests, they all showed embryonic development (table 8). The majority of unsuccessful eggs were found either with no embryo (26.5%) or in the 1st developmental stage (12.2%) (table 8). All of the excavated leatherback nests were affected by micro-predation (table 8).

The 2019 average hatching success was calculated as 61.1%, and the average emergence success was calculated as 57.5% (table 9), a significant improvement in comparison with 2018 (12.8% and 9.0% respectively, Allison 2018).

Table 7: Nest fate of triangulated leatherback (*Dermochelys coriacea*) nests (*n*=9) found from the 02nd of March to the 8th of June 2019.

Fate	**Total**	**%**
Excavated	5	55.5
Eroded	3	11.1
Not Found	1	33.4

Table 8: Contents of unhatched yolked eggs from successfully excavated triangulated leatherback (*Dermochelys coriacea*) nests (*n*=5) found from the 2nd of March to the 8th of June 2019.

Nest ID	No Embryo	Stage 1	Stage 2	Stage 3	Stage 4	PRE-Micro	PRE-Crabs	Deformed	Total
CP001	1	1	0	0	0	10	0	0	**12**
CP002	6	8	1	2	2	5	0	0	**24**
CP003	16	3	1	3	0	5	0	0	**28**
CP004	3	0	0	0	0	29	2	0	**34**
CP006	2	1	0	1	1	3	0	0	**8**
	28 (26.5%)	**13 (12.2%)**	**2 (1.9%)**	**6 (5.6%)**	**3 (2.8%)**	**52 (49.1%)**	**2 (1.9%)**	**0 (0%)**	**106**

Table 9: Hatching and emergence success (*n*=5), and the average incubation period (*n*=2) of successfully excavated leatherback (*Dermochelys coriacea*) triangulated nests found from the 2nd of March to the 8th of June 2019.

	Hatching Success (%)	Emergence Success (%)	Incubation Period (days)
Average	61.1	57.5	64
STD	± 24.2	± 23.0	± 12
Range	26.5, 82.1	24.5, 80.6	59, 74

4.4 Biometrics

Biometrics were taken, if possible, of encountered individual nesting females. The CCL minimum and CCW maximum were successfully taken on 13 out of the 14 occasions on which the female was encountered. The longest CCW recorded was 117.5 and the shortest was 104.0 (table 10). The longest CCL was 164.3 and the shortest 143.0 (table 10).

Table 10: Average biometrics taken from encountered individual nesting leatherback (*Dermochelys coriacea*) females (*n*=13).

	Av. CCWmax (cm)	Av. CCLmin (cm)
Average	111.6	155.3
STD	± 3.34	± 6.03
Range	104.0, 117.5	143.3, 164.3

4.5 Body Check

The body check was successfully performed on 13 of the encountered individuals. Of the 13 individuals, 2 (15.4%) were recorded as ‘complete’ and therefore had no observed abnormalities. The flippers (body zone 2, 4, 6, 8) were found as the most common location for abnormalities (table 11) with the most common found to be barnacles, 39% of the total recorded abnormalities, and flipper notches, also 28% of the total recorded abnormalities (fig. 15).

Table 11: Abnormalities observed per body zone during the routine body check from the encountered (*n*=13) nesting individual leatherback (*Dermochelys coriacea*) turtles.

	Body Zone								
Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Barnacles	0	2	1	10	1	0	0	5	**19**
Scars	0	0	0	0	1	0	0	0	**1**

Cuts	0	0	0	0	0	0	0	0	**0**
Flipper Notch	0	3	0	3	0	3	0	5	**14**
Bites	0	2	0	3	0	6	0	2	**13**
Tumours/Growths	0	0	0	1	0	0	0	1	**2**
Parasites	0	0	0	0	0	0	0	0	**0**
Deformed Carapace/Flipper	0	0	0	0	0	0	0	0	**0**
Missing Part of Carapace/Flipper	0	1	0	0	0	0	0	0	**1**
Hole	0	1	0	0	0	0	0	0	**1**
Total	**0**	**9**	**1**	**17**	**2**	**9**	**0**	**13**	

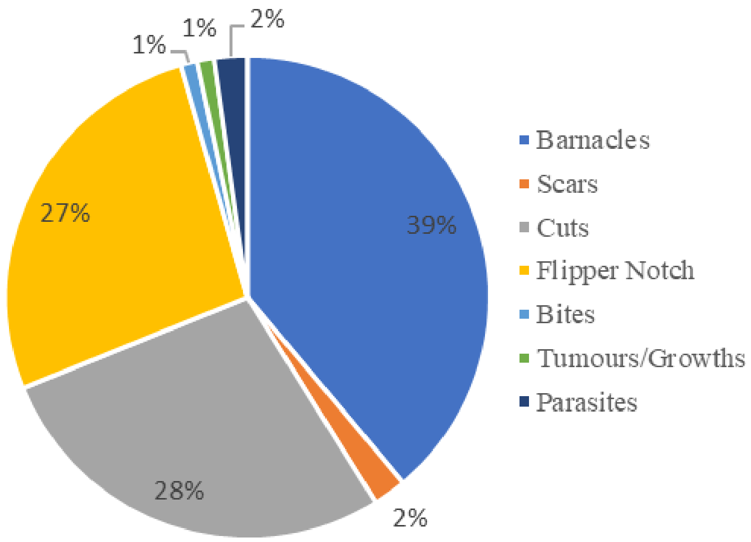


Fig 15: Most common abnormalities observed (%) from the encountered (*n*=13) nesting individual leatherback (*Dermochelys coriacea)* turtles.

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, that may have an impact upon the nesting success and nest site distribution of emerging sea turtles.

All illegal human impact recorded during the 2019 leatherback season is presented in table 12. Dogs were found to be the most frequent illegal impact on the beach representing 46.0% of all illegal activity (table 12). The presence of dogs remained stable throughout the season (fig. 16), with most recorded north of mile 2 (fig. 18). Their presence is also constant throughout the night, with observations made every hour, in contrast, locals were found to be present in the earlier hours (fig. 17). White lights are also a common issue, representing 28.1% of all illegal activity (table 12), with the majority occurring at Turtle Beach Lodge (TBL), located at mile 2 4/8 (fig. 18). An increase in local persons presence on Playa Norte, was observed between 22nd to 31st March and the 15th to the 21st of April (fig. 16).

Table 12: Human impact observations recorded on Playa Norte throughout the official leatherback (*Dermochelys coriacea)* season, 02[nd] March to 31[st] May 2019.

	White Lights	Cell Phone	Red Lights	Fires	Locals	Tourists	Dogs	Total
Total No. of Observations	206 (28.1%)	12 (1.6%)	3 (0.4%)	35 (4.8%)	118 (16.1%)	22 (3.0%)	338 (46.0%)	**734**

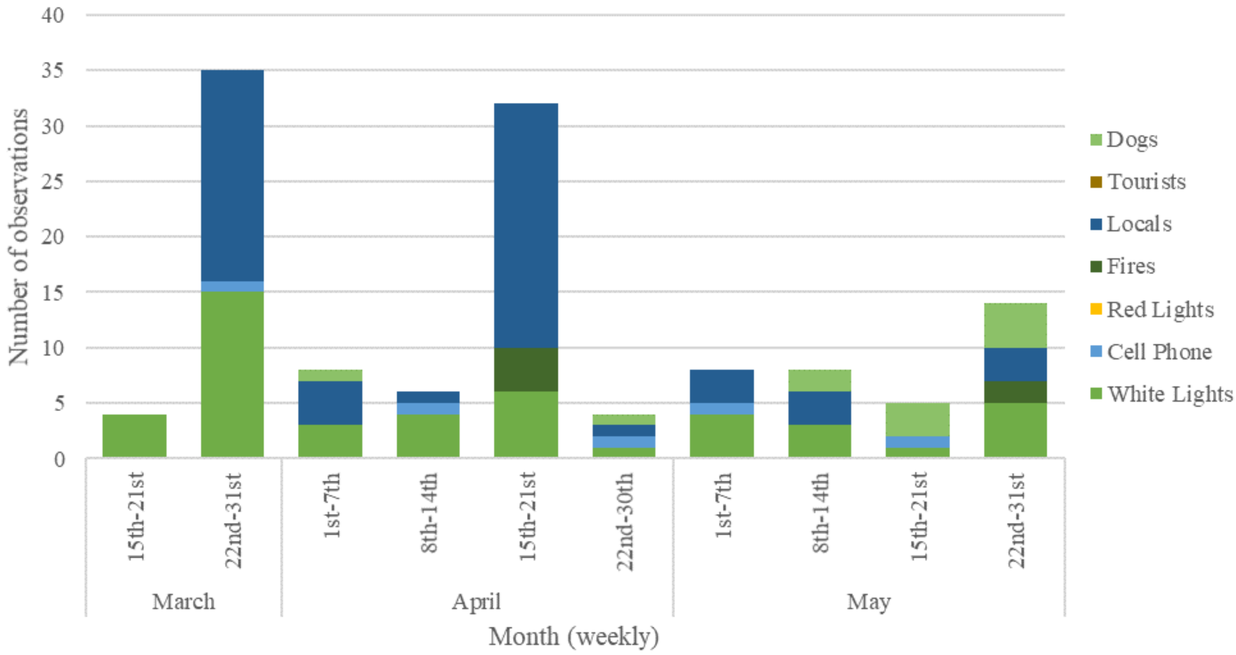


Fig 16: Temporal distribution of illegal human impact observations per week recorded along the 3 1/8-mile survey transect during leatherback (*Dermochelys coriacea*) season from the 15[th] of March until the 31[st] of May.

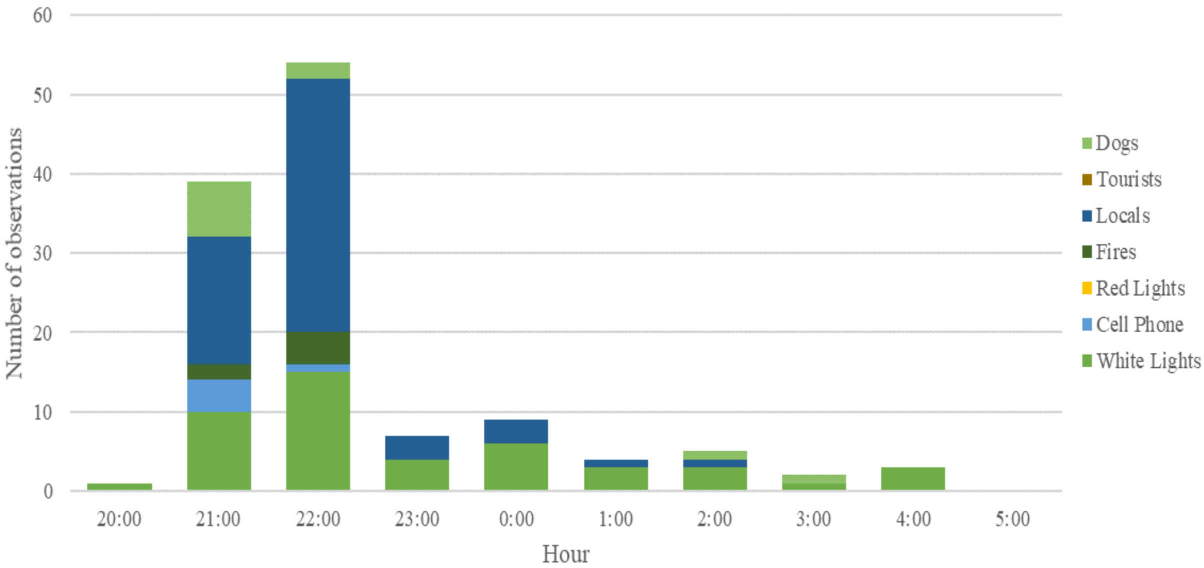


Fig 17: Temporal distribution of illegal human impact observations per hour recorded along the 3 1/8-mile survey transect during leatherback (*Dermochelys coriacea*) season from the 15[th] of March until the 31[st] of May.

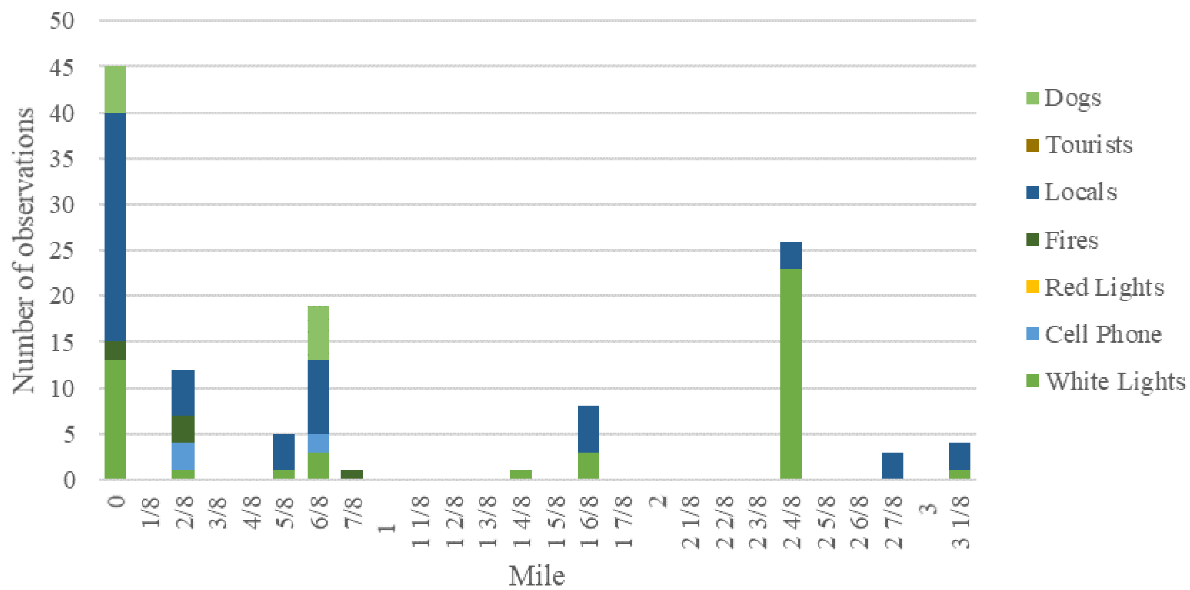


Fig 18: Spatial distribution of illegal human impact observations per mile marker (200m) recorded along the 3 1/8-mile survey transect during leatherback (*Dermochelys coriacea*) season from the 15th of March until the 31st of May.

4.7 Volunteers, Interns, and Training

During the leatherback turtle season (1st March to 31st May), a total of 28 volunteers and interns were present at the station. Eight interns were here specifically to participate in the turtle program (table 13), with 2 successfully demonstrating the practical skills to become independent patrol leaders, along with 2 mixed taxa interns.

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: Volunteers and Interns who participated in the 2019 Marine Turtle Monitoring Program during leatherback (*Dermochelys coriacea*) season.

Name	Nationality	Association	Project
Ella Wooden	American	Independent intern	-
Denise Dickenson	American	Independent intern	Turtle Project
Maria Dickenson	American	Independent intern	Turtle Project

Amelie Courbon	French	Independent intern	Turtle Project
Clara Bertrand	French	Independent intern	-
Tibaud Gracvier	French	Independent intern	-
Bert van Assink	Dutch	HAS University	
Jasmine Joy	Canadian	York University	Turtle project
Michelle Scone	Canadian	University of Toronto	University credit
Tristan Williams	Canadian	University of Toronto	University credit

Table 14: Participants of the turtle project training activities from the 1st of March to the 31st of May 2019.

Training	**No. of Attendees**	**Description**
General Biology	28	Biology and nesting behaviour of the species found on Playa Norte.
Morning Census	28	Morning census protocol.
Night Patrol	28	Night patrol protocol and a simulation of working a turtle.
Triangulation	18	Triangulation practice on the beach and relocation.
Tagging Training	10	Practice tagging exercise for trainee patrol leaders only.
Turtle Exam	18	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 2019 survey effort was notably less that previous years due to the fact that there were fewer people at Caño Palma Biological Station during leatherback season. Numbers gradually increased as the season progressed and as such we were able to have more frequent patrols. We maintained as high a night time presence on the beach as possible in order to deter poachers. When we were unable to patrol every night, we focussed our efforts around weekends, as our data from previous years shows that this is when nests are more likely to get poached (Allison, 2018; Guiterrez, 2017).. We patrolled the beach with one team every morning in order to records any nests that were missed by night patrol. The duration of night patrols gradually increased as the nesting activity increased, however this season, it became apparent maintaining the consistent survey effort was demanding especially with the low nesting activity. On 5 occasions, there were two night-patrol teams, due to an increased number of volunteers on base, however for the majority of leatherback season night patrol remained as one team. Due to consistent survey effort by MC and PM teams being reported to MINAE weekly, a positive relationship was maintained, however they were unable to support us on the beach this season.

5.2 Nesting Activity

The 2019 recorded nesting activity of the leatherback was almost double that of 2018, results show a 81% increase, however it is natural for sea turtle nesting numbers to fluctuate between nesting seasons, due to the average three-year interseasonal period. In 2019, the nesting season peaked between 1st April to the 30th during which around half of the total leatherback nesting activity was recorded. The busiest night of nesting for 2019 was the 8th of April. This coincides with the night of the new moon, suggesting a preference for dark nights. This coincides with other researchers, with 61.6% of turtles found on Gandoca beach on the Caribbean coast of Costa Rica, also emerging on dark nights, and supports the selective behaviour hypothesis that a nesting female visits the beach on a dark night as a survival strategy to avoid high rates of predation (Chacón *et al*, 1996).

5.3 Nest Success

A number of abiotic and biotic variables can affect nest success and cause partial or complete nest failure, including: temperature, moisture, root invasion, flooding, erosion, predation and poaching (Kamel & Mrosovsky, 2004). In 2019, in order to mitigate the effects of beach erosion, 7 nests were relocated to safer locations on the beach. Despite the efforts, 1 nest was still lost to erosion this season however this is an improvement compared to the 3 in 2018 and 2 in 2017 (Allison, 2018; Guiterrez, 2017). Despite leatherbacks having a naturally low hatching success, this season showed a much higher success rate than previous years with excavated nests having an average hatching success of 61.1%. This could also be as a result of relocations mitigating the effects of flooding and inundation which have affected previous years (Allison, 2018; Whitmore & Dutton, 1985). The average incubation period for the 2019 leatherback season was 65 days (± 5.7) which falls well within the global average range from 50-70 days (Chacón *et al*., 2007). The 2013 average was 63 days (±3.4) (Christen & García, 2013), and in 2016 the average incubation period was 62 days (McCargar & Humphreys, 2016). This increase from previous year may again be a result of relocating nests where shading from vegetation could have provided cooler temperatures affecting nest incubation period and possibly sex determination (Jensen *et al*, 2018).

5.4 Human Impact

Illegal human activity recorded during night patrol throughout the nesting season remained relatively constant however activity did appear to be higher during the peak of the season. The most common impacts that are recorded are white lights and locals with dogs. These observations coincide with the inhabited areas of the transect, however both locals and dogs present mobility throughout the full transect. Locals were most commonly present on Playa Norte during the earlier hours of the night, which may indicate a social presence. 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 spike increase of local activity observed on Playa Norte during the last week of March, is a result of the Easter holidays this is a yearly occurrence (Allison, 2018; Guiterrez, 2017). 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.

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.

In addition to conservation club, local beach cleans have been organised in the community with the children. This would involve an afternoon spent in groups, picking up plastic bottles 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. This season, two predation attempts on leatherback nests were recorded, however the presence of the authorities during this team helps to minimize local presence, and therefore we continue to welcome their support.

5.6 Looking Forward

We have recently received a new project coordinator, Charlie Pinson from Australia and are looking forward to a good year on the beach with him. In 2020 we intend to maintain our presence on the beach and reduce poaching as much as possible. We are hoping to use the data from the last decade to analyse trends and anomalies and use these finding to make our work on the beach as efficient as possible.

Again, in 2020, we will regularly report to MINAE and the police to gain their support, as their presence positively reduces local presence on Playa Norte.

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