Marine Turtle Monitoring and Tagging Program

Hawksbill Season Report

2019

Caño Palma Biological Station

Canadian Organisation for Tropical Education and Rainforest Conservation
Playa Norte, Costa Rica

Charles Pinson
Marine Turtle Project Coordinator
turtles@coterc.org

COTERC Marine Turtle Monitoring & Tagging Program, Caño Palma Biological Station
Barra del Colorado Wildlife Refuge, Costa Rica.

Hawksbill Turtle (*Eretmochelys imbricata*) 2019 Season Report.

Submitted to:
MINAE: Ministerio de Ambiente y Energía (Costa Rican Ministry of Environment and Energy)
COTERC: Canadian Organization for Tropical Education and Rainforest Conservation.

Authors:
Charles Pinson (BSc.)

Contact:
Estación Biológica Caño Palma,
Tortuguero, Costa Rica.
Tel: (+506) 2709 8052
URL: www.coterc.org

COTERC
P.O. Box 335, Pickering, Ontario. L1V 2R6. Canada.

Table of Contents

Acknowledgements

We would like to thank:

COTERC board members for the support, feedback, and encouragement we received throughout the season.

Institutional support

The 2019 Marine Turtle Monitoring & Tagging Program was conducted under a permit (RESOLUCIÓN SINAC-ACTO-D-RES-018-2019. Expediente M-PC-SINAC-PNI-ACTo-013-19) from SINAC (Sistema Nacional de Áreas de Conservacíon), ACTo (Área de Conservacíon Tortuguero) and MINAE (Ministerio de Ambiente y Energía). We are especially grateful for MINAE's continued support. In particular, we would like to thank Christian Robles Puchi, Victor Hugo Montero, Ana María Monge, and Elena Vargas from MINAE for their continued collaboration and interest in our projects.

Thank you to Turtle Beach Lodge for allowing our Morning and Night Patrols fill up their water bottles, and take shelter during thunderstorms and a special thanks to the night guard Wilson for his friendly support.

Sincere thanks to the Sea Turtle Conservancy (STC) and the Archie Carr Center for Sea Turtle Research (ACCSTR) for our continued collaboration, including sharing tag data and opportunities for our volunteers and interns to network with other turtle conservationists.

Personal support

We would like to express our appreciation for all the help, advice, information, hospitality, and friendship we received from many people living along Playa Norte. We would especially like to thank Macho Díaz, David José Castro, Mariví Cerdas-Beita, and Fran.

A colossal and heartfelt thank you to every volunteer, intern, visiting researcher, and student group who have given their time, hard work, and dedication to support the Marine Turtle Project this year. All photos, unless stated otherwise, in this report are courtesy of Caño Palma Biological Station staff and volunteers.

Particular thanks to our Patrol Leaders:
Molly McCargar, Nicole Allison, Anna Harris, Jasmine Joy, Elijah Dewoski, Rachel Green, Aidan Colligan, Sarah Ravoth, Fernando Lopez, Aina Pons, Suzanne Van de Straat, and Morgan Laketa.

List of Figures

List of Tables

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.

EI: *Eretmochelys imbricata.*
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 hawksbill (*Eretmochelys imbricata*) nesting season is 01st June until the 31st October, however we recorded the first hawksbill emergence on the 10th of May and the last hawksbill emergence on the 4th November 2019, therefore this report will discuss all nesting events from 10th of May 2019 until 4th 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 hawksbill 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 hawksbill 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 nesting event of the season was on the 10th of May and was encountered by the night patrol team and the last was on the 4th of November and was found by the morning census team.
- In total, there were 30 nests and 48 half-moons recorded between 10th of May and 4th of November, along our 3 1/8th mile study transect, Playa Norte.
- Of the emerging hawksbills, the encounter rate by the night patrol was 23.1% (18 out of 78) with tag data recorded on 11 occasions (5 REC, 6 REM, and 3 returned to the sea before being tagged).
- The night patrol teams encountered 8.3% (4 out of 48) of hawksbills during a half-moon.
- Of the nesting hawksbills, 46.7% (14 out of 30) were encountered by the night patrol with 43.3% (13 out of 30) encountered before or during oviposition and were triangulated.

1.3 Nest Success

- Average no. of yolked eggs 160 ± 12 ($\bar{x}$ ± std; [150, 179], *n*=5). Sample size (*n*) is based on individuals encountered before oviposition.

- Average incubation period (days) was 70 ± 3 ($\bar{x}$ ± std; [68, 72], *n*=2). 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 72.3% ± 20.0 ($\bar{x}$ ± std; [42.3, 97.7], *n*=4).
- Average emergence success was 70.7% ± 25.9 ($\bar{x}$ ± std; [42.3, 93.1], *n*=4).

The 13 triangulated nests were checked daily during the incubation process, with the following outcome:

- Four nests remained natural and were successfully excavated.
- Four nests were eroded.
- One nest was not found during the excavation process.
- Two nests were poached.
- Two nests were predated, one partially and one fully.

1.4 Biometrics

- Average (cm) minimum curved carapace length (CCLmin): 88.6 ± 3.3 ($\bar{x}$ ± std; [83.1, 94.0]; *n*=11).
- Average (cm) maximum curved carapace width (CCWmax): 79.1 ± 3.5 ($\bar{x}$ ± std; [73.4, 84.5], *n*=11).

1.5 Body Check

- The most common observed abnormality on the hawksbill were barnacles, accounting for 97.6% of all abnormalities checked for during the bodycheck.

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 hawksbill (*Eretmochelys imbricata*) 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 hawksbill name is derived from their hawk-like beak, a dietary adaptation enabling them to consume silica rich sponges, their main food source (Meylan 1988). Hawksbill stomach content analysis found over 90% of the dried content was sponge, including species known to be highly toxic to fish and with a silica content similar to opal, a type of glass (Meylan, 1988). Due to their specialised diet hawksbills inhabit tropical coral reefs and once played a unique ecological role in maintaining the structure of the reef system and maintaining the stability of the food web (Spotila, 2004). Until recently it was questioned whether this species was migratory, which the Cuban government used to argue a sovereign right to the harvest of the species in Cuban waters, despite it being afforded intentional protection (Mortimer *et al.*, 2007). However, recent mitochondrial DNA (mtDNA) haplotype data have disputed this, confirming that harvesting at the national level is likely to impact on the species globally (Bowen *et al.*, 2006). What remains unknown, however, is why the species migrates from apparently suitable nesting sites close to its feeding grounds, to nest on its natal beach hundreds, possibly thousands of miles away (Spotila, 2004). Relative to green and leatherback sea turtles, far fewer data are available on the ecology and life cycle of the hawksbill turtle.

Table 1: Nesting characteristics of the hawksbill (*Eretmochelys imbricata*) turtle found throughout Costa Rica (Adapted from Chacón *et al.*, 2007).

Characteristic	Description
Average Length Sexually Mature Female (CCLmin) (cm)	85.97
Inter-Nesting Frequency (nests/season)	5
Re-Migration Interval (yrs.)	2-3
Inter-Nesting Interval (days)	14 - 16
Average Clutch Size (yolked eggs)	155
Average Track Width (cm)	70-85
Track Shape	Asymmetrical
Average Nest Depth (cm)	45
Nesting Season on the Caribbean Coast of Costa Rica	May to November: Barra del Colorado, Tortuguero, Parasmina, Pacuare, Cahuita, Gandoca.
Nesting Season on the Pacific Coast of Costa Rica	May to January: Langosta, Manuel Antonio, Nancite, Jacó.
Pivotal Nest Temperature (°C)	29.32
Average Incubation Period (days)	47-75
General Characteristics	Four pairs of lateral overlapping scutes. Two pairs of prefrontal scales. Hawk-like beak, upper jaw thrust forward.

	Two front flipper claws.

2.2 Anthropogenic Threats

Aside from natural threats such as predation and tidal inundation of nests, hawksbill 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, 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*., 1994; Bugoni *et al*., 2001; Vélez–Rubio *et al.*, 2013).

Although Hawksbill eggs are consumed in large quantities, the greatest threat currently to this species is the trade of its much-revered shell (tortoise-shell, raw scutes) and carey (worked shell) used for ornamentation and jewellery (Márquez, 1990; Choi & Eckert, 2009).

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, hawksbill 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 (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.

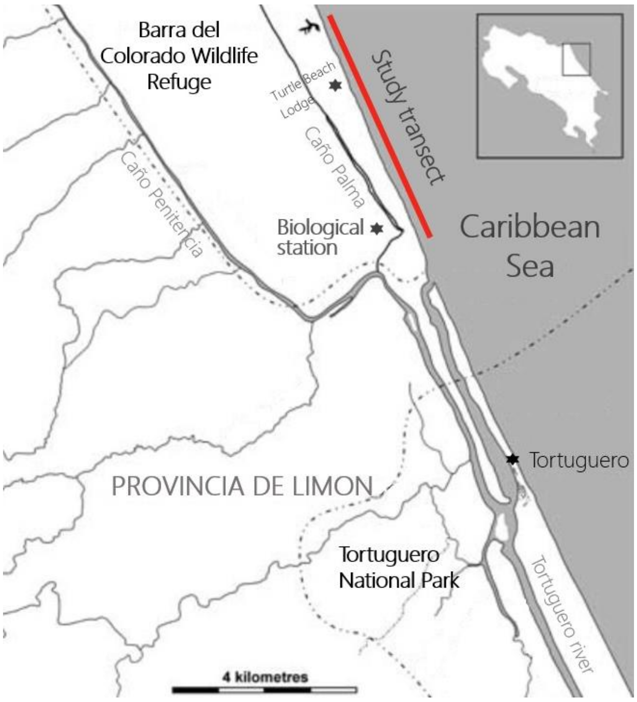

Figure 1: Descriptive map showing the 3 1/8th mile survey transect highlighted in red, and the location of Caño Palma Biological Station (CPBS) (modified from Grant & Lewis, 2010).

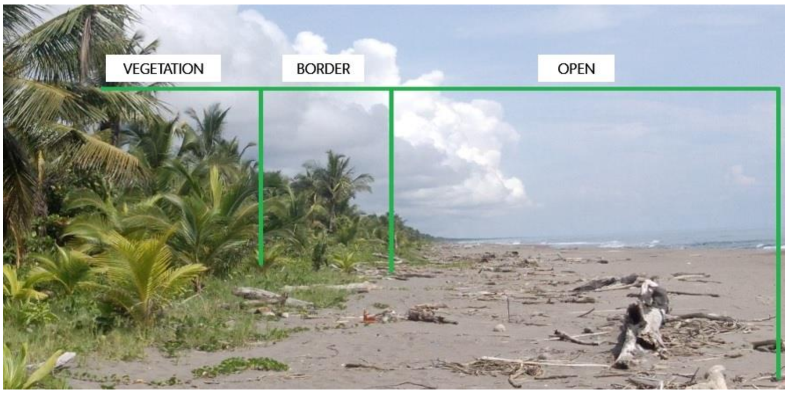

Fig 2. An illustration describing the different sectors of vertical beach zones, differentiated by the amount of shade cover each area receives.

Along the beach transect, mile markers were placed every $1/8^{th}$ 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 hawksbill sea turtle nesting season, patrols were carried out on as many night as possible given the number of people available from the 01^{st} June to 26^{th} October. The minimum duration of night patrol was 6 hours, and consisted of a minimum of three persons. On the occasion of more than one night-patrol team, 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) 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), to which a nest is disguised to minimise poaching. In the event of a hawksbill half-moon, the tracks are also disguised in an attempt to disguise hawksbill activity.

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.

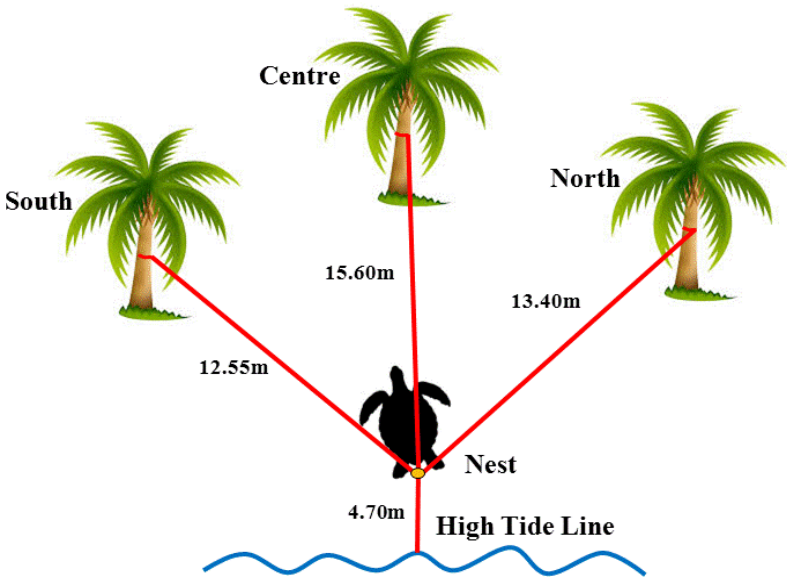

Fig 3: An example of the nest triangulation, to mark the nest location. The red lines indicate the measurements taken from the egg chamber to the three fixed points in the vegetation.

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. Hawksbills 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.

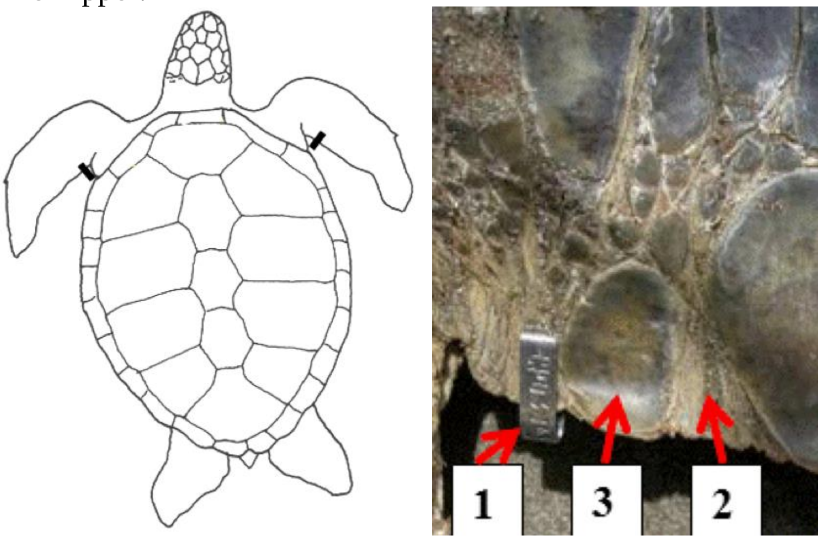

Fig 4: Tag position on hard carapace sea turtles. On the skin before the primary scale (left). Optional tag positions (right) are as follows: (1) before the primary scale on the skin, (2) in between the primary and secondary scale on the skin, (3) through the primary scale.

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.

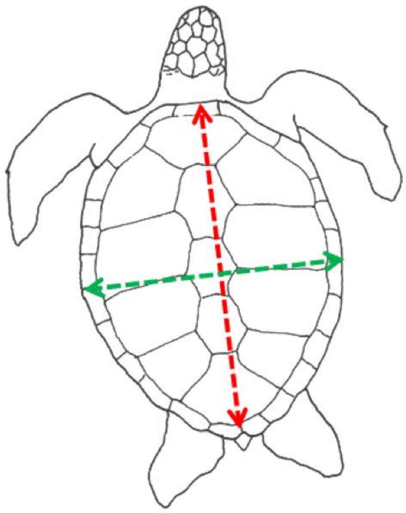

Fig 5: Diagram showing the dimensions of the biometrics taken from hard carapace sea turtles. CCWmax (green) and CCLmin (red).

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.

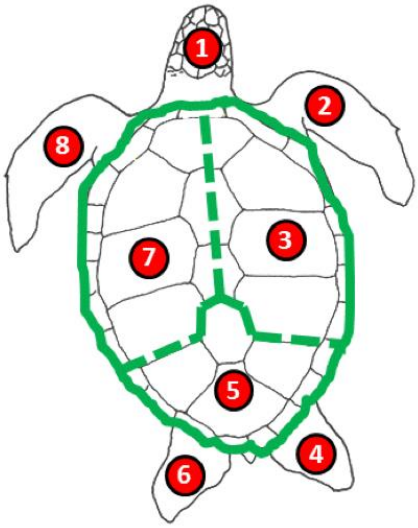

Fig 6: Body check zones. The zones are clockwise starting at zone 2, and ending on zone 1.

3.2.2 Morning Census Protocol

Morning Census (MC) was carried out daily from 1st June to 28th December during the official hawksbill 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, a material found to be significantly more effective (53%), and environmentally friendly than plastic (Pheasey *et al*, 2018), are placed, when possible, on hawksbill nests to minimise predation by domestic dogs. The average nest depth of a hawksbill nest is 45cm (Chacon *et al*, 2007), therefore mesh is placed at a depth of 10cm 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 hawksbill is estimated to have an average incubation period of 60 days, with a range of 47-75 days (Chacon *et al*, 2007). In 2017 on Playa Norte the average incubation period was 61 days (Guiterrez, 2017). At day 55 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 70 of incubation – excavate on 70^{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 when available (from embryos that died before hatching). 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.

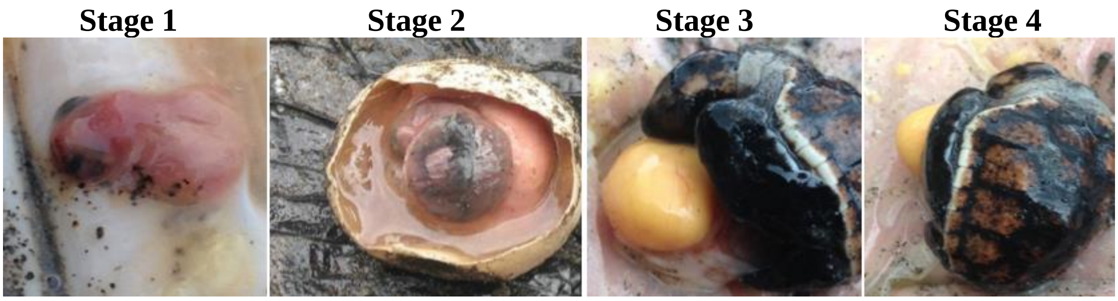

Fig 8: The different developmental stages of the sea turtle embryo.

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 hawksbill 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 2nd of March, and the beach was patrolled by at least one team on as many nights as possible. 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 hawksbill 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.

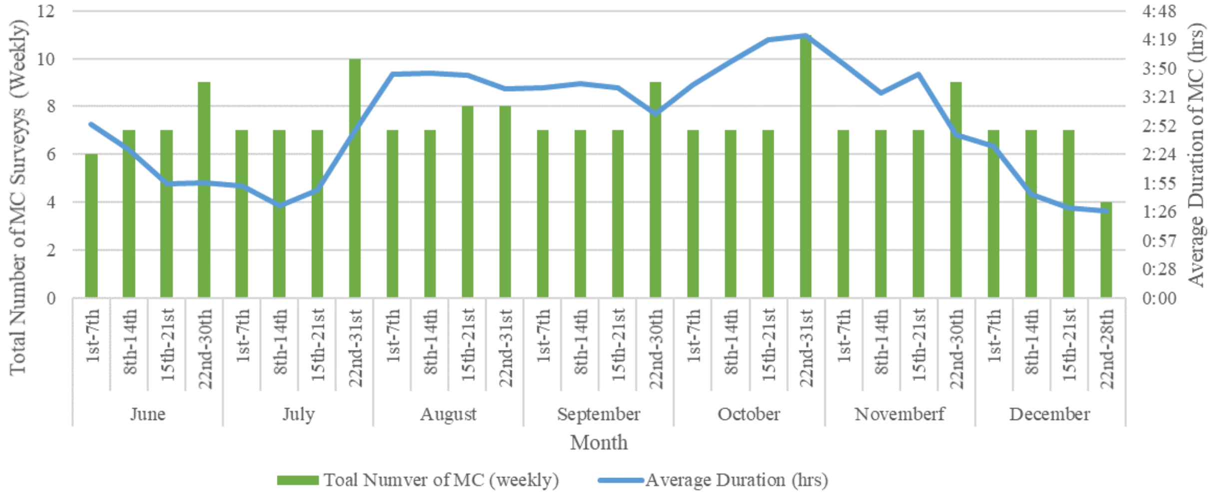

Fig 9: Morning census (MC) survey effort recorded from the 01st of June until the 28th of December 2019. Effort is given as the total no. of MC surveys per week for each month and the average duration (hrs) per week.

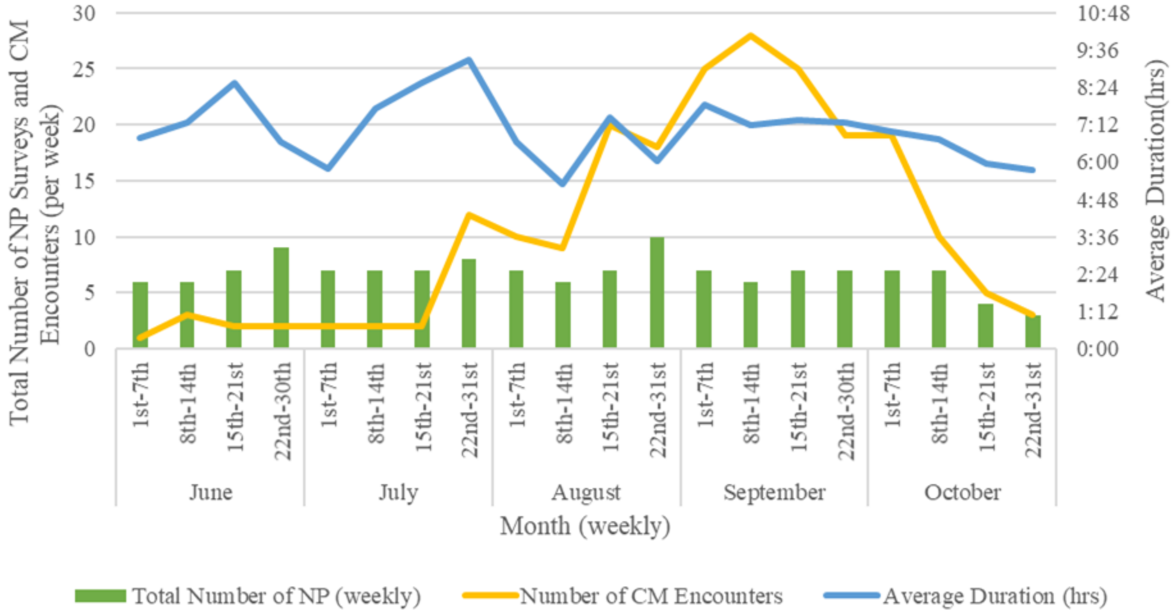

Fig 10: Night Patrol (NP) effort recorded from the 01st of June until the 26th of October. Effort is given as the total no. of NP surveys per week and the average duration (hrs) per week. The no. of encountered turtles is given per week to highlight encounter rate relative to survey effort.

4.2 Nesting Activity

There was a total of 30 hawksbill nests recorded on Playa Norte along the 3 1/8-mile survey transect between the 10th of May and the 4th of November, which shows a 37.5% decrease of nests compared with 2018 (*n*=48), however, relative to previous years, the overall nesting trend is observed to be increasing over a 14-year period (fig. 11). Throughout the 2019 season, 14 (17.9%) hawksbill individuals were encountered while nesting, and 4 (5.1%) were encountered during a non-nesting emergence (table 5), with the overall encounter rate calculated as 23.0%.

In 2019, of the 14 individual's that were encountered during the nesting process, there were 5 individuals newly tagged, and 6 individuals emerged with previous tags, and the tagging data was not collected from 3 encounters (table 6).

Peak hawksbill nesting activity on Playa Norte was between the 14th of May until 15th July, with the nesting trend decreasing consistently until November 4th (fig. 12). The hawksbill more frequently emerged between 22:00 and 02:00 hrs, with 9 of the 14 encounters recorded within this time slot (fig. 13). In terms of spatial distribution, there was no strong preference observed to a particular beach sector (fig. 14), however most nest were typically deposited in vegetated areas with a lot of debris.

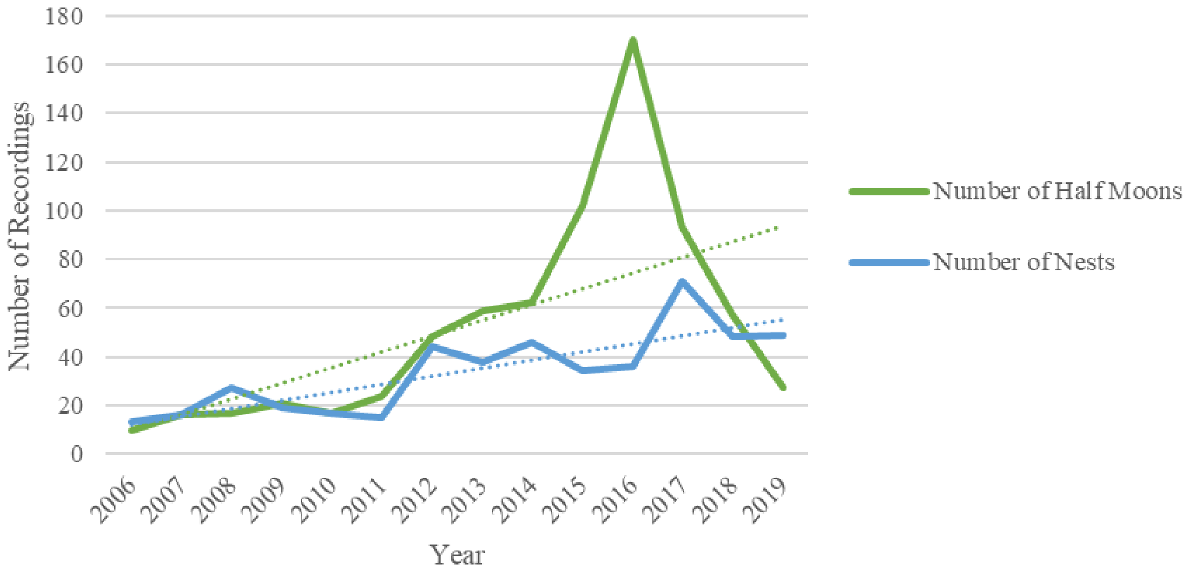

Fig 11: Temporal nesting activity of the hawksbill (*Eretmochelys imbricata*) during the time period 2006 to 2019 on Playa Norte.

Table 5: Descriptive data of the total hawksbill (*Eretmochelys imbricata*) nesting activity recorded from the 10th of May to the 4th of November 2019 and the 11th of April to the 15th of November 2018.

	2019		**2018**	
	Nest	**Half-moon**	**Nest**	**Half-moon**
Turtle Present	14 (46.7%)	4 (9.1%)	26 (54.2%)	2 (3.50%)
Turtle Absent	16 (53.3%)	44 (90.9%)	22 (45.8%)	55 (96.5%)
Total	**30**	**48**	**48**	**57**
Triangulated	13 (43.3%)	-	16 (33.3%)	-

Table 6: Tagging data of nesting hawksbill (*Eretmochelys imbricata*) turtles encountered from the 10th of May to the 8th of October 2019 and the 11th of April to the 15th of November 2018. Included is the % of re-capture status of the encountered individuals.

	2019	**2018**
REC	5 (35.7%)	15 (57.7%)
REM	6 (42.9.%)	3 (11.5%)
REN	0 (0%)	2 (7.70%)
No Tags	3 (21.4%)	6 (23.1%)
Total	**14**	**26**

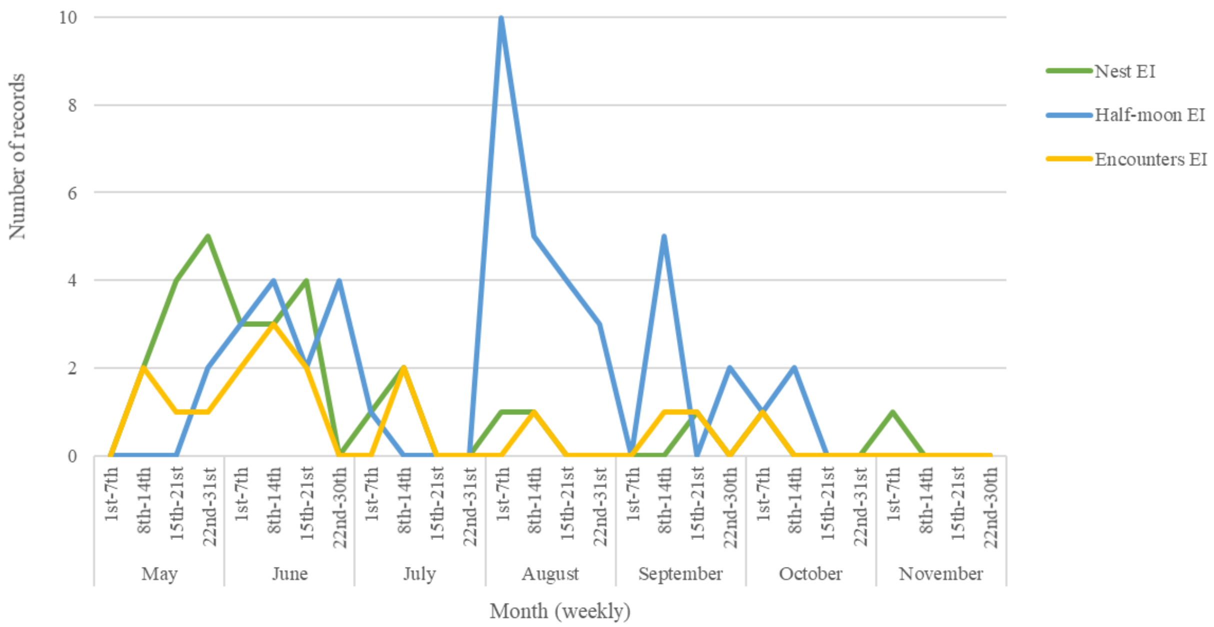

Fig 12: Temporal hawksbill (*Eretmochelys imbricata*) nesting activity from the 10th of May to the 4th of November 2019. Nesting activity is shown per week for each month of the nesting season.

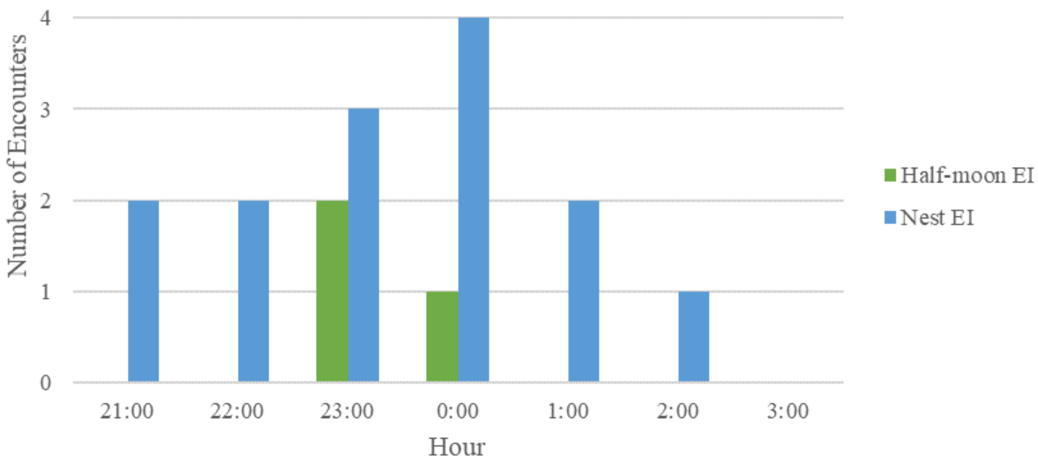

Fig 13: Temporal hawksbill (*Eretmochelys imbricata*) nesting activity from the 10th of May to the 4th of November 2019. Nesting activity is shown per hour intervals from 20:00 to 04:00.

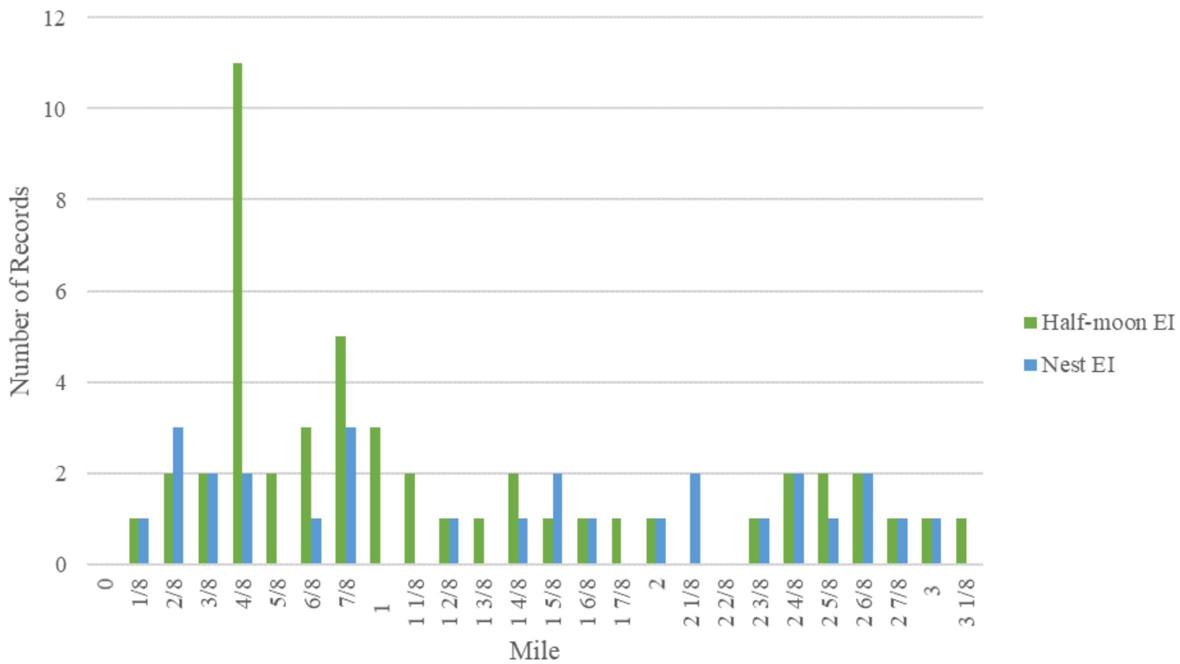

Fig 14: Spatial hawksbill (*Eretmochelys imbricata*) nesting activity on Playa Norte from the 10th of May to the 4th of November 2019. Nesting activity is shown for the full study transect (3 1/8 miles), which is divided into sectors of 1/8th of a mile (200m).

4.3 Excavations and Nest Success

After the completed incubation period, triangulated (TRI) nests and non-triangulated (NTRI) nests were excavated when possible. In total, there were 13 TRIs, of which 4 (30.1%) were successfully excavated, and 17 NTRIs, of which 5 (29.4%) were successfully excavated, none of which were showing any signs of disturbance (table 7).

During the daily nest check of the 13 TRI hawksbill nests, 7 (53.8%) were recorded as wet, 6 (46.2%) displayed signs of some form of predation, with 2 (15.4%) remaining undisturbed throughout the full incubation period. 2 (15.4%) nests were confirmed as poached during the excavation process (table 7). Hatching activity was observed from 2 TRI nests allowing the approximation of an average incubation time of 70 days (table 9).

The 2019 average hatching success was calculated as 72.3%, and the average emergence success was calculated as 70.7% (table 9), decreasing in comparison with 2018, 85.6%, 85.2%, *n*=7 respectively (Allison, 2018).

Table 7: Nest fate of hawksbill (*Eretmochelys imbricata*) nests, TRI (*n*=13) and NTRI (*n*=17) recorded from the 10th May to the 4th of November 2019 on Playa Norte.

Fate	TRI	NTRI
Excavated	4 (30.8%)	5 (29.4%)
Eroded	4 (30.8%)	-
Flooded	-	1 (5.8%)
Not Found	1 (7.6%)	7 (41.2%)
Predated (Full or Partial)	2 (15.4%)	1 (5.9%)
Poached	2 (15.4%)	3 (17.6%)

Table 8: Hatching and emergence success (*n*=7), and the average incubation period (*n*=2) of successfully excavated triangulated and non-triangulated hawksbill (*Eretmochelys imbricata*) nests found from the 10th May to the 4th of November 2019 on Playa Norte.

	Hatching success (%)	Emergence Success (%)	Incubation Period (days)
Average	72.3	70.7	70
STD	± 20.0	± 25.9	± 3
Range	42.3, 97.7	42.3, 93.1	68, 72

Turtle Mortality, Poaching and Predation

In 2019, we recorded a total of 2 adult hawksbill mortalities and 2 juveniles on Playa Norte. One adult was confirmed poached and one washed ashore with signs of bloating, and therefore the death was recorded as natural.

Of the 30 nests, it can be reported that 3 were predated (10%), with 1 partially predated (3.3%) and five showing signs of disturbance (16.6%). In total, there were partial predation events on seven separate occasions and predation attempts, identified by dog prints or digging on 4 separate occasions.

Of the 30 nests, it can be reported that 3 were poached (10%), and another 2 had signs of a poaching attempt (6.7%). In total, there were poaching attempts recorded on 5 separate occasions, identified by footprints or stick holes. The spatial distribution of poaching and predation was analysed, and can be observed that throughout the hawksbill season, nest poaching was recorded most south of mile marker 2 4/8th, with nest predation recorded most north of mile marker 2 4/8th (fig. 15).

The nest protection project continued to be implemented on hawksbill nests (*n*=5). Of the nests that received protection by mesh, 20% were predated and 20% had a partial predation. The majority, 60%, remained with no signs of disturbance (table 9). Un-protected nests (*n*=11), also received some predation disturbance (36.4%), however the majority, 63.7%, remained natural (table 9).

Table 9: Nest fate of triangulated (TRI) hawksbill (*Eretmochelys imbricata*) nests that had received mesh barriers as a protection mechanism from predation (*n*=5), and those without mesh barriers (*n*=11).

Type of Disturbance	Mesh	No Mesh
None	3	2
Predated	1	1
Partial Predation	1	0
Predation Attempt	0	0
Poached	0	2
Eroded	0	4
Not Found	0	1

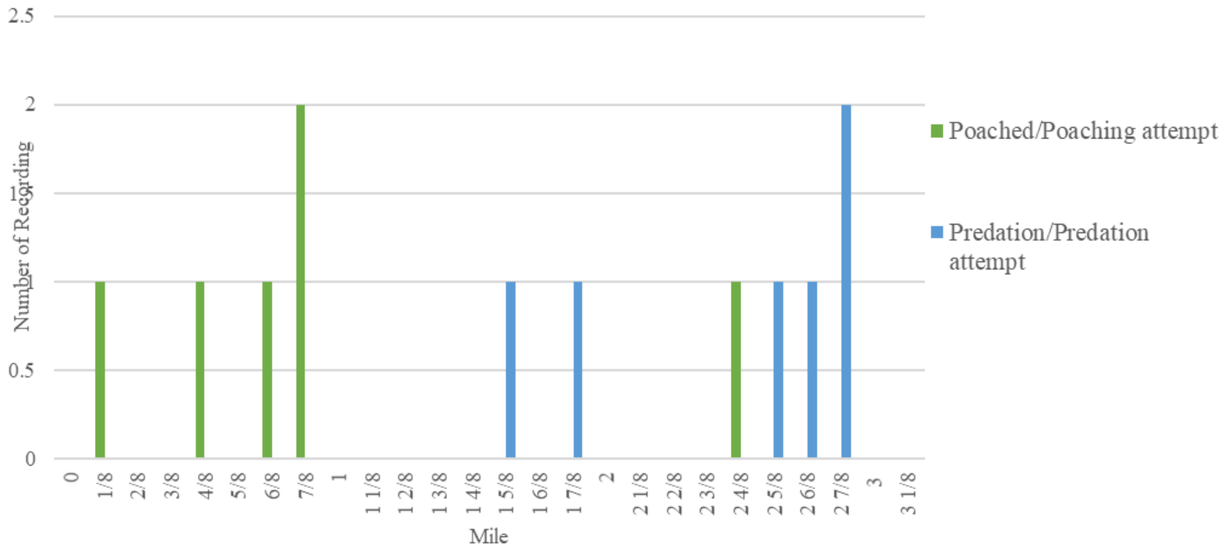

Fig 15: Spatial analysis of the poaching and predation pressure on all hawksbill (*Eretmochelys imbricata*) nests recorded from the 10th of May to the 4th of November 2019.

4.4 Biometrics

Biometrics were taken, if possible, of encountered individual nesting females. The CCL minimum and CCW maximum were successfully taken on 11 out of the 14 occasions on which the nesting female was encountered (table 10). CCW was measured on 16 occasions, due to the turtle returning to the sea.

Table 10: Average biometrics, curved carapace width (CCW) and curved carapace length (CCL), taken from encountered individual nesting hawksbill (*Eretmochelys imbricata*) females (n=11).

	Average CCWmin (cm)	**Average CCLmax (cm)**
Average	88.6	79.1
STD	± 3.3	± 3.5
Range	83.1, 94.0	73.4, 84.5

4.5 Body Check

The body check was successfully performed on 11 out of the 14 occasions when an individual was encountered. Of the 14 individuals, 1 (6.3%) was recorded as 'complete' and therefore had no observed abnormalities. The carapace (body zone 3, 5, 7) were found as the most common location for abnormalities (table 11) with the most common found to be barnacles, 97.6% of the total recorded abnormalities. The only other recorded abnormality was one carapace deformity (table 11).

Table 11: Abnormalities observed per body zone during the routine body check performed on encountered (n=11) nesting individual hawksbill (*Eretmochelys imbricata*) turtles.

	Body Zone								
Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Barnacles	0	3	9	5	6	5	8	1	**41**
Scars	0	0	0	0	0	0	0	0	**0**
Cuts	0	0	0	0	0	0	0	0	**0**
Flipper Notch	0	0	0	0	0	0	0	0	**0**

Bites	0	0	0	0	0	0	0	0	**0**
Tumours/Growths	0	0	0	0	0	0	0	0	**0**
Parasites	0	0	0	0	0	0	0	0	**0**
Deformed Carapace/Flipper	0	0	0	0	1	0	0	0	**1**
Missing Part of Carapace/Flipper	0	0	0	0	0	0	0	0	**0**
Hole	0	0	0	0	0	0	0	0	**0**
Total	**0**	**3**	**9**	**5**	**7**	**5**	**8**	**1**	**42**

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 hawksbill nesting season is presented in table 12. White lights were found to be the most frequent illegal impact on the beach representing 47.9% of all illegal activity (table 12). White lights remained constant throughout the season, with an increase between the 15th to 21st September (fig. 16), 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. 16). Locals were present from the early hours, with a peak presence between 21:00 & 23:00 (fig. 17), with most observed south of mile marker 2 (fig. 18).

Table 12: Human impact observations recorded on Playa Norte throughout the official hawksbill (*Eretmochelys imbricata)* nesting season, 01st of June to the 26th of October 2018.

	White Lights	**Cell Phone**	**Red Lights**	**Fires**	**Locals**	**Tourists**	**Dogs**	**Total**
Total No. of Observations	409 (47.9%)	16 (1.9%)	14 (1.6%)	17 (2.0%)	153 (17.9%)	0 (0%)	244 (28.7%)	**853**

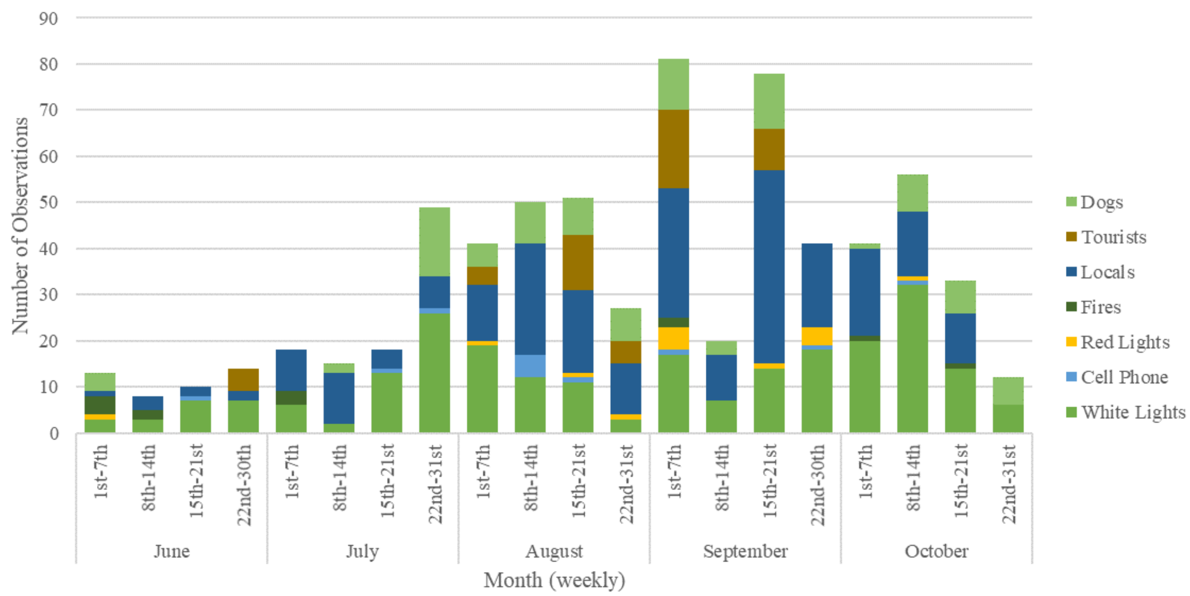

Fig 16: Temporal distribution of illegal human impact observations per week recorded along the 3 1/8-mile survey transect during hawksbill (*Eretmochelys imbricata*) nesting season from the 01st of June until the 26th of October.

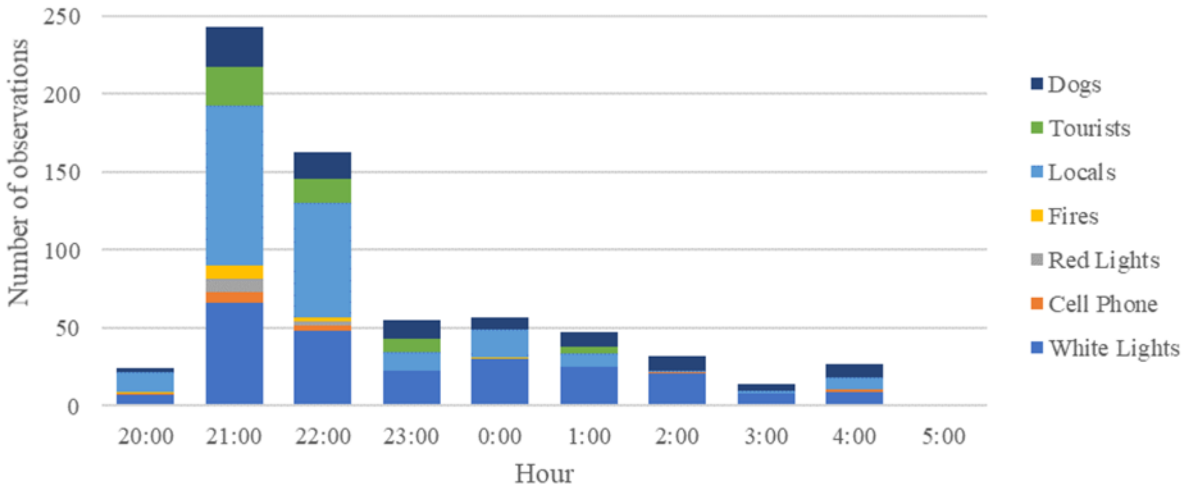

Fig 17: Temporal distribution of illegal human impact observations per hour recorded along the 3 1/8-mile survey transect during hawksbill (*Eretmochelys imbricata*) nesting season from the 01st of June until the 26th of October.

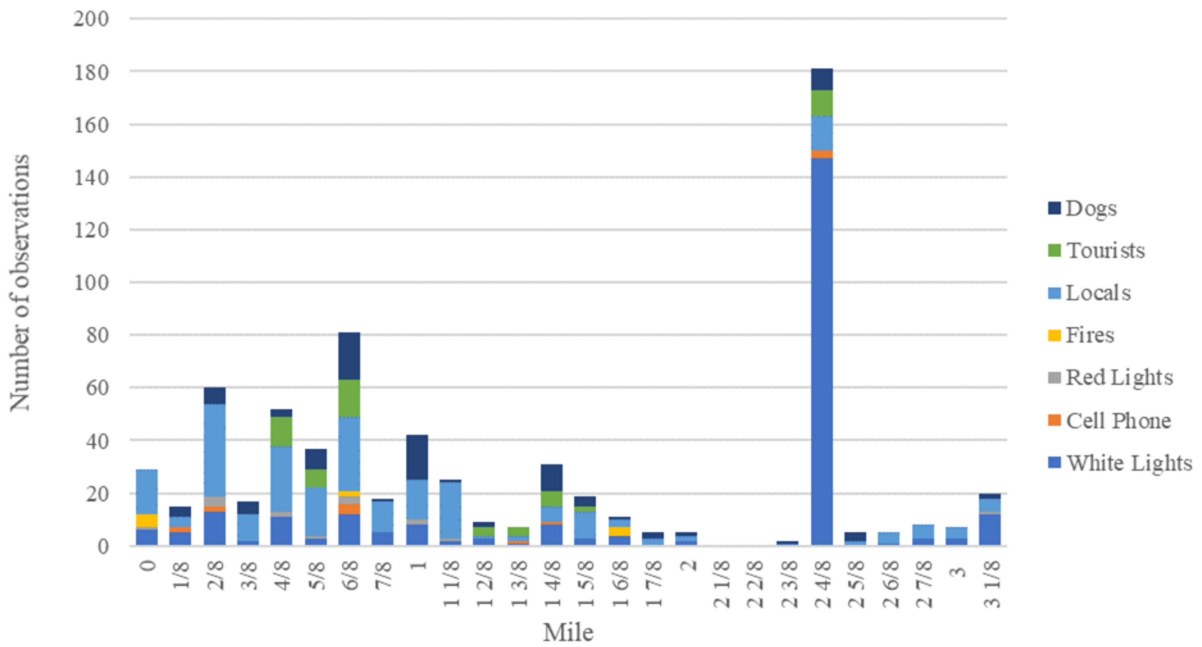

Fig 18: Spatial distribution of illegal human impact observations per mile marker (200m) recorded along the 3 1/8-mile survey transect during hawksbill (*Eretmochelys imbricata*) nesting season from the 01st of June until the 26th of October.

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 during 01st June until 28th 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 from the 01st of June until the 28th of December 2019.

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 at night 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 in the later months, due to 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 Nesting Activity

The 2019 recorded nesting activity of the hawksbill, is low compared with 2018, results show a 44% decrease, however it is natural for sea turtle nesting numbers to fluctuate between nesting seasons, due to the two to three-year migration interval to the foraging ground. 2017, recorded the highest deposition of hawksbill nests on Playa Norte in over ten years (Allison, 2018) and the observed trend is an overall increase in the number of hawksbill nests on Playa Norte. However, throughout July, Playa Norte suffered from severe weather conditions resulting in erosion, high tides and flooding. It is unknown if these conditions had an effect on the nesting success of the hawksbill. In 2019, the nesting season peaked from 21st May to the 21st June, after which nesting activity slowly declines. These peak nesting periods are earlier in comparison with 2018, the reason for this shift is unknown, but could be influenced by physical environmental pressures.

5.3 Nest Success

A number of abiotic and biotic variables can affect nest success of the hawksbill sea turtle and cause partial or complete nest failure, including: temperature, moisture, root invasion, flooding, erosion, predation, and poaching (Kamel & Mrosovsky, 2004). In 2019, 4 nests were recorded as eroded and 1 was not able to be found, of the triangulated 13. In 2018, only 1 nest suffered from erosion, of the triangulated 28 (Allison, 2018), and in 2017, no nests were lost to erosion (Guiterrez, 2017). This could be a result of the El-Niño year, causing severe erosion of Playa Norte in 2018 and 2019. The average hatching success for the 2019 Hawksbill season was 72.3%. This is low compared to 2018 and reasons for this are unknown but could be related to physical environmental conditions. In comparison with the leatherback and green hatching success, the hawksbill has a high average hatching and emergence success (61.5%, 77.1% respectively). This could be a result of nest-site choice and changing environmental conditions. The hawksbill sea turtle has similar nest site selection to the green sea turtle 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 hawksbill turtle suffers from an increased poaching pressure compared to other areas in Costa Rica due to a decreased level of law enforcment. At the beginning of the season, nest concentration is low resulting in a higher predation rate. This occurs mostly in the south section of the transect, and therefore on occasions with low personnel, effort is maintained within this sector. In 2019, a 3 out of the 30 hawksbill nests were confirmed as poached. In an attempt to minimise this, tracks are erased and nests are disguised to puzzle an experienced poacher of the exact location of the egg chamber. However, there always remains a chance that a poacher will find the eggs. In order to mitigate the lifting of the individual, the team will wait until a nesting female returns to the ocean.

One of the most significant threats to the hatchling success of sea turtles is non-natural predation by domestic dogs. In 2013, 25% of hawksbill sea turtle nests were lost to domestic dog predation on Playa Norte (Pheasey *et al*, 2018). In 2014, a protective barrier project was initiated and bamboo barriers were deployed to protect nests. In 2019, efforts were continued to deploy bamboo barriers, however materials and personnel were severely limiting factor and only a small number of nests were able to be meshed. A small total of 3 of the 13 triangulated hawksbill nests (23.1%) received bamboo barriers, with 2 remaining protected throughout the incubation period, and 1 experiencing a partial predation. This sample size is too low to determine the success of the bamboo barriers, however Pheasey *et al* (2018) reported that hawksbill sea turtle nests are more vulnerable to predation than other sea turtle species, due to their low egg chamber depth. Bamboo barriers do not have a negative effect on hatching success and there is no correlation between predation activity on nests with or without bamboo barriers, therefore deployment did not increase or decrease predators (Pheasey *et al*, 2018).

Due to frequent loss of hawksbill nests and the small number from which hatchling tracks were recorded (n=2), it is difficult to accurately calculate the average incubation period on Playa Norte for 2019. In 2019 the average incubation period was 70 days (±3), remaining within the range 47-75 days (Chacón *et al*., 2007). Although this is inconsistent with previous years. In 2018 the average was 63 (±6) days (Allison, 2018). The 2017 average was 61 days (±11) (Gutiérrez, 2017).

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 9mm 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 times 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 results of our 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 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. 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.

References

Allison, N. (2018). COTERC Marine Turtle Monitoring & Tagging Program, Caño Palma Biological Station, Green Season Report 2018. Unpublished.

Berry, M., Booth, D. T., & Limpus, C. J. (2013). Artificial lighting and disrupted sea-finding behaviour in hatchling loggerhead turtles (*Caretta caretta*) on the Woongarra coast, south-east Queensland, Australia. *Australian Journal of Zoology*, *61*(2), 137. doi: 10.1071/zo13028

Bjorndal, K. A., Bolten, A. B., & Lagueux, C. J. (1994). Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. *Marine Pollution Bulletin*, *28*(3), 154–158. doi: 10.1016/0025-326x(94)90391-3

Bourgeois, S., Gilot-Fromont, E., Viallefont, A., Boussamba, F., & Deem, S. L. (2009). Influence of artificial lights, logs and erosion on leatherback sea turtle hatchling orientation at Pongara National Park, Gabon. *Biological Conservation*, *142*(1), 85–93. doi: 10.1016/j.biocon.2008.09.028

Bowen, B. W., Grant, W. S., Hillis-Starr, Z., Shaver, D. J., Bjorndal, K. A., Bolten, A. B., & Bass, A. L. (2006). Mixed-stock analysis reveals the migrations of juvenile hawksbill turtles (Eretmochelys imbricata) in the Caribbean Sea. *Molecular Ecology*, *16*(1), 49–60. doi: 10.1111/j.1365-294x.2006.03096.x

Bugoni, L., Krause Lígia, & Petry Maria Virgínia. (2001). Marine Debris and Human Impacts on Sea Turtles in Southern Brazil. *Marine Pollution Bulletin*, *42*(12), 1330–1334. doi: 10.1016/s0025-326x(01)00147-3

Campbell, C. L., & Lagueux, C. J. (2005). Survival Probability Estimates For Large Juvenile And Adult Green Turtles (*Chelonia Mydas*) Exposed To An Artisanal Marine Turtle Fishery In The Western Caribbean. *Herpetologica*, *61*(2), 91–103. doi: 10.1655/04-26

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

Choi, G.Y. and Eckert, K. L. (2009). Manual of Best Practices for Safeguarding Sea Turtle Nesting Beaches. Wider Caribbean Sea Turtle Conservation Network (WIDECAST) Technical Report No. 9. Ballwin, Missouri. 86. Ernst, C. H. and Barbour, R. W. (1989). Turtles of the World. Smithsonian Institute Press, Washington DC and London.

Frazer, N. B. (1986). Survival from egg to adulthood in a declining population of loggerhead turtles, Caretta caretta. *Herpetologica*, 42(1):47–55.

Gordon, L. G. and Harrison, E. (2011). Reporte Final Del Programa de Tortuga Baula 2011, Tortuguero, Costa Rica (Disponible en: https://conserveturtles.org/wp-content/uploads/Tortuguero%20Reporte%20de%20Tortuga%20Baula%202011.pdf.

Grant, P. B. C. and Lewis, T. R. (2010). High speed boat traffic: a risk to crocodilian populations. *Herpetological Conservation and Biology*, 5(3):456–460.

Guiterrez, J. (2017). COTERC Marine Turtle Monitoring & Tagging Program, Caño Palma Biological Station, Leatherback Season Report 2017. Unpublished.

Horrocks, J., & Scott, N. (1991). Nest site location and nest success in the hawksbill turtle Eretmochelys imbricate in Barbados, West Indies. *Marine Ecology Progress Series*, *69*, 1–8. doi: 10.3354/meps069001

Jackson, J. B. C. (2001). Historical Overfishing and the Recent Collapse of Coastal Ecosystems. *Science*, *293*(5530), 629–637. doi: 10.1126/science.1059199

James, M. C., Ottensmeyer, C. A., & Myers, R. A. (2005). Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. *Ecology Letters*, *8*(2), 195–201. doi: 10.1111/j.1461-0248.2004.00710.x

Kamel, S. J., & Mrosovsky, N. (2004). Nest site selection in leatherbacks, Dermochelys coriacea: individual patterns and their consequences. *Animal Behaviour*, *68*(2), 357–366. doi: 10.1016/j.anbehav.2003.07.021

Márquez M., R. 1990. FAO species catalogue. Vol.11: Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date. FAO Fisheries Synopsis No. 125, Vol. 11. Rome, FAO. 81.

Meylan, A. (1988). Spongivory in Hawksbill Turtles: A Diet of Glass. *Science*, *239*(4838), 393–395. doi: 10.1126/science.239.4838.393

Mortimer, J.A & Donnelly, M. (IUCN SSC Marine Turtle Specialist Group) (2008). Eretmochelys imbricata . The IUCN Red List of Threatened Species 2008: e.T8005A12881238. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en.

Mortimer, J. A., Meylan, P. A., & Donnelly, M. (2007). Whose turtles are they, anyway? *Molecular Ecology*, *16*(1), 17–18. doi: 10.1111/j.1365-294x.2006.03252.x

Pheasey, H., Mccargar, M., Glinsky, A., & Humphreys, N. (2018). Effectiveness of Concealed Nest Protection Screens Against Domestic Predators for Green (Chelonia mydas) and Hawksbill (Eretmochelys imbricata) Sea Turtles. *Chelonian Conservation and Biology*, *17*(2), 263. doi: 10.2744/ccb-1316.1

Phelan, S. M. and Eckert, K. L. (2006). Marine Turtle Trauma Response Procedures: A Field Guide. Wider Caribbean Sea Turtle Conservation Network (WIDECAST) Technical Report No. 4. Beaufort, North Carolina USA. 71.

Safina, C. (2007). Voyage of the turtle: in pursuit of the Earth’s last dinosaur. Holt Paperbacks, New York.

Spotila, J. R. (2004). Sea Turtles: A complete guide to the biology, behaviour and conservation. John Hopkins University Press, Maryland.

Triessnig, P., Roetzer, A., & Stachowitsch, M. (2012). Beach Condition and Marine Debris: New Hurdles for Sea Turtle Hatchling Survival. *Chelonian Conservation and Biology*, *11*(1), 68–77. doi: 10.2744/ccb-0899.1

Troëng, S. (1998). Leatherbacks Face Ever Increasing Threats. Velador: Sea Turtle Conservancy Winter Newsletter https://conserveturtles.org/11698-2/ [Accessed 28/07/17].

Troëng, S., & Rankin, E. (2005). Long-term conservation efforts contribute to positive green turtle Chelonia mydas nesting trend at Tortuguero, Costa Rica. *Biological Conservation*, *121*(1), 111–116. doi: 10.1016/j.biocon.2004.04.014

Vélez-Rubio, G. M., Estrades, A., Fallabrino, A., & Tomás, J. (2013). Marine turtle threats in Uruguayan waters: insights from 12 years of stranding data. *Marine Biology*, *160*(11), 2797–2811. doi: 10.1007/s00227-013-2272-y

Whitmore, C. P., & Dutton, P. H. (1985). Infertility, embryonic mortality and nest-site selection in leatherback and green sea turtles in Suriname. *Biological Conservation*, *34*(3), 251–272. doi: 10.1016/0006-3207(85)90095-3

Witherington, B. E. and Martin, R. E. (2003). Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. 3rd ed., revised. Florida Marine Research.