ACKNOWLEDGEMENTS

Financial Support

We would like to thank:

The Donner Canadian Foundation for their continued financial support of the Marine Turtle Monitoring & Tagging Program at Caño Palma Biological Station. By supporting this project, the Foundation has facilitated its growth and enabled us to expand our education program in the community during the 2013 season.

Toronto Zoo for their financial support that enabled us to have informative signs made for the beach. The signs contain important information about sea turtle nesting biology and conservation issues and were put up at four different locations along the beach as well as in the local village of San Francisco.

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

Institutional Support

The Marine Turtle Monitoring & Tagging Program was conducted under a permit from SINAC (Sistema Nacional de Áreas de Conservación), ACTo (Área de Conservación Tortuguero) and MINAE (Ministerio de Ambiente y Energía). We are especially grateful for MINAE’s continued support and particularly the manpower we received throughout the season, helping us in our efforts to decrease poaching rates on Playa Norte. In particular we would like to thank Víctor Hugo, a representative from the Barra del Colorado Wildlife Refuge, for his extensive collaboration with us and his efforts to help us increase the presence of police and coast guard on Playa Norte and the adjacent areas.

We very much appreciate the collaboration with Vista al Mar in terms of giving us access to the beach via their property, as well as letting our personnel use their facilities for leisure purposes. Special thanks go to Lester, Carlos, Freddy and Manuel. Thanks to Turtle Beach Lodge for letting our Morning and Night Patrols fill up their water bottles and seek shelter during severe weather conditions. Special thanks to the night guards Wilson, Pablo and Orlin for their friendly support.

Thanks to the Sea Turtle Conservancy (STC) for enabling our personnel to visit their research station and incorporating us in events in Tortuguero. Thank you for your collaboration regarding equipment, data and knowledge.

Personal Support

We would like to express our appreciation for all the help, advise, information, hospitality and friendship we received from many people living along Playa Norte. We especially like to thank Machodiaz, Oscar, Don Salvador and Teresa, Ignacio, and Fran and Marivi.

A huge thank you goes to all and every volunteer, intern, visiting researcher and student group who have given their time and dedication to support the Marine Turtle Project.
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SUMMARY

Surveys Effort

- **Morning Patrol** was carried out every day between 01 July and 31 October 2013.
- **Night Patrol** was carried out every day between 01 July and 31 October 2013.

Nesting Activity & Success

- A total of 421 nests were recorded between 01 July and 31 October: **406 Green turtle** (*Chelonia mydas*) and **15 Hawksbill** (*Eretmochelys imbricata*).
- A total of 1339 halfmoons (false emergences) were recorded between 01 July and 31 October: **1307 Green turtle** and **32 Hawksbill**.

*From here onwards all results shown in this report include the entire nesting activity of Green turtle and Hawksbill recorded on Playa Norte within the 2013 season (01 March – 31 October). Only one nest (turtle absent) and one halfmoon were found for the species Loggerhead (Caretta caretta), therefore this species is not further discussed within this report.*

*Chelonia mydas* 01 March – 31 October

- **65%** (285 out of 439) of all turtles that nested on Playa Norte were encountered.
- **154 out of the 439** nests were encountered with the turtle absent.
- The first **Green turtle** nested on 12 March.
- The last **Green turtle** nested on 29 October.
- A total of **298 Green turtles** were encountered: 285 resulted in nests; 13 in halfmoons.
- Out of the 298 encounters, 107 were **REC s**, 87 **REMs** (including 10 halfmoons), and 101 **REns** (consisting of 58 distinct individuals; plus 3 halfmoons).
- The maximum number of nesting events for REns was 6.
- **197 (45%)** of the 439 nests were triangulated.
- 117 of them could be successfully excavated.
- No nests were lost due to erosion.
- 26 nests were lost due to predation by dogs.
- 45 nests were lost due to poaching.
- 9 nests were lost due to unknown reasons.
- **5 dead Green turtles** were found within the transect.
- The average hatching success was 76%.
- The average emerging success was 73%.
- The average incubation period was 59 days.
- The average number of **yolked eggs** was 112 (±27).
- **Maximum** number of yolked eggs: 173
- **Minimum** number of yolked eggs: 16
- The average number of **yolkless eggs** was < 1 (±1).
- **Maximum** number of yolkless eggs: 7
**Minimum** number of yolkless eggs: 0

**Biometrics**
- Mean minimum Curved Carapace Length (CCLmin): **105.5 ±5.8cm** (N=275).
  - **Maximum CCLmin**: 123.8cm.
  - **Minimum CCLmin**: 76.9cm.
- Mean maximum Curved Carapace Width (CCWmax): **94.9 ±5.4cm** (N=273).
  - **Maximum CCWmax**: 110.3cm.
  - **Minimum CCWmax**: 64.4cm.

<table>
<thead>
<tr>
<th>* REC</th>
<th>New Record: turtle has no previous tags.</th>
</tr>
</thead>
<tbody>
<tr>
<td>* REM</td>
<td>Re-emerging: turtle has previous tag(s).</td>
</tr>
<tr>
<td>* REN</td>
<td>Re-nesting: turtle has nested at least once before on Playa Norte within the current season.</td>
</tr>
</tbody>
</table>

**Eretmochelys imbricata 01 March – 31 October**
- **70%** (**25 out of 36**) of all turtles that nested on Playa Norte were encountered.
- **11 out of the 36** nests were encountered with the turtle absent.
- The **first Hawksbill** nested on **03 May**.
- The **last Hawksbill** nested on **30 September**.
- A total of **26 Hawksbill** were encountered: **25 resulted in nests; 1 in a halfmoon**.
- Out of the **26 encounters, 12** were *RECs, 6 *REMs (including 1 halfmoon), and **8** *RENs (consisting of 4 distinct individuals).
- The **maximum number of nesting events** for RENs was **4**.
- **20** (**56%**) of the **36** were triangulated.
- **8** of them could be successfully excavated.
- **1** nest was lost due to erosion.
- **5** nests were lost due to predation by dogs.
- **6** nests were lost due to poaching.
- No dead Hawksbill was found.
- The average **hatching success** was **87%**.
- The average **emerging success** was **71%**.
- The average **incubation period** was **67 days**.
- The average number of **yolked eggs** was **146** (±38).
  - **Maximum number of yolked eggs**: 185
  - **Minimum number of yolked eggs**: 51
- The average number of **yolkless eggs** was **< 1** (±1).
  - **Maximum number of yolkless eggs**: 2
  - **Minimum number of yolkless eggs**: 0

**Biometrics**
- Mean minimum Curved Carapace Length (CCLmin): **87.6 ±2.9cm** (N=21).
- **Maximum CCLmin**: 92.5cm.
- Minimum CCLmin: 81.5cm.
- Mean maximum Curved Carapace Width (CCWmax): 78.1 ±2.9cm (N=21).
- Maximum CCWmax: 84.6cm.
- Minimum CCWmax: 73.2cm.
INTRODUCTION

From here onwards all results shown in this report include the entire nesting activity of Green turtle and Hawksbill recorded on Playa Norte within the 2013 season (01 March – 31 October). Only one nest (turtle absent) and one halfmoon were found for the species Loggerhead (Caretta caretta), therefore this species is not further discussed within this report.

The Marine Turtle Monitoring & Tagging Program at Caño Palma Biological Station has been continually running since 2006, with the aim to 1) conduct research and collect data on nesting sea turtles on Playa Norte, 2) assess the health status of nesting females, 3) educate the public (local community and tourists) about sea turtle biology and conservation issues, and 4) decrease poaching rates. Four species of sea turtles nest on Playa Norte: Leatherback (Dermochelys coriacea), Green turtle (Chelonia mydas), Hawksbill (Eretmochelys imbricata) and Loggerhead (Caretta caretta) (Table 1). Under the IUCN Red List of Threatened Species, Leatherback and Hawksbill are listed as critically endangered (Sarti Martinez, Marine Turtle Specialist Group 2000, Mortimer & Donnelly, IUCN SSC Marine Turtle Specialist Group 2008); Green turtle and Loggerhead as endangered (Seminoff, Southwest Fisheries Science Center, U.S. 2004, Marine Turtle Specialist Group 1996). The typical regional nesting season for each species is shown in Table 1.

1. Sea Turtle Species on Playa Norte
Common and scientific names with abbreviation used in manuscript and typical regional nesting seasons.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Abbreviation</th>
<th>Nesting Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leatherback</td>
<td>Dermochelys coriacea</td>
<td>Dc</td>
<td>March–June</td>
</tr>
<tr>
<td>Green Turtle</td>
<td>Chelonia mydas</td>
<td>Cm</td>
<td>May–October</td>
</tr>
<tr>
<td>Hawksbill</td>
<td>Eretmochelys imbricata</td>
<td>Ei</td>
<td>June–October</td>
</tr>
<tr>
<td>Loggerhead</td>
<td>Careta Caretta</td>
<td>Cc</td>
<td>May–October</td>
</tr>
</tbody>
</table>

The aims stated above are achieved by conducting daily morning and Night Patrols along the beach transect, during which a range of essential data is collected, following standardised protocols.

In order to improve data collection as well as the impact of the project on the local turtle populations, the involvement of local communities and deterring of poaching, the project is constantly developing. This report provides detailed information on the standardised methods used and the results obtained from it. Furthermore, it highlights several new aspects of the project that have been developed and implemented during this season, and which the project will hopefully be able to continue in the future.
Methods

Study site
Data collection is carried out along a 3.125 mile (approx. 5 km) beach transect on Playa Norte, stretching from the Tortuguero river mouth ‘Laguna Tortuguero’ (Datum WGS84 552224.9E 1170322N) to ‘Laguna Cuatro’ (Datum WGS84 550043.7E 1175989N). Playa Norte is part of the Barra del Colorado Wildlife Refuge and borders the Tortuguero National Park at the south end. The area is managed by the Tortuguero Conservation Area (ACTo) and is regulated by the Costa Rican Ministry of Environment and Energy (MINAE). According to Costa Rican law N° 8586 (conservation of migratory species and wild animals) article 1° and 3° (including endangered marine species and habitats part of the distribution of migratory species), public access to the beach is prohibited between 18:00 and 05:00 during the sea turtle nesting season, which by law corresponds to the period from 01 May until 31 October.

Permanent mile markers at every 1/8 of a mile facilitate orientation along the transect and allow for spatial distribution analyses. Mile markers were re-painted and replaced as required in February.

An illuminated path runs parallel to the beach. Furthermore, there are two lodges (Hotel Vista al Mar and Turtle Beach Lodge) as well as several private residencies along the beach. The public lights on the path as well as the private lights from lodges and private houses can cause artificial light pollution in the vegetation along the beach as well as on the beach itself, which poses a threat to the orientation of nesting turtles and emerging hatchlings (e.g. Witherington & Martin 2003, Bourgeois 2009, Berry et al. 2013).

The use of motorised vehicles is prohibited in the area from the highest tide line to 200m inland, which includes the public path (Ley de protección de playas y humedales, Resolución ACTo-Dirección-04-2013). Despite this law, motorised vehicles such as motorbikes, four wheel quads and occasionally even tractors and little trucks are frequently observed.

Data collection

Morning Protocol

2. List of Abbreviations used in Morning & Night Patrol protocols

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLF</td>
<td>Halfmoon</td>
</tr>
<tr>
<td>NST</td>
<td>Nest (turtle absent)</td>
</tr>
<tr>
<td>DEC</td>
<td>Deceased turtle</td>
</tr>
<tr>
<td>LIF</td>
<td>Lifted turtle (only up tracks present)</td>
</tr>
<tr>
<td>HAT</td>
<td>Hatchling/Hatchling tracks (from triangulated nests)</td>
</tr>
<tr>
<td>REC</td>
<td>Turtle with no previous tags</td>
</tr>
<tr>
<td>REM</td>
<td>Turtle with previous tag(s)</td>
</tr>
<tr>
<td>REN</td>
<td>Turtle that has nested at least once before on Playa Norte during the current season</td>
</tr>
</tbody>
</table>

Morning Patrol was carried out daily from 01 July – 31 October (and was continued until the last nest was excavated, approx. at the end of December). The patrol started at 05:30am and collected data on three essential aspects along the transect: 1) nest and track information: to complete the collection of nest and track data recorded by the previous night’s patrol teams,
Morning Patrol recorded any additional tracks and nests encountered on the beach. For each encounter, the species (Table 1), next northern mile marker (Fig. 1), vertical beach zone (Fig. 2) and G.P.S were recorded (Table 3).

3. Example of Field Book Data Entry for Morning Patrol

Type of encounter [TYPE], halfmoon [HLF], nest [NST], Chelonia mydas [Cm], Dermochelys coriacea [Dc], Open [O], Border [B], Global Positioning System [G.P.S.], G.P.S. Accuracy [ACC.].

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SPECIES</th>
<th>MILE</th>
<th>ZONE</th>
<th>G.P.S</th>
<th>ACC.</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLF</td>
<td>Cm</td>
<td>5/8</td>
<td>O</td>
<td>0224578 (E)/1173476 (N)</td>
<td>3m</td>
<td></td>
</tr>
<tr>
<td>NST</td>
<td>Dc</td>
<td>1 2/8</td>
<td>B</td>
<td>0223324 (E)/1175211 (N)</td>
<td>5m</td>
<td></td>
</tr>
</tbody>
</table>

The vertical beach zone and the G.P.S. coordinates of halfmoons were taken at the point where the turtle turned around. 2) Nest Check of all triangulated nests: all triangulated nests were checked on a daily basis from the day they were laid to the day of their excavation. The status of the nest itself was assessed and any signs of abnormality recorded (Table 4). The corresponding flagging tapes used to mark the trees for triangulation were checked for legibility and intactness and replaced as required.

4. Nest Status Assessment

<table>
<thead>
<tr>
<th>NAT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WET</td>
<td>Wet: Nest is below most recent high tide line</td>
</tr>
<tr>
<td>FLO</td>
<td>Flooded: Nest/Body Pit is filled with water from either rain or tide</td>
</tr>
<tr>
<td>POA</td>
<td>Poached</td>
</tr>
<tr>
<td>PRE</td>
<td>Predated (by dogs)</td>
</tr>
<tr>
<td>UNK</td>
<td>Unknown: Signs of poaching and/or predation, but status undetermined. Nest Check continues</td>
</tr>
<tr>
<td>ERO</td>
<td>Eroded</td>
</tr>
<tr>
<td>DEP/No DEP</td>
<td>Depression present/absent (see 'Excavation Protocol')</td>
</tr>
<tr>
<td>HAT</td>
<td>Hatchling(s) or hatchling tracks present</td>
</tr>
</tbody>
</table>

Furthermore, once nests were close to the calculated hatching date, nests were checked daily for signs of hatching. Daily assessments of the nest status allowed more detailed conclusions about the nest’s eventual fate as well as temporal analyses of any disturbances. Daily assessments of the intactness of triangulation flagging tapes are essential in order to avoid
data loss, as they are regularly destroyed by termites, ants or people. 3) nest excavations: hatched nests were excavated during Morning Patrol (see ‘Excavation Protocol’).

During the peak of Green turtle season (July and August), a second team called ‘Nest Check’ was sent out later in the morning to assist Morning Patrol. The beach was split up into two halves (mile 0 – 1 4/8 and 1 5/8 – 3 1/8). Morning Patrol recorded tracks and nests along the entire transect, but only checked the status of triangulated nests in the second half. The Nest Check team checked all triangulated nests in the first half. Furthermore, during the peak weeks of nest excavations, some of the excavations scheduled for a given day were allocated to the Nest Check team, as the workload (hours spent in the sun) for Morning Patrol was to large otherwise.

Night Protocol
Night Patrol was carried out daily from 01 July – 31 October (a few additional Night Patrols were carried out in November as a consequence of encountering tracks during Morning Patrol). Each Night Patrol team carried out shifts of a minimum of 4-5h (5h if two teams or less were available) covering as many miles as possible. For safety reasons teams consisted of a minimum of three people, at least one being male. Teams were scheduled in overlapping shifts in an effort to maximise presence on the beach in terms of numbers while at the same time covering as many hours as possible during the night (Table 5). Start times and patrol strategies were changed on a regular basis to prevent creating loopholes for poachers, as well as to maximise the number of encountered turtles. For example teams starting at 19:30 used the path to walk up to mile 1 4/8 or 3 from which point they started their patrol on the beach. This strategy assured the coverage of the upper half of the beach while turtle activity was high and teams otherwise would not have reached this part of the beach during the entire patrol due to being caught up with turtles in the lower part of the beach. Figure 3 gives an example of patrol strategies used.

5. Overlapping Night Patrol Shifts.

<table>
<thead>
<tr>
<th>Time</th>
<th>PM1</th>
<th>PM2</th>
<th>PM3</th>
<th>PM4</th>
</tr>
</thead>
<tbody>
<tr>
<td>20:00</td>
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<td>20:30</td>
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<td>21:00</td>
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<td>21:30</td>
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<td>22:00</td>
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<td>22:30</td>
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<td>23:00</td>
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<td>23:30</td>
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<td>01:00</td>
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<td>01:30</td>
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<td>02:00</td>
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</tr>
<tr>
<td>03:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Patrol Strategies
Patrol Strategies. Beach areas covered by strategies A, B, and C. Miles represent mile markers within the full beach transect (0 – 3 1/8).

Image courtesy of Caño Palma Biological Station staff
The rules below must be followed by everyone conducting Night Patrols:

- Wear dark clothes
- No alcohol before or during Night Patrol
- No smoking
- Limit light usage and only use red light
- Do not apply any 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 below the most recent high tide line when possible
- Keep quiet when encountering a turtle
- Never walk in front of the turtle or shine light in its eyes
- Patrol is cancelled or delayed if lack of appropriate personnel or during severe weather conditions

Night Patrols collected data on 1) tracks and nests, 2) nesting sea turtles and carried out 3) Human Impact Surveys.

1) Tracks and Nests

For all tracks and nests encountered without the presence of the turtle, the species, next northern mile marker, vertical beach zone and G.P.S were recorded (see ‘Morning Patrol’). The vertical beach zone and the G.P.S. coordinates of halfmoons were taken at the highest point of the track where the turtle turned around.

2) Nesting Sea Turtles

For all turtles encountered, the species, encounter time, encounter activity (nesting stage), next northern mile marker, vertical beach zone and G.P.S were recorded. This also applied to turtles performing a halfmoon. In addition, depending on what stage within the nesting process the turtle was in, the measurements summarised in (Table 6) were carried out.

6. Nesting Stages

Stages within the sea turtle nesting process and the actions to be taken by the patrol.

<table>
<thead>
<tr>
<th>NESTING STAGE</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Emerging</td>
<td>Wait. Patrol leader checks on progress</td>
</tr>
<tr>
<td>2) Selecting Nest Site</td>
<td>Wait. Patrol leader checks on progress</td>
</tr>
<tr>
<td>3) Digging Body Pit</td>
<td>Wait. Patrol leader checks on progress</td>
</tr>
<tr>
<td>4) Digging Egg Chamber</td>
<td>Wait. Patrol leader checks on progress</td>
</tr>
<tr>
<td>5) Oviposition</td>
<td>Egg Counting &amp; Nest Triangulation</td>
</tr>
<tr>
<td>6) Covering</td>
<td>Tag information/Curved Carapace Length (CCL) &amp; Width (CCW)/Body Check</td>
</tr>
<tr>
<td>7) Disguising</td>
<td>Tag information/Curved Carapace Length (CCL) &amp; Width (CCW)/Body Check</td>
</tr>
<tr>
<td>8) Returning to Sea</td>
<td>Tag information/Curved Carapace Length (CCL) &amp; Width (CCW)/Body Check (if possible)</td>
</tr>
</tbody>
</table>

2.1) Egg Counting & Nest Triangulation

While the turtle was digging the egg chamber, a small superficial channel to the egg chamber was prepared, allowing to position one hand underneath the cloaca while minimising the risk
of touching it. Eggs were always counted wearing a medical latex glove. As soon as oviposition started a little piece of flagging tape containing a unique number, called “Nest ID” (Fig. 4a), was dropped into the bottom of the egg chamber. Eggs were then counted with a counter (Fig. 4b) as they dropped onto the egg counter’s hand. Yolkless eggs were counted in mind. As soon as the turtle started covering the egg chamber, the distance from the last egg to the top of the egg chamber, called the ‘Egg Depth’, was measured with a flexible 1.50m measuring tape (Fig. 4c). At the same time, as soon as oviposition started, two team members triangulated (marked) the nest. The person counting the eggs held the start of the 50m measuring tape (Fig. 4d) right above the egg chamber, while the triangulation team marked three sturdy pieces of vegetation with flagging tapes (Fig. 4a) and measured their distances to the nest (Fig. 5), as well as the distance to the most recent high tide line.

**Figure 4. Egg Counting & Triangulation Kit**
Nest ID (bottom) & Flagging Tapes (top) (a), Counter (b), 1.50m flexible measuring tape (c) and 50m measuring tape (d).

**Figure 5. Nest Triangulation**
Flagging tapes were attached to three sturdy pieces of vegetation and their distances to the nest were measured, as well as the distance to the most recent high tide line.

2.2) Tag information
As soon as the turtle started covering the egg chamber, the PL checked the flippers for existing tags as well as previous tagging evidence. If tags were present, their numbers were recorded. Old tagging evidence was recorded as Old Tag Hole (OTH) or Old Tag Notch (OTN) (Fig. 6a). Illegible tags and tags causing damage (e.g. ingrown) or putting the turtle at high risk of hurting itself (e.g. tag placed too far in or out), were removed and replaced if possible. If no tags were present, new ones were placed. The lower tag number was always placed on the right flipper and the higher on the left. Green turtle and Hawksbill are tagged in the front flippers (Fig. 6b). A correctly placed tag is positioned so that one third (or two
numbers) of the tag is outside of the flipper and two thirds inside the flipper. If possible, tags were always placed before the primary scale (in the membrane between the body and the primary scale) (Fig. 6c). 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. The last resort is to tag into the primary scale. This bears a greater risk of injuring the turtle while placing the tag and should therefore only be done by well experienced taggers.

**Other important tagging rules:** Turtles must never have two tags in one flipper; if an old tag had to be removed for reasons mentioned above this was always done before a new tag was placed in the same flipper. However, in case of a turtle with only one existing tag, which had to be removed (no tag in the other flipper), firstly the flipper with no tag was tagged with a new tag, then the old tag was removed and replaced with a new one. This prevented the risk of a turtle returning to sea with no tags, which would mean the loss of potentially several years’ worth of data.

![Figure 6. Old Tagging Evidence and Tag Position](images)

(a) Old Tag Hole (OTH) and Old Tag Notch (OTN)
(b) Green turtle and Hawksbill are tagged in the front flipper
(c) Tags are placed 1. Before the primary scale, 2. Between the primary and the secondary scale, 3. Into the primary scale. 2 and 3 are only considered if tag cannot be placed in 1 due to injury or other abnormality.

**2.3) Curved Carapace Length (CCL) & Width (CCW)**

Once the collection of tagging data was complete, the length and width of the carapace was measured with a 1.50m flexible measuring tape (Fig. 4c). We measured the Curved Carapace Length as opposed to the actual (straight) length, which in some projects is measured with the help of a calliper. The length was measured as CCL **minimum**, the width as CCW **maximum**. CCL minimum has a fixed and standardised start and end point and because of the shape of a turtle’s carapace, the resulting length is not necessarily the maximum length of
the carapace (Fig. 7). CCW maximum has a less obvious start and end point, but is attempted to be taken at the widest point of the carapace and hence the resulting width is the maximum width of the carapace (Fig. 7). The CCL\textsubscript{min} measurement is started where the skin meets the carapace at the neck, and ends along the line between the two marginal scales at the edge of the carapace (Fig. 7). It is important that the end point of CCL\textsubscript{min} is always measured along the line between the two marginal scales, even if the carapace is shorter at this point. CCW\textsubscript{max} is measured from the edge of the carapace on one side to the edge of the carapace on the other side at its widest point, which is usually around the middle (Fig. 7). While measuring, anything affecting the measurements (e.g. barnacles) was kept in mind and later included in the Body Check.

\begin{figure}
\centering
\includegraphics[width=0.6\textwidth]{figure7.png}
\caption{Minimum Curved Carapace Length (CCL\textsubscript{min}) and Maximum Curved Carapace Width (CCW\textsubscript{max})}
\end{figure}

\begin{quote}
The CCL\textsubscript{min} measurement (red) is started where the skin meets the carapace at the neck, and ends along the line between the two marginal scales at the edge of the carapace. CCW\textsubscript{max} (green) is measured from the edge of the carapace on one side to the edge of the carapace on the other side at its widest point, which is usually around the middle.
\end{quote}

\section*{2.4) Body Check}
As soon as CCL\textsubscript{min} and CCW\textsubscript{max} measurements were taken, the turtle’s body was checked for signs of abnormalities and factors affecting the measurements of CCL\textsubscript{min} and CCW\textsubscript{max} (e.g. barnacles). Abnormalities recorded were characteristics like old and new injuries (scars, holes, notches, missing parts of flippers), tumours (especially if caused by the fibro papilloma virus) (e.g. Herbst et al. 1995) and parasites. The Body Check was carried out following a standardised protocol in which each predefined body part was given a number from one to eight (Fig. 8.). The head is the most sensitive part and checking it bears the greatest risk of disturbing the turtle. Therefore Body Checks were started with number two and ended with number one, the head. While conducting the Body Check the red light was carefully shielded with one hand and directed away from the turtle’s head to minimise any potential disturbance to the turtle. In order to check the head the light was shielded with one hand so that the resulting light projection formed a very clear line which could then be carefully moved forward starting from the edge of the carapace, across the neck, but always stayed \textit{behind} the turtle’s eyes.

In addition to factors affecting the health of the turtle, characteristics affecting the carapace measurements were recorded (e.g. barnacles). This is very important, because while barnacles can add substantially to a measurement, the same barnacles might not have been present in past encounters of the same turtle or won’t be there anymore in future encounters.
Figure 8. Body Check
Body parts were predefined and numbered from one to eight. In hard-shelled sea turtle species (e.g. Green turtle) number five includes the last lateral scute on each side as well as the two last central scutes.

2.5) Disguising of nests and tracks
Once the turtle had returned to sea, the tracks as well as the nest were disguised in an effort to decrease the risk of poaching. Nest sites were first flattened out using the sand spray left by the turtle’s body pitting and disguising activities, then disguised using surrounding vegetation and driftwood material. Tracks were disguised using palm fronds or other vegetation material to sweep the area and erase any evidence.

At the beginning of the season halfmoon tracks of Green turtles were disguised as described above in order to erase any evidence of this species’ nesting activity. However, during peak season halfmoon tracks were only marked with two lines to signal other teams that the tracks had already been assessed. Any evidence of Hawksbill and Loggerhead emergences were always disguised throughout the season as particularly Hawksbill are a highly desired species by poachers due to the immense value of their carapace as well as their eggs and meat.

During rainy conditions, tracks of nests were marked with two lines and only the nest itself was disguised, as disguising of tracks in wet sand was very difficult to achieve. By marking the tracks with the two lines, nest tracks were “converted” into looking like halfmoon tracks while the nests were still disguised and therefore the risk of poaching minimised.

3) Human Impact Survey
According to Costa Rican law N° 8586 (conservation of migratory species and wild animals) article 1° and 3° (including endangered marine species and habitats part of the distribution of migratory species), ACTo (Área de Conservación Tortuguero), MINAE (Ministerio de Ambiente y Energía) and SINAC (Systema Nacional de Áreas de Conservación) have enforced an access restriction to Playa Norte. Public access is prohibited between 18:00 and 05:00 from May to October. However, due to the near complete lack of law enforcement on Playa Norte, a lot of illegal human activity can be observed nonetheless. In collaboration with MINAE, we carried out standardised Human Impact Surveys as part of our Night Patrols on a daily basis throughout the season, the results of which were reported to MINAE on a weekly basis. The temporal and spatial distribution were recorded for the following impact categories: white light (W), red light (R), fire (F), local (L) and tourist (T).

Excavation Protocol
Nest Excavations were conducted to determine the nest success of triangulated nests. Nest success was divided into Hatching and Emerging Success, Hatching Success being the
number of hatchlings that exited the egg; Emerging Success being the number of hatchlings that exited the egg and emerged from the nest. It is important to distinguish between these two categories as a nest can have a 100% Hatching Success, but 0% Emerging Success if e.g. all hatchlings die inside the nest. There are a number of measurable factors potentially affecting the success of a nest such as poaching and predation rates as well as environmental factors such as flooding and erosion.

Green turtle and Hawksbill have an average incubation period of 55 days (e.g. Eckert & Abreu-Grobois 2001, Marcovaldi et al. 1999). At day 50 the exact location of nests was re-established using the triangulation data and nests were marked with three sticks (Fig. 9) to facilitate the assessment of signs of hatching. Signs of hatching include a volcano-shaped depression in the nest area caused by hatchlings digging their way to the surface inside the nest; and hatchling tracks leading away from the nest. Possible depressions were first visually detected and then with the help of a pencil that was gently pushed into the depression area. If the sand underneath gave way very easily it was considered a depression. Important is the careful distinction between a depression and hole dug by a crab. Crab holes run diagonally into the sand and have very smooth and even walls; depressions usually run more vertically into the sand, are wider and the walls are a lot less well defined. Nests were daily checked and were excavated 1) two days after hatchling tracks were present, 2) after five consecutive days of depression, 3) at day 65 if no signs of hatching were present.

During the excavation process sand was carefully dug up until the first signs of the nest appeared (e.g. empty egg shells). The Egg Depth was taken from the first encountered egg or egg shell to the surface of the beach. Thereafter all nest contents were taken out and sorted into different categories (Table 7).

<table>
<thead>
<tr>
<th>7. Nest Contents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty egg shells &gt; 50% (EES)</td>
<td>Only shells &gt; 50% of the whole egg were counted. Bits of shells &lt; 50% were not counted as it cannot be determined from how many different eggs they stem.</td>
</tr>
<tr>
<td>Yolkless eggs (Y)</td>
<td>Yolkless eggs are non-fertilised eggs that range from a size similar to a yolked egg down to a diameter of around 1cm. These are usually only found in small numbers (if any) in Green turtle and Hawksbill clutches.</td>
</tr>
</tbody>
</table>

Picture adapted from COTERC Excavation Protocol 2010
Pipped Eggs (PE)
The egg is intact apart from a small triangular hole caused by the hatchling’s egg tooth. The hatchling is dead and the head is near the hole.

Unhatched eggs: No Embryo (NE), Embryo Stage 1-4 (E1-4)
Eggs that did not develop at all (NE) or that died during development (E1-4).
Stage 1: embryo takes up < 25% of the egg; can be as small as a spot of blood within the yolk.
Stage 2: embryo takes up 26-50% of the egg.
Stage 3: embryo takes up 51-75% of the egg.
Stage 4: embryo takes up > 75% of the egg.

Pictures 1 & 2 adapted from COTERC Excavation Protocol 2010; 3 & 4 courtesy of Caño Palma Biological Station staff

Predated (P)
Predated eggs show signs of fungal or bacterial infection, maggots, holes caused by crabs, ants, etc.

Dead-in-nest Hatchling (DH)
Hatchlings that exited the egg, but died inside the nest.

Live-in-nest Hatchling (LH)
Hatchlings that exited the egg, but have not emerged from the nest (yet).

Deformed Embryos (Albino, Twin, No-Eyes, Others)
Deformed Embryos are a subdivision of Pipped Eggs, Embryo Stages 1-4 or Live- or Dead-in-nest Hatchlings. Common deformities are abnormal numbers of scutes (1), no-eyes (eyes overgrown with skin) (2), albino (3), (Siamese) twins, injuries/tumour-like growth on head (4).

Pictures courtesy of Caño Palma Biological Station staff

Nest Depth was measured as soon as the last contents of the nest were found, from the bottom of the nest to the surface of the beach. To calculate Hatching and Emerging Success the following formulas were used:

Hatching Success = \( \frac{EES}{(EES + NE + E1 + E2 + E3 + E4 + PE + P)} \times 100 \)
Emerging Success = \( \frac{(EES - (LH + DH))/(EES + NE + E1 + E2 + E3 + E4 + P)} \times 100 \)

Egg shells < 50% were not counted as it cannot be determined from how many different eggs they stem. The categories of Deformed Embryos were not separately accounted for in the formula as they were already accounted for within other categories. They can be a subdivision of Pipped Eggs, Embryo Stages 1-4 or Live- or Dead-in-nest Hatchlings.
Excavations were stopped and postponed if more than five live hatchlings were present in the nest or if the eggs appeared to be still in development (very white and firm).

If **less than five live hatchlings** were present in the nest their condition was assessed:

- If the **plastron** was still **open** and/or they were very **inactive**, 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**, they were left to make their way to the sea.
- If the air temperature was dangerously hot, hatchlings were given shade and guided to the sea.
- If the sand temperature was dangerously hot, the hatchlings were transferred to a nearby area of wet sand (closer to the sea), but were always allowed to walk into the surf on their own. If they are able to make their own way into the water, it can be assumed that the hatchling is active enough to swim and keep its head above water in order to breath. Therefore hatchlings must **never** be put into the sea.

Unmarked nests were not excavated as important factors such as laying date, incubation period and original clutch size are unknown for those nests. However, if a non-triangulated nest was encountered while hatchlings were emerging from it, efforts were made to ensure that the hatchlings reached the sea safely and unharmed.
RESULTS

Survey Effort

Morning Patrol was carried out every day between 01 July and 31 October.

Night Patrol: Each Night Patrol team carried out shifts of a minimum of 4-5h (5h if two teams or less were available) covering as many miles as possible. From July - October the beach presence was kept at a maximum, according to the number of available personnel (Fig. 10 and 11).

![Figure 10. Survey Effort](image)
Bars indicate the number of Night Patrol teams per night from 01 July – 31 October, averaged for each week of a month (1-4).

![Figure 11. Beach Presence](image)
Bars indicate the number of hours the beach was covered every night from 01 July – 31 October, averaged for each week of a month (1-4).
Nesting Activity

| *REC | New Record: turtle has no previous tags. |
| REM | Re-emerging: turtle has previous tag(s). |
| REN | Re-nesting: turtle has nested at least once before on Playa Norte within the current season. |

From 01 March – 31 October a total of 439 Green turtle and 36 Hawksbill nests were recorded on Playa Norte (Table 8). For 65% (285 nests) of all Green turtle and 70% (25) of all Hawksbill nests the turtles were encountered at different stages of the nesting process, 154 Green turtle and 11 Hawksbill nests were recorded without the presence of the turtle. Of the encountered 285 Green turtle and 25 Hawksbill, in 197 (45%) and 20 (56%) cases, respectively, the turtle was found at a stage earlier than ‘covering’ and therefore the nest could be marked for excavation purposes.

8. Green and Hawksbill Nesting Activity

<table>
<thead>
<tr>
<th>Species</th>
<th>Total Nest</th>
<th>Nest TP</th>
<th>Nest TA</th>
<th>Triangulated</th>
<th>Halfmoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cm</td>
<td>439</td>
<td>285 (65%)</td>
<td>154 (35%)</td>
<td>31 (70%)</td>
<td>1368</td>
</tr>
<tr>
<td>Ei</td>
<td>36</td>
<td>25 (69%)</td>
<td>11 (31%)</td>
<td>20 (56%)</td>
<td>57</td>
</tr>
</tbody>
</table>

From 01 March – 31 October a total of 298 Green turtle and 26 Hawksbill were encountered; 285 and 25 resulted in nests, 13 and one in halfmoons, respectively. Out of the 298 Green turtle, 107 were *RECs, 87 *REMs (including ten halfmoons) and 101 *RENs (plus three resulting in halfmoons). A total of 1368 Green turtle halfmoons were recorded. Out of the 26 Hawksbill, 12 were RECs, six REMs (including one halfmoon) and eight RENs. A total of 57 Hawksbill halfmoons were recorded.

The 101 re-nesting Green turtles consisted of 58 distinct individuals. The maximum number of re-nesting events for an individual was 6.

The eight re-nesting Hawksbill consisted of 4 distinct individuals. The maximum number of re-nesting events for an individual was 4.

The first Green turtle nested on 12 March, the last one on 29 October. The first Hawksbill nested on 03 May, the last one on 30 September. Green turtle nesting activity started in March, however only few sporadic nests were recorded between March and mid-June. Towards the end of June nesting activity increased rapidly and peaked in the last week of July, and again in the last week of August, whereafter it steadily decreased and ceased on 29 October (Fig. 12a). Hawksbill nesting activity was more unequally spread throughout the season. After the start in May, it increased rapidly during that month and reached a peak in the first week of June, and again in the last week of June and the third week of July, whereafter it steadily decreased and ceased on 30 September (Fig. 12b).
Figure 12. Temporal Distribution of Nesting Activity
Black line represents nests ($N_{Cm}=439$, $N_{Ei}=36$), blue line represents halfmoons ($N_{Cm}=1368$, $N_{Ei}=57$) for (a) Green turtle and (b) Hawksbill. The total number of encounters is shown for each week (1-4) of a month.

Averaged over the season, the hours most likely to encounter a Green turtle were between 21:00 and 02:00, and between 21:00 and 23:00 as well as 00:00 – 01:00 for Hawksbill (Fig. 13).
The first half of the beach transect clearly saw more nesting activity than the second half for both Green turtle and Hawksbill (Fig. 14). Interestingly, for both species nesting activity was particularly low in the areas within mile markers 6/8, 1 3/8 - 1 4/8 and 2 3/8 - 4/8. Private houses are located at mile 6/8 and 1 3/8 as well as lights on the path, and Turtle Beach Lodge is located at 2 4/8. Mile 3 – 3 1/8 had very low to no nesting activity. The open area at the lagoon (between mile 2 7/8 and 3 1/8) offers only very little vegetation and is therefore not an ideal nest site for Green and Hawksbill, which usually nest in the Border or Vegetation zone of the beach (Turkozan et al. 2011, Ahmad et al. 2005, Horrocks & Scott 1991).
Figure 14. Spatial Distribution of Nesting Activity
Bars represent the total number of encounters within the section of a given mile marker along the beach transect from 01 March - 31 October. Black bars represent the total number of nests ($N_{Cm}=439$, $N_{Ei}=36$), blue bars represent the total number of halfmoons ($N_{Cm}=1368$, $N_{Ei}=57$) for (a) Green turtle and (b) Hawksbill.
Nest Success

Nest Fate
Out of the 197 (Cm) and 20 (Ei) triangulated nests, 117 (Cm) and 8 (Ei) remained natural. Various natural and non-natural (anthropogenic introduced) threats determine the percentage of nests that will survive to complete the full incubation period. 80 (Cm) and 12 (Ei) of the triangulated nests were destroyed by erosion, predation, poaching or unknown reasons (‘lost’) (Table 9).

<table>
<thead>
<tr>
<th>Fate</th>
<th>Cm</th>
<th>Percentage</th>
<th>Ei</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>117</td>
<td>59%</td>
<td>8</td>
<td>40%</td>
</tr>
<tr>
<td>Eroded</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Predated by dogs</td>
<td>26</td>
<td>13%</td>
<td>5</td>
<td>25%</td>
</tr>
<tr>
<td>Poached</td>
<td>45</td>
<td>23%</td>
<td>6</td>
<td>30%</td>
</tr>
<tr>
<td>Lost</td>
<td>9</td>
<td>5%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Excavation
To calculate the success of triangulated nests, only nests with a natural development during the incubation period were used. Nests that were disturbed or completely destroyed by erosion, predation or poaching were omitted from the analyses, as in none of these cases the individual success of a nest could be calculated.

Only data from successfully excavated nests, in which the Nest ID as well as eggs were present, were taken into account in the analyses. For example, for some Green turtle nests no evidence of the nest (neither eggs nor the Nest ID) could be found at the end of the incubation period and therefore, due to the lack of data, these nests were removed from the analyses and recorded as ‘lost’ (Table 9).

The number of eggs encountered during excavation were compared with the number of eggs counted during triangulation in order to make sure the nest did not suffer any unnoticed disturbances (such as partial poaching or predation) that could affect the accuracy of the data.

Of the 197 triangulated Green turtle nests, 117 (59%) had a natural development during the incubation period and were successfully excavated (Table 10). The incubation period could be calculated for 94 of the 197 nests. The average incubation period was 59 days (±5.1), the maximum 74 and the minimum 48 days.

Of the 20 triangulated Hawksbill nests, 8 (40%) had a natural development during the incubation period and were successfully excavated (Table 10). The incubation period could be calculated for 5 of the 20 nests. The average incubation period was 67 days (±4.7), the maximum 73 and the minimum 61 days.

The incubation period was calculated from the number of days between the laying date and the first day hatchling tracks were observed. If a nest had no recorded hatchling tracks, no incubation period was calculated, as even if the excavation showed evidence of hatchlings that had left the nest, the exact date of emergence could not be certainly determined.
10. Nest Success of Excavated Nests
\((N_{Cm}=117, N_{Ei}=8)\)

<table>
<thead>
<tr>
<th></th>
<th>Hatching Success (Cm)</th>
<th>Hatching Success (Ei)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± Standard Deviation</td>
<td>76.3% ± 33.9</td>
<td>86.6% ± 8.1</td>
</tr>
<tr>
<td>Maximum</td>
<td>100%</td>
<td>94.1%</td>
</tr>
<tr>
<td>Minimum</td>
<td>0%</td>
<td>67.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Emerging Success (Cm)</th>
<th>Emerging Success (Ei)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± Standard Deviation</td>
<td>72.9% ± 35.1</td>
<td>70.7% ± 28.7</td>
</tr>
<tr>
<td>Maximum</td>
<td>100%</td>
<td>94.1%</td>
</tr>
<tr>
<td>Minimum</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

In seven of the 117 successfully excavated Green turtle nests, both hatching and emerging success were 0%. In all seven nests all the unhatched eggs were either predated or had died in stage one of the development. In contrast, two of the nests had a 100% hatching and emerging success.

One Hawksbill nest had an emerging success of 0%. 44 dead and two live hatchlings were found inside the nest. None of the variables measured during daily monitoring were able to help explaining this outcome.

Human Impact Survey

Illegal human activity was very high during July and August and then rapidly decreased in September and October (Fig. 15). The obvious peak hours for illegal human activity were between 20:00 – 00:00, whereafter activity steadily decreased but continued until past 03:00 for tourists and past 04:00 for locals and white lights (Fig. 16). The spatial distribution showed very clearly that the first half of the beach saw more illegal human activity than the second half. An obvious peak for tourists was at mile marker 2/8, which is the area in front of Vista al Mar, where groups of tourists were encountered on the beach, often using white lights (Fig. 17). Another clear peak area is between 2/8 and 6/8 for locals, white lights and red lights (Fig. 17). In this area very often groups of locals and to a certain extent tourists were found looking for turtles, often using white lights and in some cases red lights.
Figure 15. Temporal Distribution of Illegal Human Activity (Date)
Bars indicate the total number of impacts encountered in each week (1-4) of a given month for (a) Locals and Tourists and (b) White Lights, Red Lights and Fires.

Figure 16. Temporal Distribution of Illegal Human Activity (Time)
Bars indicate the total number of impacts encountered from 01 July – 31 October within a given hour for (a) Locals and Tourists and (b) White Lights, Red Lights and Fires.
Figure 17. Spatial Distribution of Illegal Human Activity
Bars indicate the total number of impacts encountered from 01 July – 31 October within the section of a given mile marker for (a) Locals and Tourists and (a) White Lights, Red Lights and Fires.
BEACH HABITAT MANAGEMENT

Collaboration with MINAE, Police and Coast Guard

From the beginning of the season efforts were made to establish collaborations with MINAE, and more specifically Víctor Hugo, a representative from the Barra del Colorado Wildlife Refuge, with the aim to reduce poaching rates on Playa Norte. The efforts made at the beginning of the season in March were continued and expanded throughout the Green turtle season to eventually include regular collaborations with MINAE, the police and the coastguard. Table 11 summarises the collaboration from July – October.

<table>
<thead>
<tr>
<th>Date</th>
<th>Institution (Number of Representatives)</th>
<th>Patrol Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 July</td>
<td>MINAE (V. Hugo) and Coast Guard (2)</td>
<td>Morning (independent)</td>
</tr>
<tr>
<td>14 August</td>
<td>MINAE (V. Hugo) and Coast Guard (2)</td>
<td>Morning (independent)</td>
</tr>
<tr>
<td>29 Aug – 01Sep</td>
<td>Coast Guard (3) and Police (5)</td>
<td>Morning and Night</td>
</tr>
<tr>
<td>6-9 September</td>
<td>Police (5)</td>
<td>Night and independent Morning</td>
</tr>
<tr>
<td>7-9 September</td>
<td>Coast Guard (3)</td>
<td>Night/Independent Night /Boat</td>
</tr>
<tr>
<td>17-19 October</td>
<td>MINAE (V. Hugo + 2) and Police (2)</td>
<td>Morning /Independent Morning</td>
</tr>
<tr>
<td>25 October</td>
<td>MINAE (V. Hugo) and Eco-Volunteers (11)</td>
<td>Night and Morning</td>
</tr>
</tbody>
</table>

14 July: Víctor Hugo together with two representatives from the Coast Guard independently conducted a beach patrol between 04:30 – 12:00. They arrested a local guy called “Cholo” who was caught trying to poach a nest.

14 August: Víctor Hugo and two Coast Guards independently carried out a patrol on Playa Norte and in San Francisco early in the morning.

29 August – 01 September: Three Coast Guards and five policemen supported our teams at night as well as in the morning. Even though no one was arrested, the presence of authorities on the beach did have a noticeable effect on the poaching activity.

6-9 September: Five policemen independently carried out patrols on the beach at night and joined our teams during Morning Census.

7-9 September: Three Coast Guards joined us at the station in addition to the five policemen. Two of them supported us during Night Patrol. Additionally, they patrolled the Tortuguero river mouth area, which is just south of the turtle transect and a hotspot for poaching of turtles. Another group consisting of one coast guard and several policemen carried out a patrol by boat in order to check the wider area such as the river mouth, Tortuguero Beach north of the airport (another uncontrolled hotspot for poaching) and coastal waters further south with the intention to find boats from Moín, Limón, which are known to harvest immense numbers of turtles at sea.

17-19 October: Víctor Hugo together with two more representatives from the Barra del Colorado Wildlife Refuge conducted an independent morning patrol, covering the Tortuguero river mouth and our beach transect. On the 19th Víctor Hugo together with two policemen accompanied us and 11 kids to do excavations as part of the kids’ environmental education.
25 October: Víctor Hugo together with 11 eco-volunteers from Pérez Zeledón (between the Cerro Chirripó and the Cerro de la Muerte), joined us for night patrols on the 25th and for excavations on the 26th.

**Beach Clean**

Between 01 July and 31 October beach cleans were carried out whenever time allowed. No beach cleans could be carried out between end of August and mid-October, due to the high workload of Morning Census, Nest Check and excavation teams. The garbage removed from the beach was weighed and separated into recyclables and non-recyclables. All was disposed of at the recycling and refuse facilities in Tortuguero. A total of **664 kg of non-recyclables** and **44 kg of recyclables** (glass and metals) were removed from an area of approximately 1000 metres of beach. Most commonly found items were plastic bottles, toys, shoes and flip-flops, toothbrushes, crates, lollypop sticks, petrol cans and buckets.

Due to Playa Norte's location next to the Tortuguero river mouth and the strong currents in the sea, a comparatively high amount of heavy logs and driftwood washes up on the beach. These logs can cause nesting turtles, especially the smaller species (Green, Hawksbill & Loggerhead) to return to the sea without nesting, as they are not able to access the beach or hindered in their natural nesting behaviour (Laurance WF et al. 2008). This had been witnessed by us on several occasions.

Furthermore, the removal of logs and garbage facilitates a better access to the sea for hatchlings, preventing them from getting trapped or entangled in marine debris and driftwood, as has been observed on other beaches (e.g. Triessnig et al. 2012). At the beginning of the season in March, logs were moved further up on the beach and piled up (one or two piles per eighth of a mile) to reduce the area of impact. If logs were too heavy to be removed, they were turned perpendicular to the sea (shore line) so that the smallest surface faced the sea in order to reduce the area of obstruction (Ga-Young & Eckert 2009). From the beginning of the Green turtle season, driftwood was no longer piled up near the vegetation in order to avoid potentially covering any unmarked nests. Heavy logs near the shoreline continued to be moved perpendicular to the shore line and driftwood blocking the area between a nest and the sea was moved when nests were close to hatching.

**Artificial Light Pollution**

A special feature of Playa Norte beach is its small line of vegetation (a few trees) at the top of the beach behind which a path runs parallel to the beach. The public lights on the path, the lights from lodges and private houses, as well as people with torches, motorbikes and other motorised vehicles, can cause artificial light pollution in the vegetation along the beach as well as on the beach itself. Since Green Turtles' and Hawksbills' preferred nest site is in or near the vegetation (Turkozan et al. 2011, Ahmad et al. 2005, Horrocks & Scott 1991) this poses a threat to the orientation of nesting turtles and emerging hatchlings (e.g. Witherington & Martin 2003, Bourgeois 2009, Berry et al. 2013), as has been observed by us on many occasions.
Collaboration with ICE
In collaboration with ICE (Instituto Costarricense de Electricidad), the STC (Sea Turtle Conservatory) and the Tortuguero National Park, an effort was made to address this issue and reduce the impact of artificial light pollution on Playa Norte. A Light Census on Playa Norte was carried out by us to document the exact number and location of lights and their impact on the beach. The eventual aim is to shield and hence reduce the impact of all public lights along the beach. Along with this MINAE and the Tortuguero National Park further intend to convince residents of Playa Norte to reduce the impact of private lights by offering financial support to either shield the lights or replace the white light bulbs with red ones.

Light Census Protocol
The Light Census was carried out in October and November during a new moon, as during this moon phase the sky is dark and the lights are better visible from the beach. The area observed extends from the edge of the village of San Francisco to Laguna Cuatro, covering approximately three miles. All lights, both private and public, visible from the beach were recorded (Fig.18). Moving lights observed on the path running parallel to the beach were excluded from the census.

![Figure 18. Public and Private Lights on Playa Norte](chart.png)
Bars indicate the total number of lights recorded within the section of a given mile marker. The number of lights within each mile marker represents an averaged count from data collected in October and November.

**Figure 19** shows the overall spatial distribution of turtle nests of the species Leatherback (*Dermochelys coriacea*), Green turtle (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) during the 2013 season, summarised for each eighth of mile. It is important to emphasise that the lights do not affect the entire area represented by a mile marker, which is approximately 200 metres. Therefore, in some of the areas affected by light, such as mile 2/8, the nesting activity does not seem to be directly affected. However, in areas with less vegetation such as mile 1 4/8, a very clear effect on nesting activity can be observed.
Figure 19. Distribution of Lights and Nests
Bars indicate the total number of nests encountered for Leatherback, Green turtle and Hawksbill on Playa Norte from 01 March 31 – October. [X] indicate miles affected by light pollution.

Figure 20 shows pictures taken from the beach in direction of public lights, in order to demonstrate their visibility on the beach, especially in areas without vegetation.

(a)  
(b)  
(c)  

Pictures courtesy of Caño Palma Biological Station staff

Figure 20. Light Pollution
Light pollution caused by public lights observed from the beach. Mile 2/8 (17N 0223621 1172331 and 17N 02223534 1172332) (a), mile 6/8 (17N 0223246 1173185) (b), mile 1 4/8 (17N 0222889 1174186 and 17N 0222839 1174295) (c).
On the part of the Caño Palma Biological Station it was proposed to the residents of Playa Norte that the white lights at their houses that are projecting light directly over the beach should be exchanged with red ones. Red light is a lot less visible (Fig. 21b and c) and therefore has less of an effect on turtles (Witherington & Martin 2003). Residents that showed interest in the proposition were provided with red light bulbs (Fig. 21a). This type of light bulb can be bought in Tortuguero at a price of 1400 CRC (approx. 2.80 US$).

![Pictures courtesy of Caño Palma Biological Station staff](image)

**Figure 21. Change from White to Red Light**

Red light provided for interested residents (a). The effect of exchanging a white light bulb (b) with a red one (c).

**VOLUNTEERS AND INTERNS**

**Turtle Training and Testing**

From 01 July – 31 October a total of seven interns, 22 volunteers and two external researchers were trained (Table 12). Four turtle interns completed training as Patrol Leader.

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Country</th>
<th>Association</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intern</td>
<td>Australia</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Intern</td>
<td>Canada</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Intern</td>
<td>Holland</td>
<td>HAS University of Applied Science</td>
<td>2</td>
</tr>
<tr>
<td>Intern</td>
<td>USA</td>
<td>State University of New York at Oswego</td>
<td>1</td>
</tr>
<tr>
<td>Intern</td>
<td>USA</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Volunteer</td>
<td>Canada</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Volunteer</td>
<td>Denmark</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Volunteer</td>
<td>Hungary</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Volunteer</td>
<td>Switzerland</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Volunteer</td>
<td>United Kingdom</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Volunteer</td>
<td>USA</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>External Researcher</td>
<td>USA</td>
<td>University Minnesota</td>
<td>2</td>
</tr>
</tbody>
</table>

A standardised training and testing program was established at the beginning of the season in March. The training program was updated and extended as the season progressed and new aspects such as excavations became a more important part during the daily work of volunteers and interns. Training consisted of four presentations and two practical sessions every project participant had to attend within the first week after arrival (Table 13).
13. Training Program for Volunteers and Interns

**Presentations:**

1) Introduction to Marine Turtle Monitoring Project
   - Biology of Green turtles & brief introduction to the other three species
   - Identification of Tracks
2) Egg Counting & Triangulation
3) Measuring, Body Check & Tagging
4) Excavations

**Practicals:**

1) Triangulation practice on beach
   - *Part I:* burying of a coconut (= nest dummy), triangulation & field book writing
   - *Part II:* find coconut with the help of the field book (if two teams available, find other team’s coconut)
2) Measuring, Body Check & Field book writing practice (using dummy turtles)

Training was followed by a written test of around 50 questions, which participants had to sit 10 – 14 days after arrival. Tests were continually updated and adjusted during the season to focus on the most important current subjects. 80% was the minimum score to reach for everyone wanting to participate in fieldwork on the beach. People scoring below 80% were required to re-sit the test within one week.

95% was the minimum score to be considered as a potential patrol leader. However, only participants planning to stay for a minimum of 6 weeks were considered as potential patrol leaders, due to the amount of time and resources it takes to complete the full patrol leader training. With a score of 90% or above, oral re-takes were conducted. Participants with a score of 95% and the desire to become a patrol leader were then practically tested as a patrol leader on the beach during Night Patrol. If the performance was satisfying, they then received tagging practice on base using cardboard as turtle flipper dummies. Initial tagging of turtles in the field was always accompanied by one of the turtle coordinators until the candidate was considered as being able to carry out all aspects of tagging to the project’s standards on their own.

In order to give interns a chance to acquire additional desirable work experience as well as decrease the coordinators’ workload, selected interns throughout the season were trained to take over the presentations and practical parts of the turtle training. The testing, practical assessment of potential patrol leaders and the tagging practice was always carried out by the project coordinators.

**Spanish Classes**

The main purpose of these lessons was to qualify volunteers and interns to hold a conversation in Spanish in order to improve relations with the community and especially with the residents along Playa Norte. Most locals do not understand or speak English. If at any time an emergency occurs and it is not possible to return to the station, the neighbouring houses and hotels are the nearest places to seek help. Furthermore, it is very useful to understand the language of the people passing the beach as they are an important source of information regarding poaching activities and any potential threats on the beach.
Spanish lessons were given once a week throughout the nesting season, from early March to late September. Classes lasted between one and two hours, depending on the material covered and the other station activities on a given day. The most important aspect was that interns were able to build up their Spanish skills. Since they stayed at the station for an extended amount of time they were going to be more involved with locals compared to short-term volunteers.

Therefore two levels of classes were offered:

**Basic Level:** interns and volunteers were taught to introduce themselves correctly and explain where they work as well as the most important vocabulary regarding the work with turtles. This was particularly important as locals and tourists often wanted to know more about the work that we do on the beach. Furthermore, the building and understanding of some important phrases they should know for their own safety and that of their team.

**Second Level:** intended for interns who stayed at the station for an extended amount of time (6+ weeks). These lessons taught more general vocabulary like: animals, kitchen utensils, tools, food, etc. Furthermore, they were taught advanced grammar, conjugation and different verb tenses as well as how to answer the phone properly. In addition they were asked to put together lists of sentences they would like to know in Spanish, which were then translated together in class.

All people who stayed at the station for a month or more had to take a Spanish written exam. This helped them to review the most important concepts and find out where their main difficulties lay. With a score of less than 60%, participants were asked to retake the exam during the next round.

Noteworthy is also that students with a more advanced Spanish were offered to practise conversations in Spanish with the coordinators at any given time in order to receive feedback on any grammatical mistakes and expressions.

**PUBLIC EDUCATION**

**Tourists and Students**
From July – October six presentations were given at Hotel Vista al Mar (Table 14).

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Origin of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 July</td>
<td>Vista al Mar</td>
<td>DuBois Area High School, Pennsylvania, USA</td>
</tr>
<tr>
<td>19 July</td>
<td>Vista al Mar</td>
<td>N/A</td>
</tr>
<tr>
<td>17 August</td>
<td>Vista al Mar</td>
<td>N/A</td>
</tr>
<tr>
<td>28 September</td>
<td>Vista al Mar</td>
<td>Instituto San Joaquin de Flores, Costa Rica</td>
</tr>
<tr>
<td>12 October</td>
<td>Vista al Mar</td>
<td>N/A</td>
</tr>
<tr>
<td>19 October</td>
<td>Vista al Mar</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Presentations for tourists always started with a brief introduction of COTERC and the Caño Palma Biological Station, followed by an introduction to the Marine Turtle Project. Since most tourist groups that stayed at Vista al Mar went on illegal turtle tours on Playa Norte, it was attempted to minimise their potential impact on nesting turtles by kindly making them
aware of the illegality of their activity and informing them about appropriate behaviour while on the beach.

Making use of the variety of nationalities that were present at the station at any given time, we were able to offer presentations in English, Spanish, German, Dutch and French. Whenever tourist groups were present, arrangements were made to get in touch with their guide to inquire whether presentations were desired and what topics they should preferably cover. Apart from presentations on the Marine Turtle Project held by the project coordinators, presentations made and given by our interns, volunteers and visiting scientists included Cane Toads (*Bufo marinus*), Tent-making Bats, River Otters (*Lontra longicaudis*), marine debris/plastic pollution and the history of Tortuguero.

**Environmental Education for Local Children**

The goal of the environmental education program was to educate the children of the school of San Francisco in environmental topics. This program began in April and lessons were taught once a week.

The topics taught consisted of lessons accompanied by activities relating to conservation, biodiversity and the environment surrounding the community. The lesson outlines were developed by COTERC and were put together by people qualified in teaching. The program was well received by all students, teachers and parents. The same lessons were given to all school grades but methods and activities were adapted depending on the age of the students. Between April and June a total of 12 lessons were given covering the biology of the sea turtle, jaguar, caiman and ants. Lessons were given once a week rotating through the different grades. One of the coordinators together with a volunteer or intern taught the lessons at the school and supervised the activities.

Due to the positive feedback received for the program it was decided to try to increase the regularity of the lessons and offer them every day after school. However, this required to recruit additional qualified personnel in the form of two environmental education interns.

In addition to the lectures at school, we organised activities for the children on the beach in order to provide them with an experience of what it is like to work in the conservation of sea turtles. These activities were organised under the permission of the authorities and a written parental consent. Activities were offered both during the night and during daytime, in both cases we were at all times accompanied by members of the police and the national park:

**Night activity:** children were invited to come to the beach to observe sea turtles in their nesting process and to see how we work with them. Before heading out to the beach, children were given an introduction about the exact activity on the beach and were reminded about the rules of conduct while carrying out a Night Patrol, which had previously been discussed at the school during a turtle presentation. Children were split into different groups accompanied by a Patrol Leader and at least one other trained team member as well as members of the police or the nation park. The event was held twice and both times nesting turtles were encountered and the entire nesting process could be explained to the children.
**Daytime activity:** children accompanied us for nest excavations so they could see and learn the process of the development of eggs and the difficulties hatchlings face when trying to reach the sea. This activity was performed three times and all the children were able to see live hatchlings, different stages of embryos and predated eggs.
DISCUSSION

Large Morning Census
The Large Morning Census could not be continued after June due to the immense workload during the peak of the Green turtle nesting season. Available volunteers were needed for Morning Census, Nest Check and Excavations.

Disguising of Nests and Tracks
We recommend that the way tracks are marked during Night Patrols should be slightly varied throughout the season, as other people on the beach (possibly poachers) tend to copy the methods. This could result in missing an emerged turtle due to the fact that tracks have misleadingly already been marked. In addition to marking tracks with two lines, we marked them at the top of the track with the patrol leader’s initials using sticks or bits of driftwood.

Despite our disguising efforts many nests seemed to get poached during the peak of the Green turtle season. The disguising of nesting tracks can only be done in a satisfying way when the sand is very dry. In wet conditions, this is very difficult or impossible to achieve. Since halfmoon tracks were only marked but not disguised, the attempt to disguise nesting tracks in wet conditions bore the risk of making nests stand out compared to halfmoon tracks. Therefore the strategy was adapted to only disguise the nest site itself and the tracks were “converted” into a track that looked like a marked halfmoon.

Survey Effort
We strongly suggest it should be intended to carry out Morning and Night Patrols every day of the season, in order to maximise the number of encountered turtles. This not only guarantees the collection of essential data, but can also significantly decrease the risk of turtles and nests being poached at night. In addition, during the peak of the Green turtle nesting season it is essential to adapt patrol strategies in a way that allows the coverage of the entire beach transect despite the high encounter rate of nesting turtles. In particular, this should involve having some teams starting their patrol at mile 1 4/8 and 3. Daily Morning Patrols, among other aspects, provide beach presence during the early hours, again reducing the risk of poaching.

In previous years the status of nests was only assessed for the first two days after laying as the first 48 hours bear the greatest risk of poaching. However, daily assessments of the nest status of all triangulated nests as well as checking of the intactness of corresponding flagging tapes from the day nests were laid to the day of their excavation, is essential for the interpretation of excavation data and prevents that nest success data is lost due to loss of flagging tapes. We strongly recommend that this new aspect of data collection is maintained.

Nesting Activity
Data summarised in this report refer to data collected from 01 March - 31 October. However, Morning Patrol continues until the last of the triangulated nests is excavated (approx. end of December). Eight more Green turtle halfmoons and one nest were recorded at the beginning of November. The last nest was recorded on 7 November, the last halfmoon on 13 November.
The results of the remaining excavations are summarised within an extra report, available towards the end of December.

Nest Fate

Green Turtle: Almost 60% of all triangulated Green turtle nests hatched, however a substantial number of nests were not able to complete the development due to anthropogenic caused threats. With 23% of nests destroyed by poaching, this was the most significant threat, closely followed by predation by dogs (13%).

No Green turtle nests were eroded, which is generally more unlikely in this species compared to Leatherback nests, due to their preference to nest higher up on the beach within the Border or Vegetation zone.

Approximately 5% of the nests could not be found (‘lost’) during attempted excavations. In three cases the flagging tapes used to mark the trees for triangulation had been lost during the incubation time and could not be replaced. For the remaining ‘lost’ nests no evidence of poaching, predation or other form of disturbance was recorded during the daily monitoring. Possible explanations are inaccurate triangulations or unnoticed poaching.

Hawksbill: The most alarming outcome was the fact that 60% of all triangulated Hawksbill nests failed to hatch because of mainly anthropogenic caused threats. The most significant impact was caused by poaching (30%), which means that poaching is responsible for 50% of all failed nests. 25% of all triangulated nests were destroyed by dogs, which is another anthropogenic caused threat.

Only one Hawksbill nest was eroded, which is likely due to their preference to nest higher up on the beach within the Border or Vegetation zone.

Poaching of turtles: five dead turtles were found within the beach transect:

- One male turtle was found washed up entangled in a wide-meshed fishing net.
- One female was found washed up with ropes forced through each of her flippers, a method often used by poachers who catch turtles at sea. They leave them floating alive in the sea, with their flippers tied up and connected to the boat by a rope. This way the ropes can simply be cut off should any authorities arrive. However, once cut loose, the turtle usually drowns because its flippers are tied together.
- On one occasion the track of a lifted turtle was found. Only up-tracks were found, accompanied by blood and tracks of a four-wheel quad.
- The carapaces of two dead turtles were found within the transect; one near mile 6/8 and one at 2/8, not far from Vista al Mar. Another carapace was found in the area of the Tortuguero river mouth, a few hundred metres outside of the transect.
- On one occasion the fresh head of a Green turtle was found around mile 2 3/8, not far from Turtle Beach Lodge, however we cannot be sure that this turtle was killed on Playa Norte as it could have been washed up from somewhere else.

Beach Habitat Management

Human Impact Survey: Our efforts to collect regular and standardised data on illegal human activity on Playa Norte provided new and useful information for the Barra del
Colorado Wildlife Refuge. We were contacted by Ana Monge, the research supervisor of the refuge, who expressed her appreciation for the Human Impact Survey included in our weekly reports to MINAE. The weekly results from this survey provided the refuge with information on temporal and spatial distribution of illegal activity on the beach, which they intend to use to improve and increase the presence of authorities on the beach.

The collaborations with MINAE and particularly Víctor Hugo, the police and coast guard, need to be maintained and if possible extended. It is important to establish these relations as early as possible in the season in order to have a well working collaboration set up once the Green turtle season starts and hence the poaching rates increase. The presence of authorities on the beach did have a noticeable effect on the poaching activity.

**Light Census**: Following up the Light Census, another meeting is planned together with ICE and the STC, in which it will be discussed if and how the ICE is going to proceed to reduce the impact of public lights. Furthermore, it will be discussed what efforts can be made and what financial support can be offered to inspire local residents to reduce the light pollution caused by private lights.

**Beach Clean**: Considering the vast amount of garbage that was collected from a comparatively small area of beach, this seems a necessary and desirable aspect of the project that should be continued next year whenever time allows. In addition to removing garbage from the beach, we also consider it very important to free the beach from driftwood and big logs at the beginning of the season to facilitate access to the beach for nesting females, as well as access to the sea for hatchlings. The data summarised in the current report refers to the period from 01 July – 31 October, however beach cleans were continued after the end of the season for as long as personnel was available.

**Public education**

Presentations at Vista al Mar, which had first started in April, continued to be successful during the Green turtle season and in addition to the already well established relationships with the owner and manager, we further made an effort to extent these relationships to include the various guides who regularly bring their tourist groups there. As early as possible in the season, efforts should be made to make sure staff as well as tourist guides are aware of the availability of presentations.

**CONCLUSIONS**

The allocation of two coordinators to this project has enabled us to improve and expand the project in many aspects. Baseline data collection was improved in order to reduce data loss compared to previous years. Furthermore, new aspects were added to the project, among which the collaboration with MINAE, the police and the coast guard as well as the efforts to decrease artificial light pollution along the beach, were considered priorities by us. We recommend continuing to run this project under the coordination of two people, as this will allow the project to further grow, improve and increase its impact.
REFERENCES


