Sea Turtle Monitoring and Research Report

Pacuare Reserve

2017

Prepared by Renato Bruno

Pacuare Reserve

PACUARE RESERVE
ECOLOGY PROJECT INTERNATIONAL

2017 Field Coordinators

Renato Bruno – South Station

Hayi Valverde – North Station

2017 Field Assistants

Ashleigh, Carlos, Eva, Fabio, Gilles, Javier, Jhazel, Joana, Magali, Maria Jose, Rebeca

Table of Contents

1. Introduction ... 5
1.1. Pacuare Reserve ... 5
1.2. Location of Pacuare Reserve ... 6
1.3. Sea Turtle Species ... 6

2. Methodology ... 9
2.1. Preparation ... 9
2.2. Beach Patrols and Nesting Surveys ... 9
2.3. Morning Census ... 11
2.4. Individual Sea Turtle Identification ... 12
2.4.1. Flipper Tagging ... 12
2.4.2. Passive Integrated Transponder (PIT) Tagging ... 12
2.5. Biometric Data ... 12
2.6. Nest Relocation ... 13
2.7. Nest Triangulation ... 15
2.8. Nest Excavation ... 16

3. Results ... 18
3.1. Leatherback Turtles ... 18
3.1.1. Temporal Distribution ... 18
3.1.2. Spatial Distribution ... 20
3.1.3. Timing of Activity ... 22
3.1.4. Stage of Nesting Process ... 23
3.1.5. Tagging and Biometric Data ... 23
3.1.6. Nesting Success ... 24
3.1.7. Nest Excavation ... 25
3.1.8. Hatching and Emergence Success ... 25
3.2. Hard-Shelled Turtles ... 28
3.2.1. Temporal Distribution ... 28

3.2.2. Spatial Distribution 30
3.2.3. Tagging and Biometric Data 31
3.2.4. Nesting Success 31
3.2.5. Hatching and Emergence Success 32

4. Discussion 18
4.1. Leatherback Nesting Trends 33
4.2. Beach Patrols 33
4.3. Mark and Recapture Program 35
4.4. Egg Poaching 36
4.5. Nest Relocation and Triangulation 37
4.6. Eroded and Lost Nests 39
4.7. Green Turtle Season 40

Appendix A. Leatherback Tag Catalog 43

1. Introduction

1.1. Pacuare Reserve

The Endangered Wildlife Trust (EWT) is an English NGO that has been committed to sea turtle and wildlife conservation in Costa Rica since 1989. The Trust was founded by John Denham, who visited the Caribbean coast of Costa Rica in the late 1980s seeking a piece of property on which to build a holiday home. Noticing the alarmingly high level of sea turtle egg harvest, he instead created EWT to raise funds and purchased 800 hectares of land fronting 5.7 kilometers of sea turtle nesting beach. The property was a mix of deforested farmland and small pockets of rainforest, which naturally reforested the cleared areas once the land was protected being christened Pacuare Reserve (PR). In addition to providing habitat for the diverse flora and fauna that had been threatened by habitat degradation, reforestation of land adjacent to the beach made beach access more difficult for poachers and served as a natural deterrent to sea turtle egg poaching.

Initially, nest poaching at PR was estimated to be as high as 95%, which was then a common problem throughout Central America. The Endangered Wildlife Trust made various cooperative efforts with the Costa Rican Ministry of Environment (MINAE) to protect sea turtles during the annual nesting season. By 1991, the property was officially protected as Pacuare Reserve (PR). By the start of the 1994 nesting season, a comprehensive sea turtle monitoring and conservation program was underway, started by John's daughter Alexandra and conducted with the help of a small team of volunteers.

The project has grown enormously in the decades since, and EWT now operates research stations at the northern and southern limits of the Reserve. Nest poaching on the 5.7-kilometer beach has been reduced to under 5%, and the Reserve hosts some 211 species of bird, more than 20 species of mammals, 43 species of reptiles, and 16 species of amphibians on the 800 hectares of protected rainforest. The Reserve is also home to a diverse array of invertebrates, trees and plant life, and aquatic species inhabiting the surrounding canal and shoreline. The Reserve attracts biologists, conservationists, and researchers from around the world as well as students and independent volunteers who visit to learn about nesting sea turtles and experience the amazing biodiversity flourishing at the Reserve.

Since 2016, Ecology Project International (EPI) has taken over the responsibilities of EWT in managing PR. EPI is a nonprofit educational organization that improves and inspires science education through field-based student-scientist partnerships. The organization was co-founded by Scott Pankratz and Julie Osborn, both American citizens that worked and studied in Costa Rica in the 1990's and recognized the necessity for local based environmental education efforts as a response to lack of knowledge of many Costa Ricans about their country's biodiversity.

In 2000 they launched the first of EPI's programs in Costa Rica to take local students that lived within 5 miles of Pacuare Reserve to experience a sea turtle nesting event. Students learned about the biology of sea turtles and took part in data collection performed by PR's scientists.

In that first trial EPI took 61 students to Pacuare and since then it has grown to operate, with a similar approach, in areas of biological interest of 5 different countries within the Americas. Although EPI has now sensitized more than 30.000 students from all over the world, its roots are intricately related to PR's.

1.2. Location of Pacuare Reserve

Pacuare Reserve is located along the Caribbean coast of Costa Rica. The Reserve is 30 kilometers northwest of the port of Limón and 45 kilometers southeast of Tortuguero. Tortuguero Canal separates PR from the mainland to the west. The Reserve's northern border is one kilometer south of the Pacuare River mouth and the southern border is at Mondonguillo Lagoon. The Reserve's sea turtle monitoring project operates on the 5.7 kilometers of beach protected by PR (*Figure 1*). Two research stations, one at the northern limit and one at the southern limit, are operational throughout the sea turtle nesting season.

1.3. Sea Turtle Species

Three of the world's seven species of sea turtle nest in Pacuare. The high-energy and erosion-prone beaches of the Caribbean coast of Central America, more specifically of Costa Rica and northern Panama, hold the third most important nesting ground for the Northwest Atlantic

Ocean subpopulation of the leatherback turtle (*Dermochelys coriacea*). The leatherback nesting season occurs between February and August, and Pacuare Reserve receives an average of 770 leatherback nests every year.

Two species of hard-shelled sea turtle also nest in Pacuare: the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*). The green turtle nesting season is between June and November, and the world's largest nesting colony of green turtles is located only 45 kilometers northwest of Pacuare at Tortuguero National Park. Critically endangered hawksbill turtles nest throughout the season, though in much smaller numbers. In 2017, even though such encounters are rare, our monitoring program have also reported loggerhead turtle (*Caretta caretta*) nesting in the area.

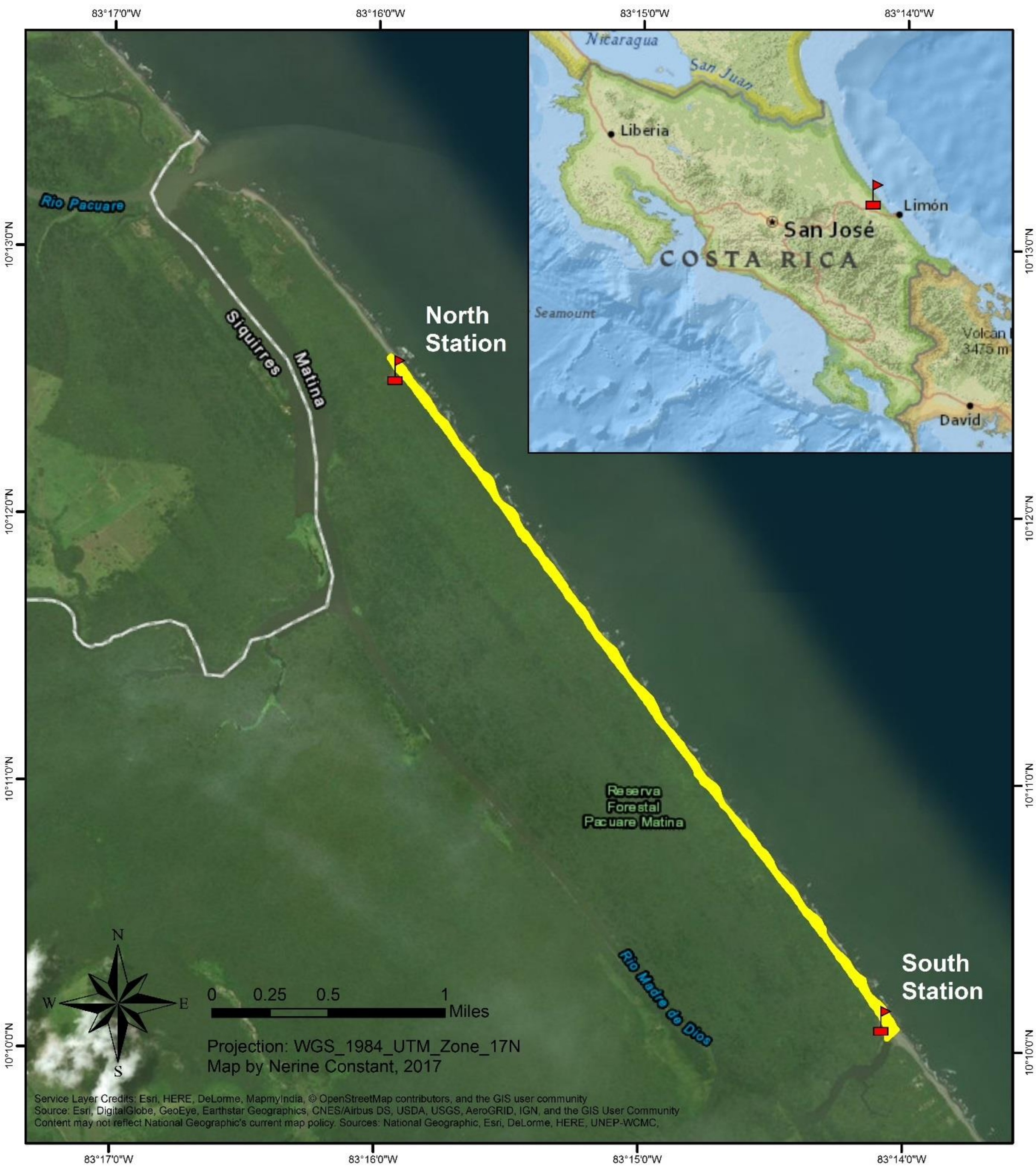

Figure 1. Map of Pacuare Reserve showing its location within Costa Rica (inset map) and the extent of beach monitoring (in yellow). Map credit: Nerine Constant

2. Methodology

2.1. Preparation

To start the season fully equipped, PR staff cleaned equipment, prepared offices, and purchased missing equipment. Field Coordinators trained Field Assistants with an intensive field techniques course to ensure they were suitably prepared for the onset of the nesting season. The course included lessons on sea turtle ecology and biology, species identification, safe working practices, use of equipment, data collection protocol, tagging methodology, nest relocation and triangulation procedures, beach patrol ethics and leadership, and health and safety practices.

We divided the beach into monitoring sectors by placing numbered wooden markers at 25-meter intervals along the entire 5.7-kilometer beach. Markers at 100-meter intervals were numbered with whole numbers from 0 in the south to 57 in the north, and markers in between were numbered in increments of 0.1 from the previous 100-meter marker (e.g. the southernmost 100 meters of the study area were marked 0, 0.1, 0.2, 0.3, and 1).

2.2. Beach Patrols and Nesting Surveys

We conducted nightly beach patrols from February 21st to July 28th to monitor all sea turtle activities on the beach and to keep the poaching rate to an absolute minimum. Either a Field Coordinator or Field Assistant led each patrol, accompanied by small groups of volunteers. Each group patrolled for a minimum of four hours, with patrols starting from both stations at 20:00, 22:00 and 00:00. This schedule allowed us to maximize turtle encounters by having multiple patrols on the beach simultaneously and covering the beach until almost sunrise. During night patrols, we encountered tracks and turtles and performed tagging, measuring, and nest relocation protocols.

For each activity, we recorded the following data in a waterproof notebook.

- **Patrol leader’s name**

- **Date:** The patrol date (does not change after midnight, so all patrols in one night have the same date recorded)
- **Time:** Recorded in 24-hour time the minute the patrol encountered the turtle
- **Sea turtle species:**
  - **DC:** *Dermochelys coriacea* (Leatherback, Baula)
  - **CM:** *Chelonia mydas* (Green, Verde)
  - **EI:** *Eretmochelys imbricata* (Hawksbill, Carey)
- **Activity type:**
  - **S**alida **F**alsa (False Crawl): An activity that did not result in a nesting attempt
  - **N**o **P**uso (Did Not Lay): The turtle dug a body pit, but did not oviposit
  - **N**o **S**é (Not Confirmed): An activity with all the characteristics of a nest, but the patrol did not witness oviposition
  - **I**n **S**itu: A confirmed nest that the patrol left in the turtle's original nesting site
  - **R**eubicado (Relocated): A confirmed nest that the patrol relocated to a safer site
- **Zone:** Vertical area of the beach where the activity occurred
  - **V**egetación: In the vegetation
  - **A**lta: Upper part of the beach
  - **B**aja: Lower part of the beach
  - **M**area: Below the high tide line

When the turtle was encountered in addition to the track, we also recorded the following information.

- **Stage of nesting process:** The turtle's behavior when encountered by the patrol
  - **S**aliendo (Emerging): Emerging from the water or searching for a suitable nest site

- **B**añando (Bodypitting): Making a body pit with her front flippers
- **E**xcavando (Digging): Digging the egg chamber
- **P**oniendo (Laying): Oviposition, or laying eggs
- **T**apando (Covering): Covering the egg chamber with her rear flippers
- **C**amuflando (Camouflaging): Camouflaging her nest
- **R**egresando (Returning): Returning to the sea

- **Tagging data** (see *2.4. Individual Sea Turtle Identification*): Left and right flipper tag number, PIT tag number, whether tags were old or newly applied, and evidence of lost tags (old tag holes and notches)
- **Size measurements** (see *2.5. Biometric Data*): Carapace measurements in centimeters
- **Body condition:** Any notable observations on turtle body condition, including injuries, deformities, and parasites

For in situ and relocated nests, we also recorded the following information.

- **Nest depth:** Measured in centimeters from surface to bottom of egg chamber
- **Egg count:** The number of fertile and infertile (yolkless) eggs laid in the nest
- **Nest location measurements** (see *2.7. Nest Triangulation*)

2.3. Morning Census

We conducted the morning census at dawn to monitor the status of in situ and relocated nests; record evidence of poaching, erosion, or hatching activity; and conduct nest excavations (see *2.8. Nest Excavation*). We also marked unconfirmed nests with flagging tape if we observed evidence of hatching that confirmed oviposition. Morning census also functioned as the final patrol, allowing us to record any turtle activities that occurred after the last night patrol.

2.4. Individual Sea Turtle Identification

2.4.1. Flipper Tagging

Once turtles finished laying, we marked untagged turtles with metal flipper tags using tagging pliers. Each tag has a unique series of letters and numbers that allows for individual identification (Carr 1954). Leatherbacks were marked with Monel tags placed in their left and right rear flippers and hard-shelled species were tagged with Inconel tags in the second scale of their left and right front flippers (*Figure 2*).

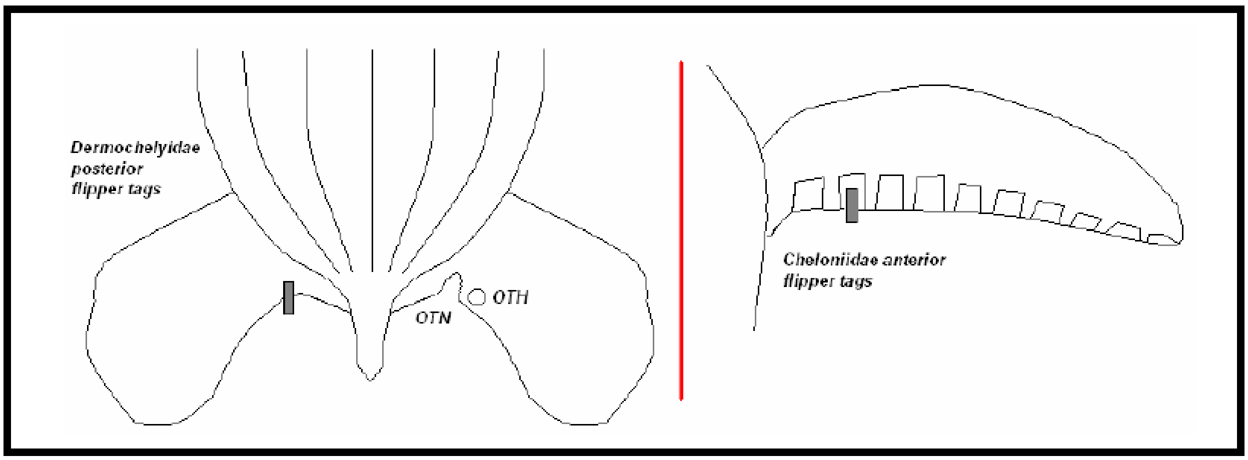

Figure 2. Flipper tagging locations for leatherbacks (left) and hard-shelled species (right). Evidence of lost tags noted as old tag notch (OTN) and old tag hole (OTH).

2.4.2. Passive Integrated Transponder (PIT) Tagging

As a secondary individual identification method, we also marked turtles with Passive Integrated Transponder (PIT) tags after scanning for existing tags. These tags use a transponder the size of a grain of rice that provides a unique series of letters and numbers when read with a scanner. We injected PIT tags into the front muscle of the right shoulder (Dutton and McDonald 1994).

2.5. Biometric Data

We counted eggs during oviposition (for nests left in situ) and during nest relocations. Leatherbacks also lay smaller yolkless eggs after the fertilized eggs, which we counted separately. When handling eggs, we always wore medical gloves to protect humans, turtles, and eggs. For leatherbacks, we measured curved carapace length (CCL) along the right side of the central ridge from the nuchal notch following the curving shape of the carapace to the tip of the caudal peduncle (*Figure 3 A.I, B.I*). We also noted if the caudal peduncle was complete or incomplete. We measured the curved carapace width (CCW) across the widest part of the carapace from the outer carapace ridges (*Figure 3 A.II, B.I*). For green turtles and hawksbills, we measured CCL and CCW in a similar manner, down the center of the carapace and at the widest point respectively (*Figure 3 B.II*) (Georges and Fossette 2006).

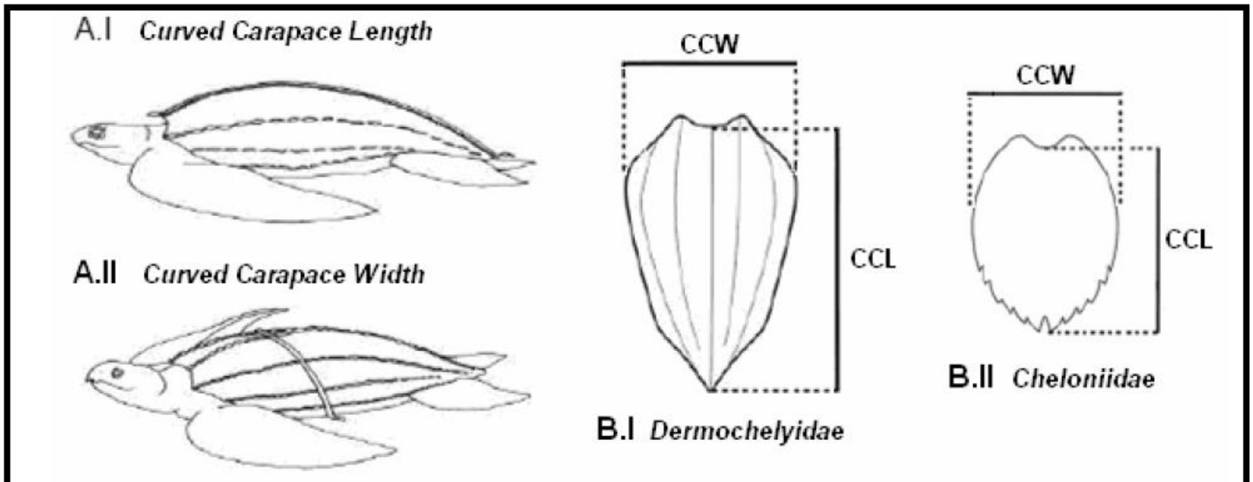

Figure 7. Curved Carapace measurements.

Figure 3. Measurement protocols for leatherbacks (A, B.I) and hard-shelled species (B.II).

2.6. Nest Relocation

We relocated nests that were laid in areas prone to nest failure due to erosion or elevated microbial content. If we encountered the turtle before oviposition and determined it was necessary to relocate the nest, we waited until the turtle had finished digging the egg chamber before placing a sterile plastic bag inside the nest to collect the eggs as they were laid. If the turtle had already finished laying and we determined the nest was at risk, we used a metal probe to find the egg chamber. We carefully transferred the eggs to an appropriate relocation site as near to the original nesting location as possible. Relocation sites were selected to minimize risk of erosion and elevated microbial content (Pintus et al. 1999). To rebury the eggs, we dug a chamber matching the depth (70 centimeters for leatherbacks) (Pacuare unpublished data) and shape of original nest and placed the eggs in the same order as they were laid. We mimicked the turtle covering and camouflaging process, and we also cleared our footprints to prevent detection by potential poachers.

2.6.1 Relocation Area

In 2017 we built a relocation area with $120m^2$ and capacity for 109 nests. It served as a relocation site for all the nests located in the target zone (from markers 0 to 2) and as a research grid for the application of new relocation techniques.

We prepared the area prior to relocating nests into it. We dug the sand one meter deep, sieved and chlorinated all the sand to get rid of roots and microorganisms that were likely to compete with embryo for resources once the egg development had started. The procedure mimicked the one adopted by Las Tortugas Station.

2.7. Nest Triangulation

We triangulated all in situ and relocated nests, except those in the relocation area, which allowed us to return after the incubation period and find the exact location of the egg chamber when conducting nest excavations (see *2.8. Nest Excavation*). We measured from the center of the chamber to the three closest sector marker posts using a 30-meter tape measure, and we recorded these distances to the nearest centimeter (*Figure 4*).

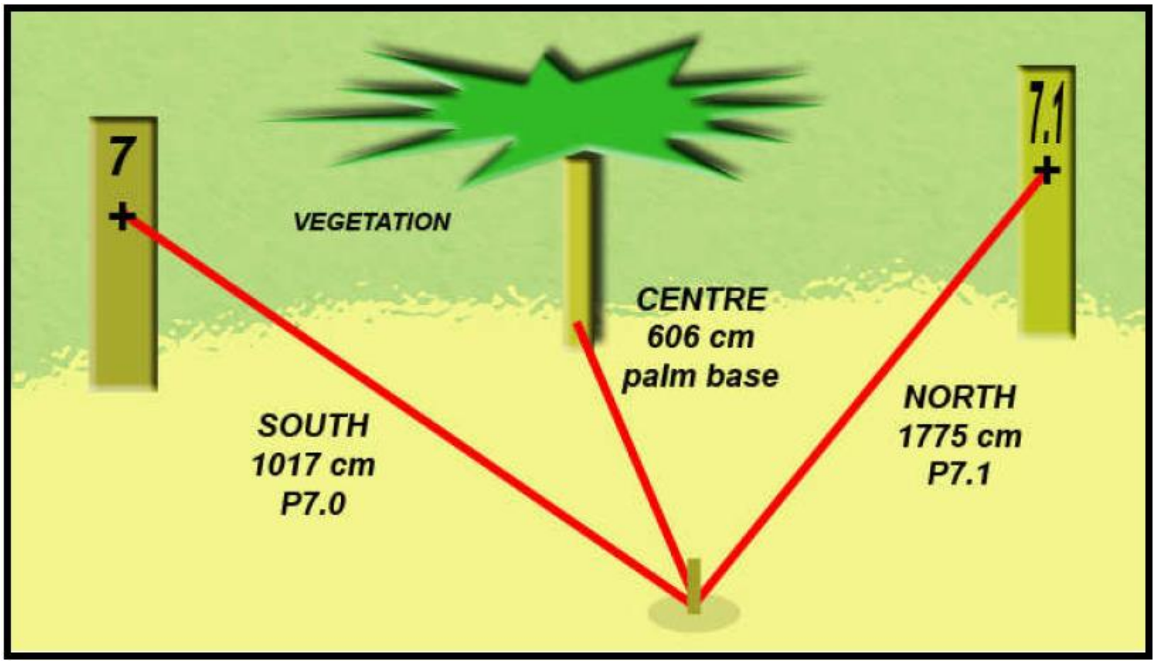

Figure 4. Example nest triangulation protocol.

2.8. Nest Excavation

To calculate hatching and emerging success and evaluate beach productivity in terms of hatchling production, we conducted nest excavations for all in situ and relocated nests. We also excavated nests located using hatching evidence during morning census. Within five days of hatching activity or by the full 75-day incubation period for nests with no hatching activity reported, we exhumed the contents of nests. We wore medical gloves to protect any trapped hatchlings and avoid contact with decomposing nest contents. We recorded depth to the first and last egg and width of the egg chamber to the nearest millimeter.

We separated nest contents into the following categories.

- Hatched eggs: empty shells
- Unhatched eggs: whole eggs
- Yolkless eggs: small, misshapen eggs
- Pipped alive or dead hatchlings: hatchling pierced the shell with egg tooth but did not completely emerge from the egg

- Alive or dead hatchlings: hatchling completely left its shell

We counted and recorded all nest contents and opened any unhatched eggs to determine if the egg was undeveloped or if the embryo had died during development. Undeveloped eggs were recorded when only the yolk and albumen were visible. If blood vessels or an embryo were visible, we recorded phase of embryonic development, determined by percentage of egg volume occupied by the embryo (*Figure 5*).

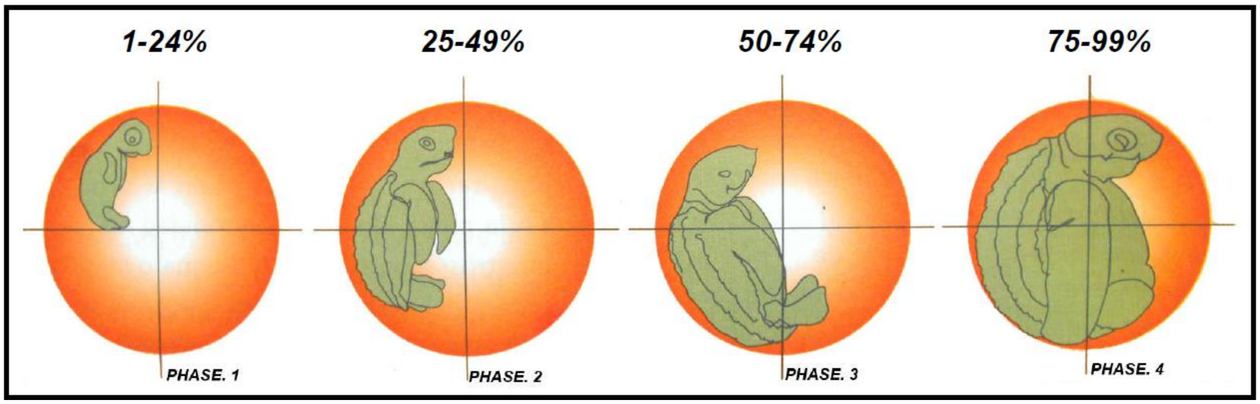

Figure 5. Protocol for categorizing embryos in unhatched eggs. Early Phase 1 embryos may be so small that only tiny black eyes are present, and late Phase 4 embryos appear fully developed with only a small yolk sack remaining.

Hatching success = $\frac{Shells}{total\ eggs} X100$

Emergence success = $\frac{Shells - Hatchlings\ inside}{total\ eggs} X100$

We also recorded evidence of predation by crabs and fly larvae, the presence of mites (ácaros) and fungus, and whether eggs had been damaged by roots or appeared to have been exposed to high incubation temperatures ("cooked").

3. Results

3. Results

3.1. Leatherback Turtles

3.1.1. Temporal Distribution

There were 847 leatherback turtle nesting activities in PR from February 29th to July 30th, 2017. Of these, 63.2% (n=536) were nests and 36.8% (n=311) were false crawls. The season reached its peak by the end of April and start of May 2017 (*Figure 6*). This corroborates historical data. Activities between the 24th of March and the 14th of May account for 32.7% (n=277) of the total number of activities recorded during the nesting season (*Figure 7*). More than 50% (n=426) of all leatherback activities and nearly 50% (n=267) of all nests recorded occurred between weeks 11 and 15 of the 2017 nesting season, from April 24 to May 28 (*Figure 6, Figure 7*). The nights with the three highest recorded nesting activities were:

- April 26 with 24 activities (12 nests and 12 false crawls),
- April 29 with 24 activities (18 nests and 6 false crawls),
- May 12 with 21 activities (13 nests and 8 false crawls).

Comparing the 2017 nesting season data with historical data reveals that 2017 was a below average nesting season (*Figure 8*). In the 2017 nesting season we recorded 102 nests more than in 2016, but, when compared to historical data, there were only 3 seasons with a lower number of nests than 2017 (2003, 2013, 2016). The next lowest season was 2013, which exceeded 2016 by 18 nests (*Figure 8*).

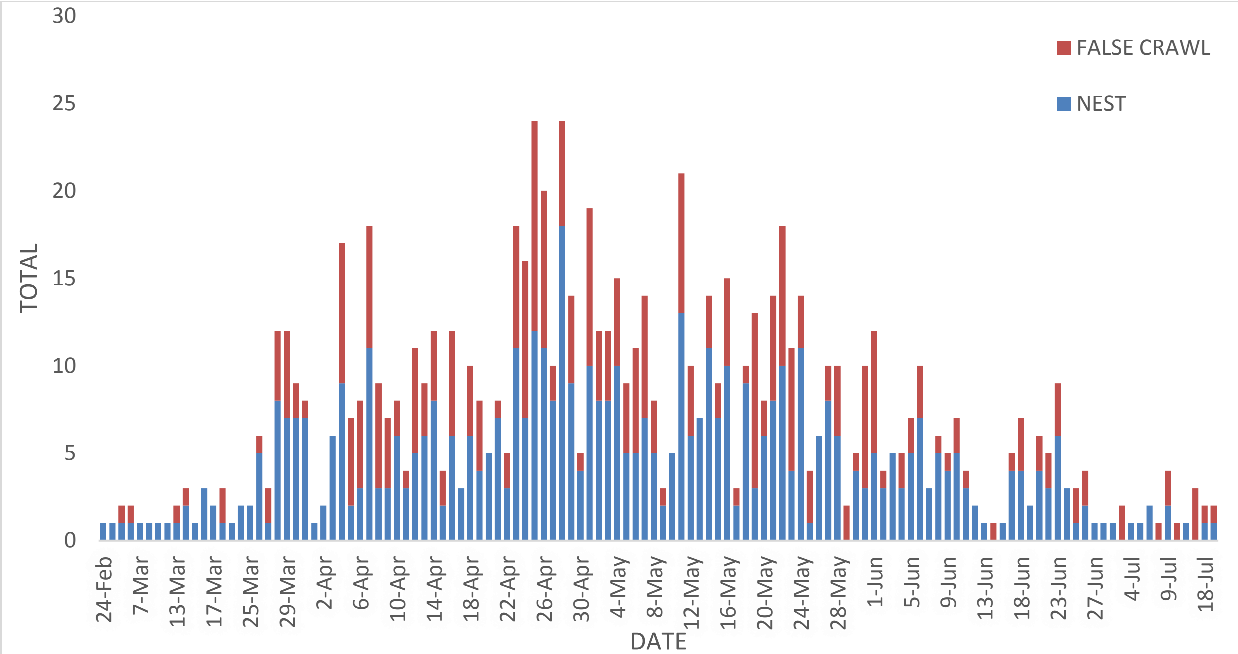

Figure 6. Temporal distribution of leatherback nesting activities in 2017.

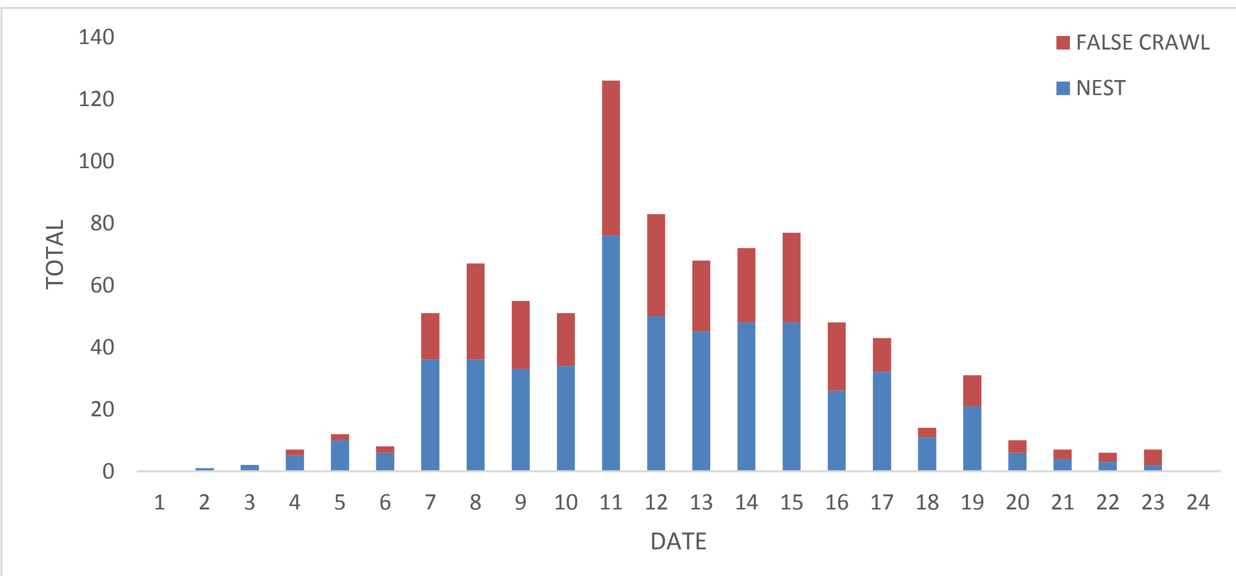

Figure 6. Number of leatherback nesting activities per week in 2017.

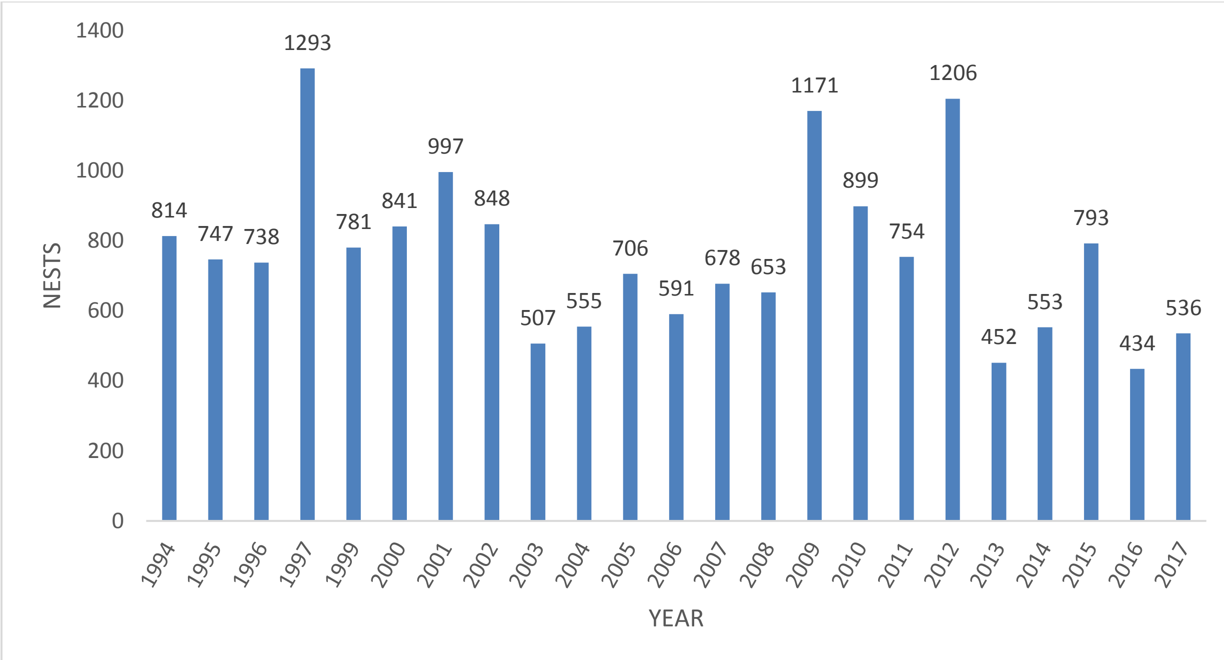

Figure 7. Number of leatherback nests per year in PR since 1994. No data reported for 1998.

3.1.2. Spatial Distribution

Activities were evenly distributed over the 5.9-kilometer monitoring area, despite there being more beach erosion on the southernmost 3 kilometers of beach (*Figure 9, Figure 10*). South sectors (0-30) received 44.2% (n=237) of the recorded nests and North sectors (30.1-56.3) received the remaining 55.8% (n=299) (*Table 1*).

The average nesting density for Pacuare Reserve was 90.85 nests per kilometer. The portion of the beach with the highest density of nesting activity was the north-central portion of the beach, between sectors 35.1 and 46.3 (*Figure 9*). We recorded 131 nests and 50 false crawls in sector four alone (*Figure 10*), which corresponds to 24.4% of the total number of nests and 21.4% of all recorded activities.

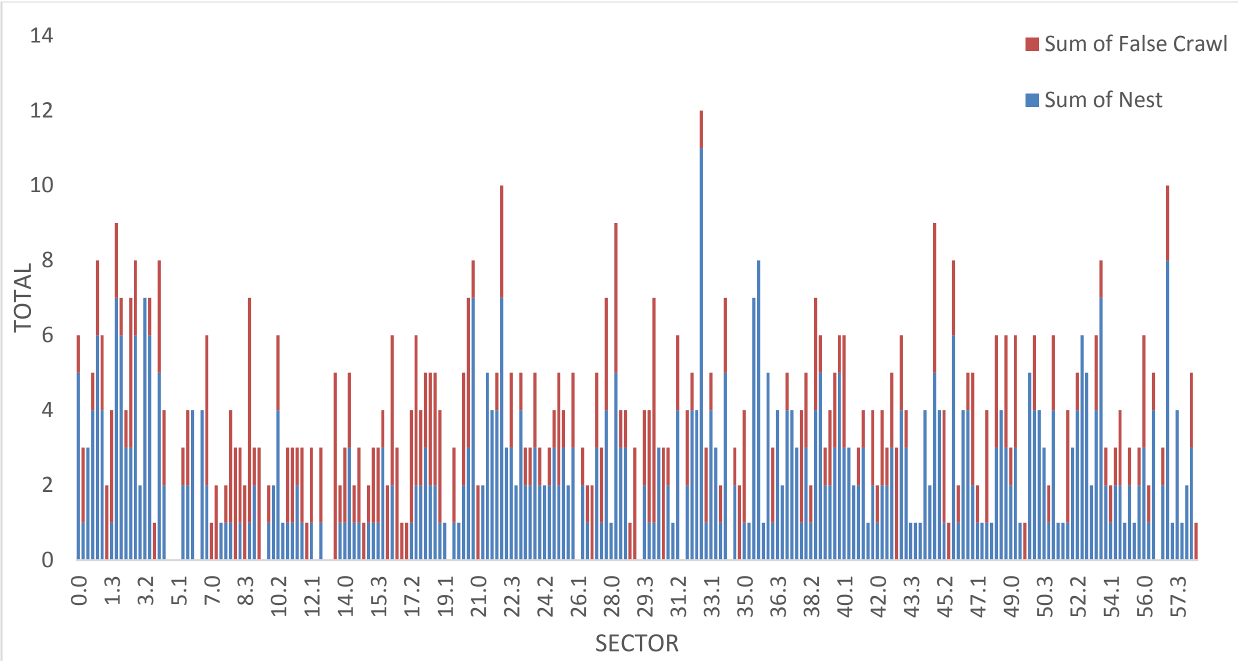

Figure 8. Number of leatherback activities per 25-meter sector in 2017.

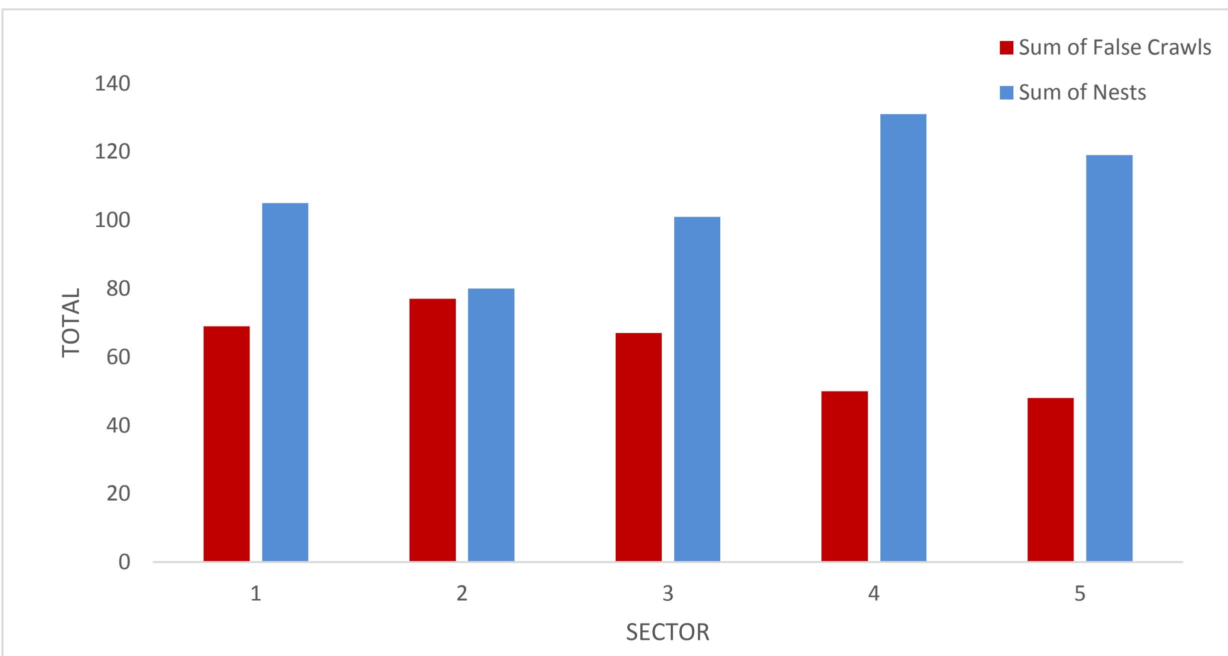

Figure 9. Number of leatherback activities per 1.18-kilometer sector in 2017

Table 1. Number and percent of leatherback activities per 1.18-kilometer sector in 2017

Sector	Nests	%	False Crawls	%	Total	%
1	105	19.6	69	22.2	174	20.5
2	80	14.9	77	24.8	157	18.5
3	101	18.8	67	21.5	168	19.8
4	131	24.4	50	16.1	181	21.4
5	119	22.2	48	15.4	167	19.7

3.1.3. Timing of Activity

During the 2017 season, all leatherback nesting activity occurred between 18:00 and 6:00 (*Figure 11*). Of all activities, 92.7% (n=785) were recorded between 20:00 and 3:00 (*Figure 11*). The peak interval for leatherback activity was between 23:00 and 00:00, with 20.7% (n=175) of activities recorded during this time (*Figure 11*).

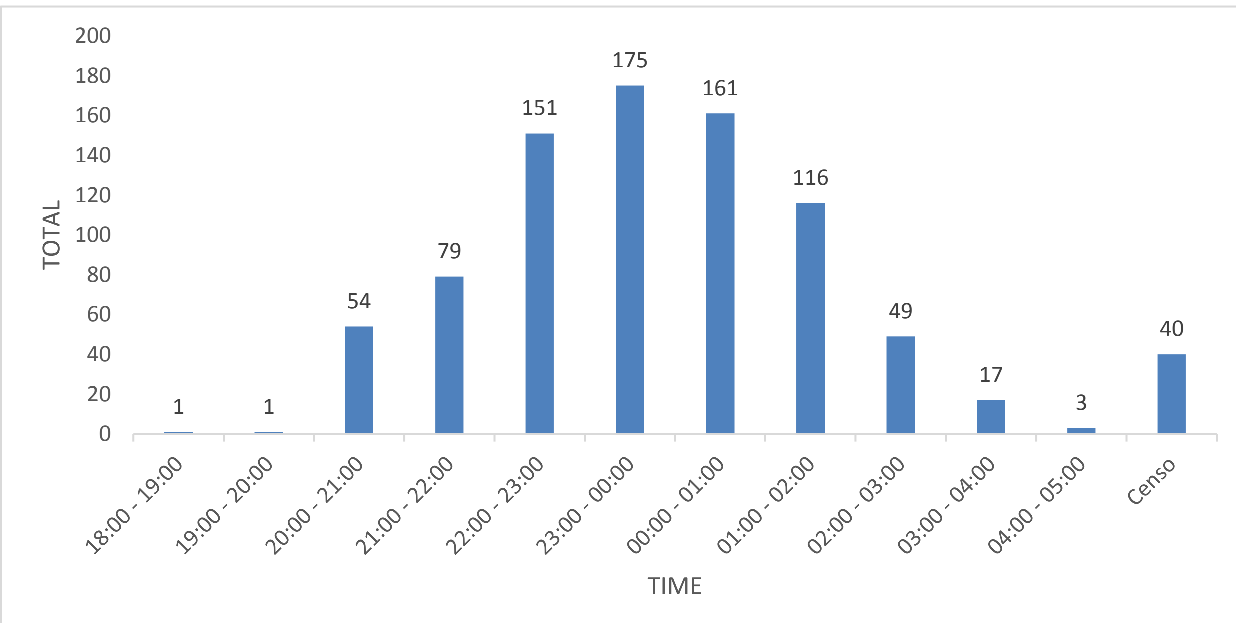

Figure 10. Number of leatherback activities per time interval in 2017.

3.1.4. Stage of Nesting Process

For 66.8% (n=566) of the leatherback activities recorded in 2017, the nightly patrols encountered the turtle during the nesting process (*Figure 12*). For the remaining 33.2% (n=281), the nightly patrols found the tracks without encountering the turtle. Of the 566 encounters with leatherbacks during the nesting process, 17.7% (n=100) resulted in false crawls and 82.3% (n=466) resulted in nests. In 67% of encounters, we found turtles in stages prior to oviposition, which facilitated nest relocation if necessary (*Figure 12*). Most turtles were either digging the body pit (29%), emerging or covering (20%) when encountered by night patrols (*Figure 12*).

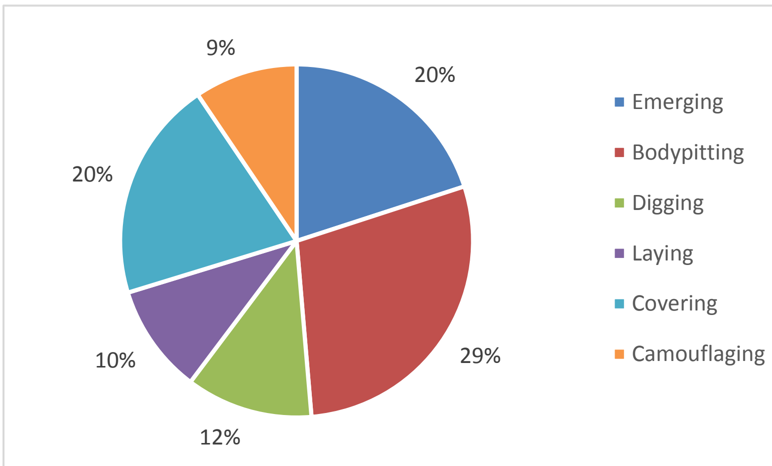

Figure 11. Percent of leatherbacks encountered in each phase of nesting process in 2017.

3.1.5. Tagging and Biometric Data

Our tag and recapture program encountered and identified individual leatherbacks on 505 occasions. Based on tagging information (Appendix A), we identified a total of 249 different females in PR during the 2017 season. Of these individuals, 86.3% (n=215) had existing tags or evidence of previous tags. The remaining 13.7% (n=34) did not have metal tags, a PIT tag, or any evidence of previous tags when first encountered and were therefore considered to be neophytes.

Of the individually identified turtles, 49.8% (n=124) we only saw once and 50.2% (n=125) were reencountered. Four of the females identified at the start of the season were encountered on 6 different occasions and 83.3% of the emergences resulting in a nest.

We obtained a total of 451 CCL and 446 CCW measurements of leatherbacks and the averages were 150.3 centimeters and 108.5 centimeters, respectively.

3.1.6. Nesting Success

Of the 847 leatherback activities recorded at PR in 2017, 63.3% (n=536) resulted in nests (in situ, not confirmed, or relocated), and 36.7% (n=311) did not result in oviposition (did not lay or false crawl) (*Table 2, Figure 13*). Overall leatherback nesting success for 2017 was 63.3%. Of the 536 nests, 31.7% (n=170) were relocated, 32.7% (n=175) were left in situ, and 35.6% (n=191) were not confirmed (*Table 2, Figure 13*). Of the 311 activities that did not result in oviposition, only 9.3% (n=29) were abandoned after bodypitting, and 90.7% (n=282) were false crawls (*Table 2, Figure 13*).

Table 2. Number of leatherback activities of each type per month in 2017.

Month	In Situ	Not Confirmed	Relocated	False Crawl	Did Not Lay
February	1	0	1	0	0
March	20	13	17	17	3
April	79	58	51	109	12
May	55	83	63	111	5
June	19	35	30	38	5
July	1	2	8	7	4
Total	175	191	170	282	29

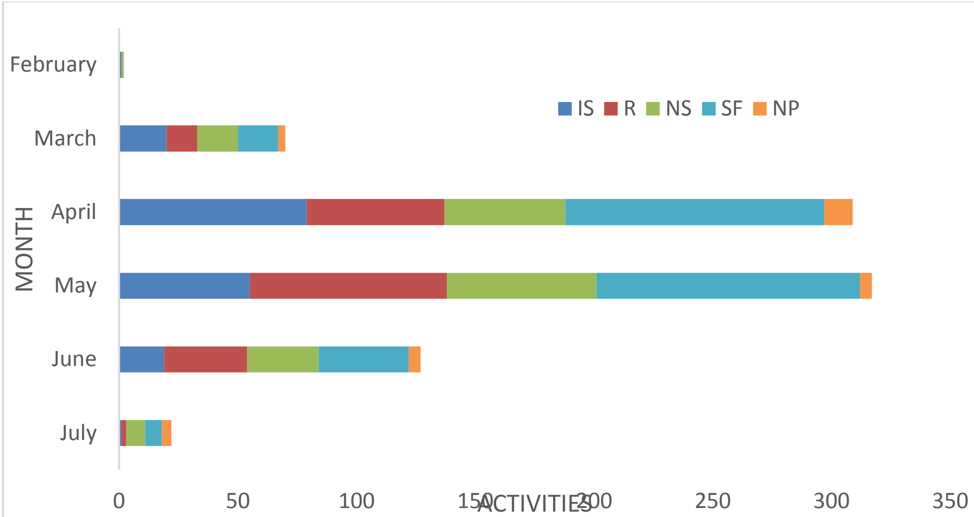

Figure 12. Number of leatherback activities of each type per month in 2017.

3.1.7. Nest Excavation

We excavated 75.8% (n=406) of the 536 nests laid during the 2017 season. We triangulated 68.3% (n=366) of all nests, and we excavated 86.9% (n=318) of triangulated nests. The remaining 13.1% (n=44) were either eroded by the sea, poached, or lost due to triangulation error. Ten nests were eroded.

Of the 191 relocated nests, we excavated 85.9% (n=164). The remainder were either poached (1.6%, n=3) or lost due to poor triangulation (17.8%, n=34).

3.1.8. Hatching and Emergence Success

In 2017, average hatching success was 42.1 %, and average emergence success was 37% (*Table 3*). These values are higher than reported by the PR sea turtle monitoring program in 2016, and this was true both for in situ and relocated nests. In situ nests had an average hatching success of 48.1% and average emergence success of 43.3% (*Table 3*). Relocated nests had an average hatching success of 32.5% and average emergence success of 27.1% (*Table 3*). Nests relocated at the designated relocation area had the lowest hatching (11.7%) and emergence success (9.0%) experienced during 2017 nesting season in Pacuare.

Table 3. Leatherback turtle nest contents and success per nest type in 2017.

Nest Type	Eggs	Hatched	Unhatched	Pipped Live	Pipped Dead	Average Hatching Success (%)	Average Emergence Success (%)
In-Situ	18551	8695	9560	5	215	48.1	43.3
Relocated	11624	3607	7591	11	161	32.5	27.1
Overall	30175	12302	17151	16	376	42.1	37

We excavated a total of 30175 leatherback eggs, 40.8% (n=12302) of which hatched (*Table 3*). We had hatching date for 329 of the excavated nests and mean incubation period for leatherback nests in 2017 was 61 days. Of the 17151 excavated eggs that did not hatch, 45.7% (n=7829) had no visible embryo (undeveloped), and 24.61% (n=4222) had an embryo in the first phase of development (*Figure 14*). The remaining phases of embryonic development accounted for 12.2% (n=2098) of unhatched eggs, and we were unable to identify the embryonic stage of development for 17.5% (n=3002) of unhatched eggs (*Figure 14*).

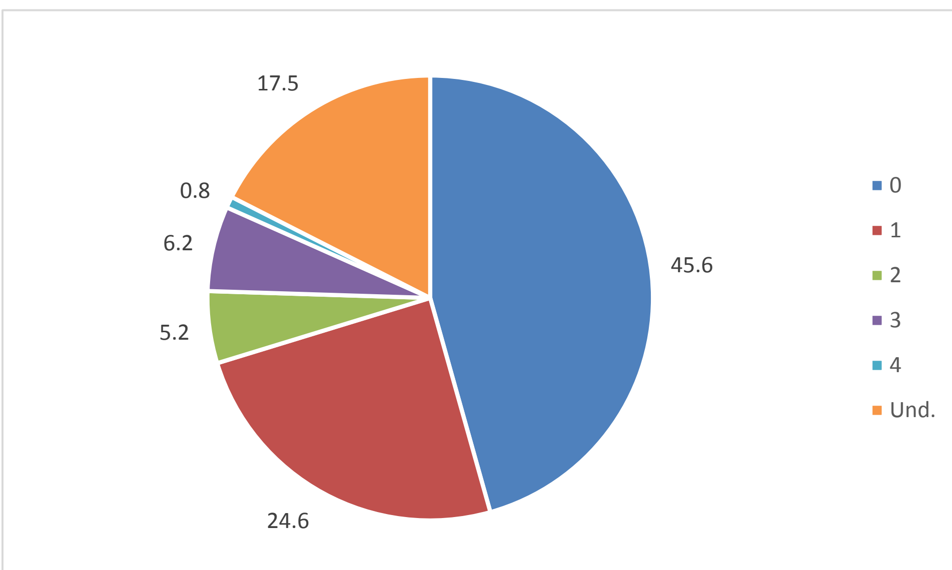

Figure 13. Percent of unhatched leatherback eggs reaching each stage of embryonic development in 2017 (n=17151).

Of the 17151 eggs that failed to hatch, 36% (n=6170) were recorded as cooked and 37.6% (n=6449) were affected by fungus (*Table 4*). These were the two most important factors related to egg failure and mortality in the 2017 nesting season. A relatively small percentage of unhatched eggs were affected by other sources, with only 8.3% (n=1430) by larvae, 1.8% (n=309) by roots, 3.7% (n=642) by mites and 0.8% (n=139) by crabs. Off the non-hatched eggs, 11.8% (n=2012) were not recorded in any of the categories.

Table 4. Number and percent of leatherback eggs affected per stage of embryonic development in 2017.

Phase	Total Eggs	Larvae		Cooked		Fungus		Crabs		Roots		Mites	
		Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Undev.	7829	74	0.9	3945	50.4	3814	48.7	2	0.0	168	2.1	36	0.5
1	4222	31	0.7	1264	29.9	1375	32.6	89	2.1	85	2.0	15	0.4
2	897	15	1.7	279	31.1	216	24.1	2	0.2	3	0.3	8	0.9
3	1060	37	3.5	231	21.8	349	32.9	3	0.3	8	0.8	7	0.7
4	141	2	1.4	39	27.7	6	4.3	0	0.0	0	0.0	0	0.0
Undet.	3002	1271	42.3	412	13.7	689	23.0	43	1.4	45	1.5	576	19.2
Total	17151	1430	8.3	6170	36.0	6449	37.6	139	0.8	309	1.8	642	3.7

3.2. Hard-Shelled Turtles

3.2.1. Temporal Distribution

There were 102 nesting activities of hard-shelled turtle species in PR from February 15th to September 29th, 2017 (*Table 5*). Green turtles accounted for 86.3% (n=88), hawksbills accounted for only 7.8% (n=8), and loggerheads accounted for 5.9% (n=6) of hard-shelled turtle nesting activity (*Table 5*). Green turtle activity was recorded between February 15th and September 29th, and hawksbill activity was recorded from May 15th to July 9th (*Table 5*). Hawksbill presence in between May and July corroborates data from previous years, green turtles, however started nesting much earlier than what is known to be the nesting season for this species (Carr 1954).

In 2017 we recorded five activities of loggerhead sea turtles confirmed by an encounter. All five activities were false crawls recorded on the 11th of July.

Of the 88 green turtle activities, 36 were non-successful nesting attempts and 52 were nests (*Table 5*). August was the peak of green turtle activity with 14 unsuccessful nesting attempts and 30 nests for a total of 44 activities (*Figure 15*). This peak corroborates historical data regarding the peak of the green turtle nesting season in the region. Of the 8 hawksbill activities, 5 was a false crawl and 2 were nests (*Table 5*). June was the peak of hawksbill activity with 4 false crawls. The only hawksbill nest recorded was in July.

Table 5. Number of green turtle, hawksbill, and loggerhead activities per month in 2017.

Green Turtle						
Month	**In Situ**	**Relocated**	**Not Confirmed**	**False Crawl**	**Did Not Lay**	**Total**
February	0	0	1	0	1	2
March	2	0	0	2	0	4
April	3	0	0	1	2	6
June	1	0	0	4	0	5
July	1	1	2	6	1	11
August	0	0	30	11	3	44
September	0	0	11	2	3	16
Total	**7**	**1**	**44**	**26**	**10**	**88**
Hawksbill						
May	1	0	0	1	1	3
June	0	0	0	4	0	4
July	0	0	1	0	0	1
Total	1	0	1	5	1	**8**
Loggerhead						
July	0	1	0	5	0	6
Total	0	1	0	5	0	**6**
Hard-Shell Total	**8**	**1**	**45**	**36**	**11**	**102**

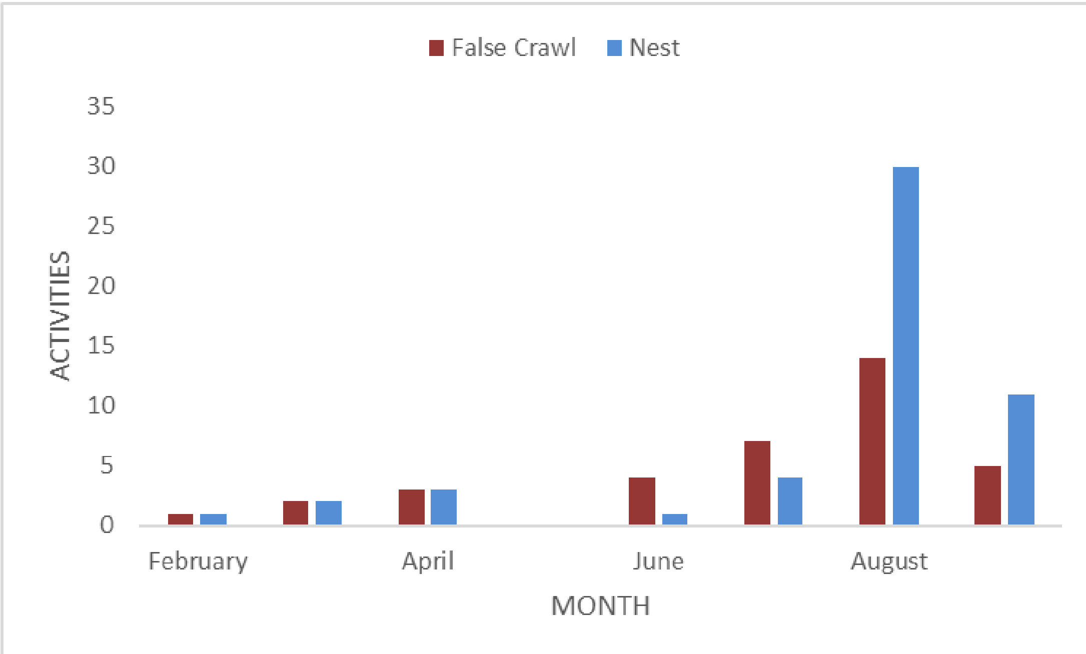

Figure 14. Number of green turtle activities per month in 2017.

3.2.2. Spatial Distribution

Green turtle, hawksbill, and loggerhead turtle activities were evenly distributed over the 5.7-kilometer monitoring area. Sector 53.1 received the most activities, with 3 nests. Sectors 53.2 and 19.3 both received a false crawl and two nests each (*Figure 17*).

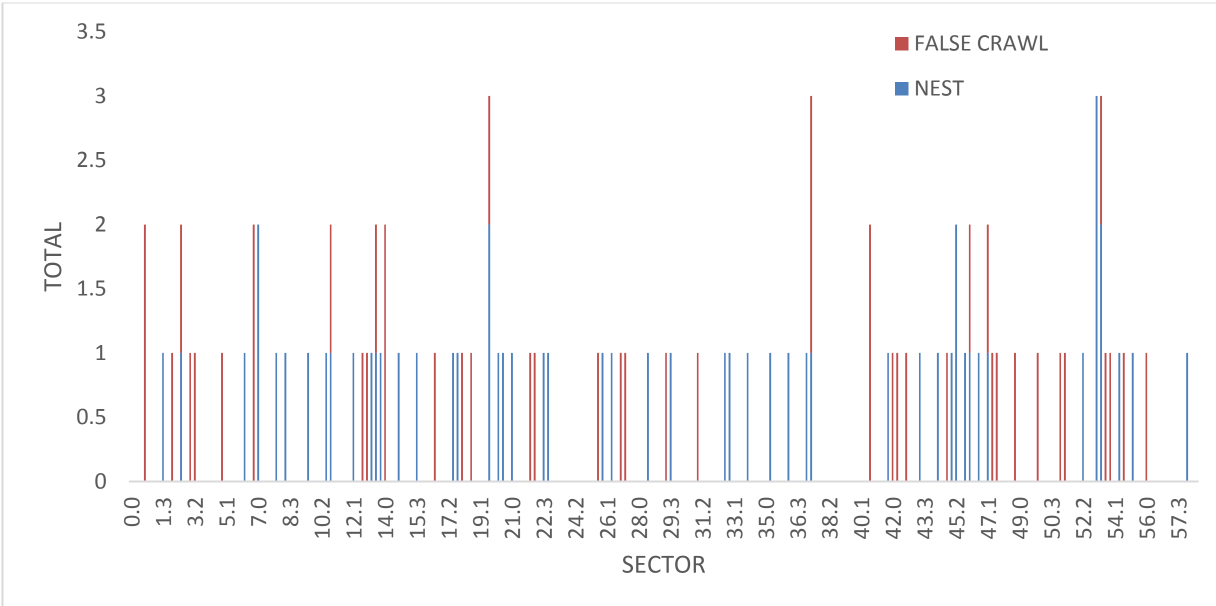

Figure 156. Number of hard-shelled turtle activities per sector in 2017.

3.2.3. Tagging and Biometric Data

Our tag and recapture program identified four different individual green turtles and one loggerhead during the 2017 season. We encountered one of these female green turtle five times during the season. All five turtles (four Cm and one Cc) were neophytes because they were not previously tagged. We identified no Hawksbills individually in 2017. Average green turtle CCL was 102.6 centimeters, and average CCW was 93 centimeters. The loggerhead had a CCL of 95.5 centimeters and a CCW of 87.5 centimeters.

3.2.4. Nesting Success

Of the 102 hard-shelled turtle activities recorded at PR in 2017, 53.9% (n=55) resulted in nests (in situ, not confirmed, or relocated), and 46.1% (n=47) did not result in oviposition (did not lay or false crawl) (*Table 6*). Overall hard-shelled turtle nesting success for 2017 was 79.6%. Of the 55 nests, 3.6% (n=2) were relocated, 14.5% (n=8) were left in situ, and 81.9% (n=45) were not confirmed (*Table 6*). Of the 47 activities that did not result in oviposition, 23.4% (n=11) were abandoned after bodypitting, and 76.6% (n=36) were false crawls.

3.2.5. Hatching and Emergence Success

We excavated 14 green turtle nests, one hawksbill nest and one loggerhead nest for a total of 16 hard-shelled turtle nests. The average hatching success for hard-shelled turtle nests was of 79.6% whereas average emergence success was 74.2% (*Table 7*). The average hatching success for green turtle nests was 4.3% and average emergence success was 83.1%. The only hawksbill nest excavated had an emergence and hatching success of 88.1%, whereas the only loggerhead nest excavated presented 5.9% and 78.2% of emergence and hatching success, respectively. We excavated a total of 1424 hard-shelled turtle eggs, 82.9% (n=1180) of which hatched (*Table 7*). Of the 244 that did not hatch, 42.6% (n=104) had no visible embryo (undeveloped), 11.5% (n=28) were phase 1, 2% (n=5) were phase 3, 2.9% (n=7) and 41% (n=100) could not be determined (unidentified).

Table 6. Hard-shelled turtle nest contents and success in 2017.

	Eggs	Hatched	Unhatched	Pipped Live	Pipped Dead	Average Hatching Success (%)	Average Emergence Success (%)
Total	1424	1180	244	0	7	79.6	74.2

4. Discussion

4.1. Leatherback Nesting Trends

The 2017 nesting season had a lower than average number of leatherback nests (Rivas et al. 2015). Historical leatherback nesting data for Pacuare Reserve reveals cycles in which there are distinct four-year peaks in nesting activity (e.g. 1997, 2001, 2005, and 2009) with intervening declines. However, we registered an increase in nesting activity and overall number of nests from 2016 to 2017. It is possible that the results of the 2016, the lowest number of nests in the monitoring history, are related to this nesting population's natural cycles and varying use of other nesting beaches in the region, to an overall population decline, or to a trend of movement of the nesting leatherbacks towards the south. Continued monitoring of nesting activity at PR is essential to determining if this is the case. Fluctuating environmental conditions, climate change, and anthropogenic threats in foraging and nesting areas may also impact nesting numbers. Without access to accurate, region-wide data on this nesting population, it is not possible to determine the influence of these factors on nesting activity this season.

4.2. Beach Patrols

Nightly beach patrols succeeded in encountering leatherbacks during the nesting process for 60% of the nesting activities recorded in 2017 compared to an encounter rate of 62% of 2016. That is mainly due the large extents of beach that each patrol has to cover and the rapidity that some of the activities, such as false crawls, take place. To increase the proportion of turtles encountered while nesting, communication between patrol groups is essential and will ensure the beach coverage. Thus, we emphasize the need for proper radio communication between patrols and with the field stations. It would provide more capability of patrols to cover ground and to report back to the station in case of finding a turtle or facing an emergency. That would also open a possibility to work with larger groups of people at the same time, because, upon a turtle being encountered, patrols would be able to communicate back to the station and the groups could be conducted via trail directly to the turtle's location and take turns observing the nesting process with decreased likelihood of causing disturbance to the nesting individual or to other turtles coming onto the beach.

The participation of PR station guards is invaluable to the monitoring effort because they provide additional beach coverage near the stations. Guards successfully alerted patrol groups when they encountered turtles and also marked nests for later triangulation or relocation, although if communication between patrols and between south and north station was enhanced, the encounter rate would definitely raise as well.

Another point to consider when discussing beach coverage is the number of research personnel needed. In 2017 we had an initial research group of 12 people, 4 more than in 2016. However, the lack of evident increase in the encounter rates can be attributed to the fact that research assistants left during the season and the number of patrollers during the peak of the season was similar to the one in 2016.

Pacuare Reserve's beach is approximately 6km long and to support all visitor groups both North and South Stations have two to three night patrols per night. That takes at least 9 patrol leaders per night and 1 more to conduct the morning census. If the format of patrollers being followed by EPI groups is to be kept, we need more field assistants (FAs) to cover the functions. Having in mind that FAs have one day off a week and have to leave to renew the visa every three months a couple of scenarios could be proposed:

1) PR could have two groups of research assistants in different times of the season (February-May and May-August) overlapping for at least a week in the station to assist with training of the newly arrived. In that case we would not have to let assistants go out of the reserve for more than a week at a time and would be reflected in more available personnel at all times. In this scenario, we would also experience the assistants to not be completely exhausted by the end of the season and take advantage of the renewed stamina. Although, the transition between one group and the next would take place in a critical part of the season potentially causing problems with inexperienced assistants accompanying EPI groups or carrying out the protocols erroneously. It would also cause the logistics of hiring FAs more complicated. One possible solution is to hire assistants with more "turtle experience" for the second group.

2) EPI instructors could be trained as patrollers in the start of the season to be able to collect the required data and carry out field protocols. FAs often take EPI groups accompanied only by chaperones during the 10 o'clock patrols and that does not seem to affect the enjoyment of the groups. Potentially, instructors could cover ground in between one patrol of FAs and another leaving the beach uncovered for less time and enhancing the likelihood of encounters with nesting females. This option along with enhanced capability of communication would probably increase the beach coverage and the rates of encounter. We emphasize the necessity of training in order to not disturb nesting animals with the intention of bettering the groups' experience.

Counting on the total cooperation between south and north stations are also essential in order to beach coverage be enhanced. During 2016/17 seasons if the north station coordinator had not been unwilling to adopt new protocols and follow some of the basic rules of conduct stablished we would have had a better success in encountering turtles and in the overall work. Thus, I reiterate the need for someone trustworthy commanding the whole play and people on the ground that would carry out the plans that were lined up beforehand.

4.3. Mark and Recapture Program

Corroborating data from 2016 season, approximately 10% of individually identified leatherbacks were neophytes, despite regional trends showing increasing numbers of new females. Continued monitoring of nesting activity at PR is necessary to determine if this finding is simply part of normal fluctuation in the nesting population. Both the total number of females and of neophytes were lower than average for Pacuare (Rivas et al. 2015). Again, that could be caused by many factors including natural fluctuations, climatic phenomena affecting nutritional pathways and consequently the allocation of body resources towards reproduction (Bjornadal 1985), or even by a shift in the geomagnetic field of Earth. Further research is needed in order to clarify such cause-effect relation.

Most species of sea turtles are non-annual breeders and number of females nesting in one season are variable. Leatherbacks have intervals that can vary from 2 to 4 years between one nesting season and the next. That may be caused due to the energetic threshold that turtles have to reach in order to undergo costly reproductive activities such as egg production and migration (Wallace et al. 2007). The variation and relatively low numbers of neophyte turtles could be evidence of a decline on the population or a cyclic phenomenon caused by local variation in food availability in their feeding grounds. Further analysis of the metadata accumulated over the long-term monitoring of PR and adjacent programs is necessary to tell a complete story of what is happening to the Caribbean nesting populations of leatherback sea turtles. We should focus efforts in unifying data collection protocols with other organizations working around Pacuare, create a task force for data comparison and analysis, and foment the creation of new conservation projects. The local knowledge suggests that often the peak intensity areas of nesting turtles vary cyclically and the scientific method suggests that turtles orient using the geomagnetic field of the planet (Brothers and Lohman 2015), which also changes periodically, but if we don't know what is happening in the beaches down the road from us, we will not be able to understand it. Leatherbacks can travel almost 200km between one nest and the next (2 week-period) (Almeida et al. 2011) and migrate for more than 1,000 kilometers to get to Pacuare (Wyneken et al. 2013). This level of mobility makes it difficult to even have the slightest idea of what the trend of a population is by only looking at 6km of its nesting range. We have started discussions with Stanley Rodriguez from Las Tortugas Station to hold an encounter of turtle organizations dealing with leatherback turtles in the Caribbean of Costa Rica. Such a meeting would allow for the creation of alliances to increase conservation efforts at population level.

4.4. Egg Poaching

Three leatherback nests were poached during the 2017 nesting season, 1 less than in 2016. Though this is a vast improvement from poaching rates before the monitoring project began, these 3 nests represent only 0.5% of the total number laid during the 2017 season, it is alarming to know that poachers are still roaming around the beach of PR. Despite the best efforts and protection provided by PR station guards, PR staff were disturbed on several occasions by people from outside the Reserve walking on the beach at night. It is imperative that the Coast Guard continues to assist with sea turtle protection inside Pacuare Reserve by patrolling the beach and arresting poachers.

The number of guards in PR during the season was a theme of internal discussion. During 2016 and 2017 seasons the number of guards fluctuated between 2 and 3 guards in each station and their posts were fix at the first 300 meters of beach. They alternated in shifts that lasted from 4-6 hours and had the duty of accompanying any of the female field assistants during morning census. It is a heavy night shift that can be pretty dull for the guards, who, sometimes, in the absence of supervision, leave their watch to go rest in the hammocks. That happens especially in between patrols and after the last shift.

Poachers tend to be well-known villagers to many of other locals including our staff. They end up knowing what the schedules of our patrols are, when they start, when they end, when the guards are likely to go take a nap, and they use it against us. It was proposed many times that a shift clock (punch clock) was positioned somewhere near marker 3 on the beach and that guards had to confirm their positions hourly and the ones that failed doing so could take responsibility for their actions. Guards that leave their posts jeopardize not only the conservation work, but also the safety of research personnel and visitor groups. The suggestions also included not hiring guards from the neighboring communities and having a chief guard in charge of the other ones. The number of guards also seem insufficient to avoid that poachers or any other unwelcome person enters the reserve or the stations.

PR has extensive area in land that protect invaluable biodiversity and we have not a clue of what is happening inside the forest in PR. We do not monitor trails that can allow the entrance and exit of poachers with loads of eggs, we do not patrol the forests in order to prevent other wildlife crimes such as lumbering and hunting. In 2016 and 2017, several shots were heard coming from the forest and we had a boat stolen from the in the Sendero Puma. Security as whole must be improved.

4.5. Nest Relocation and Triangulation

We triangulated nearly 60% of the leatherback nests laid in 2016. We relocated approximately 30% of leatherback nests this season due to concerns over erosion and high tidal levels, the effect of deleteriously high temperatures, and for research purposes. Beach erosion this season was not as severe as previously recorded. Hatching success of nests left in situ was almost 15% higher than the hatching success of all relocated nests. Overall the hatching and emergence successes recorded in 2016 and 2017 were expressively lower than the historical averages recorded since 1994 (Rivas et al. 2015).

Nests relocation is theme of great discussion within the scientific community because it can jeopardize the hatching success of nests that are not imperiled, however it can save doomed nests. It is also a tricky subject when it comes to leatherbacks because this species already presents a lower hatching success than most other species of sea turtles (Bell et al. 2003). Additionally, nests incubated on very similar conditions in closely spaced location have very different fates. In 2017 we observed nests that incubate very close to each other and one hatches almost 80% whereas the other does not hatch at all. Characteristics of the beach associated with higher hatching success are still to be discovered in Pacuare, however the most obvious elements that are affecting it are ratio of sun/shade, proximity to the water, and substrate composition. These environmental factors will influence physical factors important for egg incubation such as temperature, humidity, and gas exchange.

In 2017, we built a relocation area for trial purposes and relocated 60 nests into it. For reasons that we still do not fully comprehend, the nests relocated to the hatchery had very low hatching and emerging success (averages 11.7% and 9%, respectively). When we exclude the hatchery nests from the relocated nests analysis the emerging and hatching success of relocated nests go up from 32% and 27% to 40% and 45% respectively. Additionally, If nests that were incubated in the southernmost part of the monitoring area (before marker 4) are excluded from analysis, relocated nests hatching success reach 48 %, which is the same as the hatching success obtained by nests in-situ in 2017. Nests incubated in this area had a hatching success of 13% and an emerging success of 10%.

Corroborating data from 2016, in 2017 we observed higher hatching and emerging success for nests in the southernmost area of the beach with the progression of the season. Nests laid or relocated there in March and April had an average hatching success of 11% and 6% of emerging success, whereas nests laid or relocated in the area in May, June, and July had values of 20%

and 19 %, respectively. We have made 2 meter deep holes in the sand to observe underground water circulation near the location of the hatchery and that indicates that those nests were definitely not inundated.

Put together this data suggests that, until further research, nests should not be relocated nor a hatchery built on the southernmost 400 meters of the PR's monitoring area. The environmental factors that change predictably over the nesting season are temperature, precipitation, and tidal variation and the demise of the nests incubated on the southernmost monitoring area are likely correlated to factors associated with these environmental parameters. These factors affect microbial infection by fungus and bacteria, changes in oxygen diffusion through the sand into the nest, and overall nest depth temperature. We preliminarily assessed temperatures inside and superficially to the nests in the area mentioned above. The superficial temperatures greatly varies from 60^{o} to 20^{o}, although temperature inside the nests are much more stable (citation). We had research partners assessing nest-depth temperature with accurate data loggers, although we could not have access to that information in a timely manner.

Hatching and emerging success might be improved in future seasons by leaving a greater proportion of nests in situ and by relocating nests only as needed and the closest to the original nesting site as possible.

4.6. Eroded and Lost Nests

Beach erosion was responsible for the failure of less than 1.8% of leatherback nests during the 2017 season. Only 10 nests were eroded, which reflects the success of our relocation program in moving nests away from high-risk erosion-prone areas.

Lost nests were the result of lack of coordination between the patrol leader that marked the nest and the excavation team attempting to recover it and/or measurement error during triangulation. Triangulation techniques should be further emphasized during the intensive training course provided to field assistants at the start of the season.

4.8. Green Turtle Season

There was not a single green turtle poaching event at PR this season. This is in part thanks to PR being the only research station in the area that continues to work during green turtle nesting season. Poachers likely target areas to the south or north of the Reserve.

Green turtle monitoring at PR would benefit from efforts to compile and enter green turtle data in a digital database. The digital record of monitoring is incomplete, and efforts need to be made to update and maintain this important record. Regional research efforts and other specialist groups working in the Caribbean would also benefit from the availability of this information, as would the sea turtles we are all working to protect.

Hard-shell numbers in 2017 were lower than in 2016 but the variation does not seem abnormal because of factors we proposed earlier in this report. For the first time to our knowledge a Loggerhead sea turtle was encountered by PR research personnel in 2017. The closest loggerhead rookeries are located in the Yucatan Peninsula, Mexico and the Gulf and Atlantic coasts of Florida, USA. Hybridization is thought to happen between loggerheads and hawksbills as well as green turtles so a partnership with researchers studying genetic composition of loggerhead populations would come handy to explain what are those animals we are seen. Do they have a viable population in the Caribbean of Central America or they interbreed?

5. Conclusion and further suggestions

Pacuare Reserve conducts long term monitoring of one the most important beaches for the nesting of one of the most important subpopulations of the endangered Leatherback sea turtle. It seems imperative that more research is fomented to serve as base for conservation. As for now, the most important topic is how to get hatchling production up. That is of special concern in a changing world where climatic events are gradually more extreme and common.

With the global warming, sea levels will tend to rise and some coastal areas are prone to disappear. How are we going to further the survival of the turtles is a question that presses turtle conservationists all over the world. Either via partnerships with research institutions or by conducting in-house investigation, a budget should be established to sponsor research projects that aim to answer the following questions regarding leatherbacks nesting at Pacuare:

- What are the main factors influencing the hatching and emerging success of leatherback nests in Pacuare?

- What roles do temperature and oxygen concentrations inside the nests play in the hatching success of leatherbacks in the Caribbean of Central America?

- Most other sea turtle species have hatching successes that approach 100%. According to historical data, leatherback nests also used to show elevated rates of hatching, but that is not true anymore. Why? Do the shorter beaches make gas exchange more challenging?

- Why is the hatching success so low in the southernmost 400 meters of the monitoring area? Does the proximity of the river mouth change the substrate and, in turn, affect gas exchange? Does river mouth proximity make the environment in the nest more humid and therefore more prone to fungal infections? Does the river mouth proximity makes those nests subject to chemicals and pesticides that have runoff into the canals from adjacent agricultural operations?

- How do turtles select their nesting sites? Even though the southernmost part of the reserve has low hatching success, why is it one of the hot spots for turtle nesting within PR?

- What is the most effective *ex situ* incubation method? Sea levels will invariably continue to rise. What will happen to turtle nests when there is no more beach? How can we keep them hatching in such circumstances?

5.1 Research Partnership

Finally, when partnerships are stablished the institutions should sign a contract with EPI detailing each parts' duties and responsibilities. In 2017 we had a negative experience with one of the professors from the Botanical Garden Group. He undermined the research personnel in PR and opened a sea turtle nest on the beach to show the eggs to his students even after being asked not to conduct such activity. If didactic activities and research projects are to be conducted in Pacuare Reserve, they should be carried out in accordance to what was previously stablished with EPIs Scientific Coordinator and with the necessary permits from MINAE. If we are not strict and professionally critics about what kind of research and in what terms will happen in Pacuare, it will jeopardize the conservation efforts that should be the first priority.

The contract between EPI and research institution should emphasize also the necessity of this data coming back to Pacuare to help with management strategies. For example in 2016, Sean Williamson from Monash University in Australia came to Pacuare and collected data for his PhD, which refers to the development of eggs under different conditions of oxygens treatments. He analyzed and searcher for good practices of ex situ incubation. This will be very interesting and transformed into daily actions if he had given the data back with a report of what he found and how to use it.

With Sandra and Maria from the Botanical Gardens of Madrid, it happened the same. They fussed and fought to relocate apparently safe nests to the hatchery in order to carry out their experiments, which again included good practices of ex situ incubation and nest-depth temperatures, both subjects of utter interest for the management of the reserve. Once this researchers are gone, their data is gone with them and the practical benefits for the reserve are null.

For in-house research, PR Science Coordinator has reach out to partner with organizations to carry out procedures that we cannot. If we are interested in research with microbial content, we reach out to people that have written papers recently regarding this subject and offer place for their students to come and collect or we offer to get permits and send samples to them. There are a ton of graduate students that would appreciate having data sent to them instead of depending on getting grants to travel for research purposes. There are plenty of grants to which EPI as an institution could back up the scientific coordinator to apply for. Finally, it seems that a new age is dawning in PR and lots of exciting opportunities lie ahead. Come what may, research should always be an integral and important part of what happens in PR and in what guides the conservation work.

6. References

Almeida, A. P., S. A. Eckert, S. C. Bruno, J. T. Scalfoni, B. Giffoni, M. Lopez-Mendilaharsu, J. C. A. Tome. 2011. Satellite-tracked movements of female *Dermochelys coriacea* from southeastern Brazil. Endangered Species Research 15:77-86.

Bell, B. A., J. R. Spotila, F. V. Paladino, R. D. Reina. 2003. Low Reproductive Success of Leatherback Turtles *Dermochelys coriacea*, is due to high embryo mortality Biological Conservation 115:131-138

Bjorndal, K. A. 1985. Nutritional Ecology of Sea Turtles. *Copeia* 3 (3): 736–751.

Brothers, J. R., K. J. Lohamann. 2015. Evidence of Geomagnetic Imprinting and Magnetic Navigation in the Natal Homing of Sea Turtles. Current Biology 25: 392-396.

Carr, A. F., 1954. The Passing of the Fleet. American Institute of Biological Sciences Bulletin 4: 17-19.

Dutton, P. and D. McDonald. 1994. Use of Pit-Tags to Identify Adult Leatherbacks. Marine Turtle Newsletter 67:13-14.

Eckert, K. L., K. A. Bjornadal, F. A. Abreu-Grobois, M. Donnely (eds.)**.** 1999. Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

Georges J. Y. and S. Fossette. 2006. Estimating Body Mass in Leatherback Turtles *Dermochelys coriacea*. Marine Ecology Progress Series, Inter-Research, 2006 318: 25-262.

Pintus, K. J., B. J. Godley, A. McGowan, A. C. Broderick. 2009. Impact of Clutch Relocation on Green Turtle Offspring. Journal of Wildlife Management 73(7): 1151-1157.

Rivas, M. L., C. Fernandez, and A. Marco. 2015. Nesting Ecology and Populational Trend of the Leatherback Turtles Dermochelys coriacea at Pacuare Nature Reserve, Costa Rica. Fauna & Flora International, Oryx, 2015:pf1-9.

Wallace, B. P., P. R. Sotherland, P. S. Tomillo, R. D. Reina, J. R. Spotila, and F. V. Paladino. 2007. Maternal Investment in Reproduction and Its Consequences in Leatherback Turtles. Oecologia 152: 37–47. Lipids 12: 1032-1041.

Appendix A. Leatherback Tag Catalog

FECHA	OLD PI	OLD PD	NEW PI	NEW PD	OLD PIT	LCC	ACC
1-Apr	79153	79154			985121020475025	142.3	109
10-Apr	79153			PN5020	985121020475025	143.9	111.4
18-Apr	79153	PN5020			985121020475025	144.5	
6-Mar	PN1757	VC5913			985121020431427	143.5	
27-Mar	PN1757	VC5913			985121020431427	146.2	
5-Apr	PN1757	VC5913			985121020431427	145.0	
14-Apr	PN1757	VC5913			985121020431427	147.5	108.0
21-Apr	PN2329	PN2943			989001005109649	156.5	110.3
30-Apr	PN2329	PN2943			989001005109649	156.4	
11-Apr	PN2445	PN1735			132738352A	158	
19-Apr	PN2445	PN1735			132738352A	158.4	
7-Jun	PN2445	PN1735			132738352A	158.2	
17-Jun	PN2445	PN1735			132738352A	158.7	
10-Mar	PN2538			PN5164	985121020472958	158.0	
30-Mar	PN2538	PN5164			985121020472958	158.0	
29-Mar	PN2717	PN2162			900118001508843	168.0	
8-Apr	PN2717	PN2162			900118001504461	165	117.6
26-Apr	PN2717	PN2162				165	
6-May	PN2717	PN2162			90011800150884	167	
25-May	PN2717	PN2162				165.5	
4-Jun	PN2717	PN2162			900118001508843	168.0	
5-Apr	PN3605	PN3606					
8-Apr	PN3605	PN3606				144.9	
5-May	PN3605	PN3606					
30-Mar			PN4503	PN4504		162.0	
2-May	PN4503	PN4504				158.5	
5-Apr		VC3379	PN5011		900118001501629	147.6	
26-Apr	PN5011	VC3379			900118001501629	149.2	
16-May	PN5011	VC3379				147	
25-May	PN5011	VC3379					
25-May	PN5011	VC3379			900118001501629	148.5	

22-Apr		VC3527	PN5027			150.5	
2-May	PN5027	VC3527			989001005109610	150.0	
10-Apr		ASVO038	PN5039	PN4526	900118001484920	148.4	
29-Apr	PN5039	PN4526			900118001484920	148.3	
16-Apr	PN5041	PN2910			151549425A	154.5	112.3
7-Apr	PN5041	PN2910			151549425A		
27-Mar	PN5041	PN2910			151549425A	154	
17-Apr					151549425A		
16-Mar		PN2910	PN5041			156.2	
30-Mar			PN5111	PN5112	989001005109666	153.5	
8-Apr	PN5111	PN5112			989001005109666	152.5	106.5
4-Apr		VC3474	PN5149		132751224A	153.5	114.9
22-Apr	PN5149	VC3474			132751224A	153.8	115.3
10-Jun	PN5149	VC3474			132751224A	153.5	108.2
17-Mar		VC1608	PN5155			145.2	111.2
30-Mar	PN5155	VC1608				146.6	112.5
30-Mar	PN5155	VC1608					
19-Apr	PN5155	VC1608			989001005109606	146	112
17-May	PN5155	VC1608				145	111.5
5-Jun	PN5155	VC1608			989001005109606	146.5	110.0
31-Mar			PN5161	PN5162	989001005109616	141.5	105.9
29-Apr	PN5161	PN5162			989001005109616	141.6	104.0
20-May	PN5161	PN5162			989001005109616	141.5	103
28-May	PN5161	PN5162			989001005109616	141.0	105.0
6-Apr			PN5177	PN5178	989001005109691	154	110.3
24-Apr	PN5177	PN5178			989001005109691	157.3	108.9
29-Mar			PN5179	PN5180		160.0	104.5
17-Apr	PN5179	PN5180			989001005109624	159.3	111.5
1-Apr			PN5189	PN5199	989001005109697	139	99.5
30-Apr	PN5189	PN5199			989001005109697	140.0	100.0
25-May	PN5189	PN5199				138.3	98.8
2-Jun	PN5189	PN5199			989001005109697	140.0	100.0
23-Mar		PN3814	PN5197		900118001504947	141.8	109.2

11-Apr	PN5197	PN3814					
13-Mar	PN5198	VA8696			985121020545950	148.3	104.5
25-Mar		VA8626	PN5198		985121020545950	147.0	105.0
28-May	PN5198	VA8696				147.5	105.7
25-Apr	PN5203	PN5205			900118001485236	164.0	114.2
15-Apr			PN5203	PN5205	900118001485236	164.5	114.0
4-May	PN5203	PN5205				165.0	113.8
13-May	PN5203	PN5205			900118001485236	164.7	114.3
23-May	PN5203	PN5205			900118001485236	164	113
10-Jun	PN5203	PN5205			900118001485236	163.0	108.0
16-Apr		VC6246	PN5206		989001005109687	140.3	106
25-Apr	PN5206	VC6246			989001005109687	139.5	105.2
27-May	PN5206	VC6246			989001005109687	139.5	104.1
13-Jun	VC6080	VC6246			989001005109687		
27-Mar	VA1673			PN5134		158.6	113.2
8-Apr	VA1673	PN5134			989001005109740	158	112
5-May	VA1673	No			989001005109740	159.2	112.0
13-May	VA1673	No			989001005109740	158.5	112.4
22-May	VA1673			PN5067	989001005109740	160	112.1
9-Apr	VC2057	PN3826			985121020512774	151.7	110.2
18-Apr	VC2057	PN3826			985121020512774	153	112.1
11-Jun	VC2057	PN3826			985121020512774	152.2	109.6
19-Jun	VC2057	PN3826			985121020512774	152.7	110.5
27-Jun	VC2057	PN3826			985121080512774	151.9	111.8
24-Apr	VC2099	VC5863		PN5233	985121020504532	149.3	110.0
15-Apr	VC2099	VC5863			985121020504532	148.5	115.0
1-Apr	VC3205	VC3206			989001001695157	152.8	108.0
20-Apr	VC3205	VC3206			989001001695157	153.1	108.2
29-Apr	VC3205	VC3206			989001001695157		
18-May	VC3206	VC3205			989001001695157		
6-Jun	VC3205	VC3206			989001001695157	153.1	108.9
17-Apr	VC5743	VC5744			989001005109773	145.5	109.5
8-Apr	VC5743	VC5744			989001005109773	146.1	109.5
7-Mar	VC5947	VC5948			989001005109638	148.3	108.0

25-Mar	VC5947	VC5948				147.9	112.0
11-Apr	VC5947	VC5948			989001005109638	150.2	108.5
30-Jun	VC5947			PN5072	989001001695121	143.3	105.9
26-Apr	VC6145	VC6146		PN5144	989001005109644	155.5	113.9
7-Apr	VC6145	VC6146			989001005109644	154.4	115.5
29-Mar	VC6145	VC6146			989001005109644	154.7	102.3
22-Apr	VC6235	VC6236			989001005109615	149.7	107.4
12-Apr	VC6235	VC6236			989001005109615	151.0	102.0
12-May	VC6235	VC6236			989001005109615	149.0	108.5
24-Jun	VC6235	VC6236			989001005109615	147.5	106.2
5-Apr		WC16524	PN5104		AVID*084*534*864	151.3	109.6
13-Apr	WC16524						
13-Apr		PN1578	PN5185		989001005109613	154.5	112
25-Apr		PN1578			989001005109613		
7-Mar		PN2268			985121020476672	147.8	104.5
19-Mar		PN2268			985121020476672	148.6	104.8
29-Mar		PN2268	PN5043		985121020476672	148.9	103.9
23-May	PN5043	PN2268				149.0	104.0
11-Apr	PN5197	PN3814					
23-Mar		PN3814	PN5197		900118001504947	141.8	109.2
6-Apr		PN5148					
26-Mar		WC18100	PN5119	PN5148	151538645A	144.5	94.4
3-May	PN2871	PN5007			133233533A	162.6	113.8
29-Mar	PN2871			PN5007	133233533A	161	113
30-Mar	PN4596			PN5033	989001001695120	133.0	102.2
4-May	VC6231				989001001695120		
20-May	VC6231	PN5055				133.2	103.2
25-Apr		PN2517	PN2518		132329546A	155.3	117.0
3-May	PN2517	PN2518			132329546A	155.0	117.5
8-Apr	WC18532	WC18533				145.2	103.4
25-Apr	WC18532	WC18533			989001005109689	145.8	104.3

8-Apr	PN3537	PN3538			989001005109643	151.0	108.0
26-Apr	PN3537	PN3538			989001005109643	149.5	107.8
8-Apr	PN1770	VC4507				141.3	108.7
28-Apr	PN1770	VC4507			989001005109763	141	108
19-Apr	PN3622	D8065				161	116.3
28-Apr	PN3622	D8065				160	115
8-May	PN3622	D8065			989001005109726	161.4	115.3
24-Jun	PN3622	D8065			989001005109726	160.4	115.6
20-Apr	VC6176	PM0728			989001005109662	152	107.5
29-Apr	VC6176	PM0728				149	107.5
17-May	PM0728	VC6176			989001005109662	149.5	106.5
21-Apr			PN5227	PN5232	989001001536903	156.8	115.4
29-Apr	PN5227	PN5232			989001001536903	155.6	113.5
4-Apr	VC6159	VC6160			985121020510694	149.0	107.0
24-Apr	VC6159	VC6160			985121020510694	150.6	106
14-May	VC6159	VC6160			985121020510694	150.5	106.8
25-Apr	VC6189	VC6190					
26-Apr	VC6189	VC6190				157.8	111.2
15-Mar	VC0267			PN5031		149.0	108.2
27-Apr	VC0267	PN5031			151618535A	148.4	107.3
12-Apr		WC18888			989001005109659	152.2	116.1
30-Apr			PN4510				
2-May			PN4510		989001005109659		
22-Apr	VC6053			PN5142		160.0	117.0
30-Apr	VC6053	PN5142					
13-Apr	WC18682	WC18681	PN4525		989001005109672	151.7	102.0
1-May	PN4525	WC18681				152.5	101.6
15-Apr			PN5213	PN5214		153.0	111.0
1-May	PN5213	PN5214			989001005109741	152.1	111.3
17-Apr	WC18696	PN3810			989001001695152	145.7	101.4
17-Apr	WC18696	PN3810			989001001695152		

5-May	WC18696			PN4583	989001001695152	146.3	103.2
23-May	WC18696	PN4583			989001001695152	146.8	102.0
27-Mar		VA4952	PN5049		989001001695085	152.3	114.2
5-May					989001001695085		
27-Apr			PN5231	PN5230	989001005109653	149.0	105.0
6-May	PN5231	PN5230			989001005109653	148.4	105.0
15-May	PN5231	PN5230			989001005109653	149.0	105.0
26-Apr	VC1241	VC2122			985121020507051	157.1	114.6
5-May	VC1241	VC2122			985121020507051	157.8	116.9
27-Apr	VC3493	VC3494			989121020515710	149.2	110
6-May	VC3493				985121020515711		
3-Jun	VC3493			PN5071	985121020515711	149.5	109.3
11-Jul	VC3493	PN5071			985121020515711		
29-Apr	VC6269	VC6270				154.0	107.3
8-May	VC6269	VC6270			989001005109694	157.2	108.4
20-Apr			PN5207	PN5208	989001005109759	137.4	108.8
8-May	PN5207	PN5208			989001005109759	138.5	106.1
1-Apr	WC18539	VC3560				148.8	108.6
29-Apr	WC18539	VC3560			989001005109608		
8-May	WC18539	VC3560			989001005109608	148.2	108.0
31-Mar	WC18770	VC1482			985121020512259	153.5	105.5
9-May	WC18770	VC1482			985121020512259	154.1	105.5
25-May	VC1482	WC18770			985121020512259	154.5	106.0
12-Jun	WC18770	VC1482			985121020512259	153.3	107.5
14-Apr	VC4549	VC4548			151613521A	158.0	110.5
11-May	VC4547	VC4548			985120009987057	159.0	112.5
1-Jul	AP0353	VC4547			989001005109661	146.0	104.0
3-May	VC6250	VA4822			989001005109623	147.3	106.3
12-May	VC6250	VA4822			989001005109623	147.2	108.5
23-Jun	VC6250	VA4822			989001005109623	147.5	106.3
17-Apr	VC5389			PN5237	989001005109622	155.5	109.5
13-May	VC5389	PN5237				154.4	107.9

31-Mar			PN5025	PN5026		140.0	102.1
15-May	PN5025	PN5026				139.2	101.1
4-Apr	CH1970	CH8557				155.0	113.0
16-May	CH1970	CH8557			989001005109609	157.8	114.0
4-Jun	CH1970	CH8557					
23-Jun	CH1970	CH8557			989001005109609	157.8	115.8
30-Mar			PN5167	PN5168	132848144A	151.7	106.8
16-May	PN5167	PN5168			132848144A	149.5	108.1
28-Apr	WC16487	WC16488			900118001505744	148.5	108.0
17-May	WC16487	WC16488				148.5	106.3
4-Jun	WC16487	WC16488				148.0	107.7
23-Jun	WC16487	WC16488			900118001505744	148.0	112.5
24-Apr	PM0345	VC4537			98512009984079	152.5	105.5
10-May	PM0345	VC4537			985120009984079	152.0	105.2
19-May	PM0345	VC4537			985120009984079	154.7	110.5
30-Apr			PN5121	PN5122		152.0	102.5
21-May		PN5121	PN5240		989001006601651	153.5	103.9
4-May	VC6183	VC5814				152	125.5
13-May	VC6183	VC5184			900118001506574	152.3	111.0
22-May	VC6183	VC5184			900118001506574	151.0	109.3
10-Jun	VC6183	VC5814				152.0	
24-Apr	79440	VA7272			12711593A	164.5	118.0
23-May	79440	VA7272			127115293A	164.2	120.0
10-Jun	79440	VA7272				164.0	117.0
7-May	PN3635	PN3636					
8-May	PN3635	PN3636				143.4	100.6
16-May	PN3635	PN3636			989001005109738	141.8	99.8
23-May	PN3635	PN3636					
23-May	PN3635	PN3636					
24-May	PN3635	PN3636			989001005109738	142.4	100.8
5-May	WC16768					146.5	108.2
16-May		WC16768			989001005109753	146	106.5

5-May	WC18567	WC18568				154.5	109.1
15-May	WC18567	WC18563				154.2	110.2
25-May	WC18567	WC18568			989001005109683	154.8	109.9
3-Apr	WC18989	WC18990				157.0	112.0
11-Apr	WC18989	WC18990				156.3	110.6
6-May	WC18989	WC18990			989001005109704	157	112.5
14-May	WC18989	WC18990			989001005109704	156	110
6-Apr	VA1579	PM0562			151613194A	162.2	118.4
4-May	VA1579	PM0526			AVID*084*597*039	161	
22-May	VA1579	PM0526			AVID*084*597*039	164.0	106.0
31-May					AVID*084*597*039		
9-Jun	VA1579	PM0526			AVID*084*597*039	164.1	119.0
8-Apr	VC3549	VC6132			989001005109664	158.0	112.8
4-May	VC3549	VC6182			989001005109664	158.9	112.3
27-Apr	PN2084	PN2085				148.2	110.4
5-May	PN2084	PN2085			151547501A	148	110.5
8-May	AP0165	AP0166			151539371A		
8-May	AP0165	AP0166			151539371A	153.7	114.5
9-May				PN5066	989001005109752	147.7	105.1
18-May		PN5066			989001005109752	147.0	104.0
29-Apr	WC18579	WC18578				147.7	110.6
9-May	WC18579	WC18578			989001005109794	148.0	109.5
24-Apr	VC2079	WC18030			985121020519125	146.0	108.5
12-May	VC2079	WC18030			985121020519125	146.6	107.5
28-May	VC2079	WC18030			985121020519125	147.5	107.0
24-Jun	VC2079	WC18030			985121020519125	146.3	108.0
15-Apr	VC6193	VC6194			989001005109636	148.4	109.0
12-May	VC6193	VC6194			989001005109636	149	106.6
12-May	WC18202	WC18620			151550782A	138.2	103.5
23-May	WC18202	WC18620			151550782A	139	103
26-Mar		PN1826		PN4511	989001001536933	142.0	111.7
5-Apr		PN1826				142.0	112.1

12-May	PN1826	PN4511			989001001536933	142.0	109.8
7-May	PN2740	PN2656					
16-May	PN2740	PN2656					
17-May	PN2740	PN2656				164.0	107.0
27-Apr	WC18897	WC18891				147.0	107.0
17-May	WC18897	WC18891			989001005109628	147.5	106
26-May	WC18897	WC18891			989001005109628	148.2	105.7
26-Apr	VC5974			PN5018	989001001695121	141.3	105.0
17-May	VC5974					142.4	105.8
12-Jun	VC5974				989001001695121	146.0	103.0
21-Jun	VC5974				989001001695121	145.0	106.0
20-May	VC6196	VC5876					
21-May	VC6196	VC5876				159.0	
21-May	VC6196	VC5876			989001005109745	158.0	112.0
17-Mar		VC1182	PN5193			157.5	113.5
21-May	PN5143	VC1182				157.9	112.2
3-Apr		VC3457	PN5044			150.0	108.0
22-May	PN5044	VC3457			985121020432918	150	107.9
29-May	PN5044	VC3457					
21-Apr	VC3423	VC6241			900118001505622	146.5	104.5
1-May	VC3423	VC6241			900118001505622	149.1	103.4
22-May	VC3423	VC6241				150	104.5
30-May	VC3423	VC6241					
4-May			PN5064	PN5065		146.0	103.4
23-May	PN5064	PN5065			989001005109630	146.7	104.3
28-Apr		VC5886	PN4509		900118001505749	154	112.5
25-May	PN4509	VC5886					
4-Apr			PN5103	PN5002		148.5	103.0
27-May	PN5103				989001005109705	146.5	104.5
1-Apr			PN5191	PN5192	151612397A	142.0	101.2
18-May	PN5191	PN5192			151612397A	139.1	100.2
27-May	PN5191	PN5192			151612397A	141.0	99.5

2-May	PN3596	CH6295			989001005109668	152.5	111.0
28-May	PN3596	CH6295					
29-May	PN3596	CH6295			989001005109668	151.3	110.5
13-Apr	VC1353	WC16902					
29-May	WC18055	WC16902			985120010029375	149.1	102.5
11-May	WC18839	WC18833				145.5	102.8
28-May	WC18839	WC18833				145.0	104.6
14-May	WC18847					151.1	117.2
24-May	WC18847			PN5295	985121020559568	150.5	114.0
28-Apr	PN2992	PN2993			989001001695070	156.0	108.3
25-May	PN2992	PN2993			989001001695070		
22-Jun	PN2992	PN2993			989001001695070	153.5	106.0
7-May			PN5293	PN5294	989001005109607	146.2	104.0
26-May	PN5293	PN5294			989001005109607		
29-Apr	VC6049			PN4528		142.1	111.3
28-May	VC6049	PN4528			900118001506931		
7-Jun	VC6049	PN4528				144.0	112.0
25-Jun	VC6049	PN4528			900118001506931	140.0	109.5
11-Apr	WC16545		PN5170		989001005109676	140.5	100.3
31-May	WC16545	PN5170			989001005109676	142.0	
14-Apr	VC2012	VC2027				151.3	108.5
29-May	VC2012	VC2027				149.5	107.2
11-May	VC6223	VC6224			989001005109746	154.5	110.7
1-Jun	VC6223	VC6224			989001005109749	154.0	112.0
15-May	VC6227	VC3846			989001005109693	137.6	98.4
2-Jun	VC6227	VC3846			989001006601582	133.5	101.5
17-May	VC6185	VC6186				145.0	107.0
6-Jun	VC6185	VC6186				144.0	105.5
26-Apr	PN1846			PN5186		155.0	105.4
1-Jun	PN1846	PN5186			985121020514793	157.0	106.0

24-May		VC6195	PN5068		989001001536915	144.5	104.5
2-Jun	PN5068	VC6195			989001001536915	145.4	100.4
29-Apr	VC6220	PN3700				142.5	110.5
2-Jun	PN3700	VC6220				142.3	110.2
24-May	AP0149	AP0171			989001005109605	152.8	104.0
3-Jun	AP0149	AP0171			989001005109605		
26-Apr		PN2502	PN5239		989001001536901	141.5	100.8
7-Jun	PN5239	PN2502			989001001536901	143.4	99.3
27-Apr		VC6112			1515447287A	147.0	108.0
11-Jun	VC0458	VC6112			151547287A	146.0	108.0
19-Apr	VC1489	VC1426			151548685A	148	101.2
11-Jun	VC1489	VC1426				147.0	104.0
21-May	WC18484	WC18485				160.5	105
8-Jun	WC18484	WC18485				158.3	108.5
21-May	WC16609	WC16946			900118001508105	154.0	108.1
8-Jun	WC16609	WC16946				153.0	108.0
18-Jun	WC16609	WC16946			9001180015081O5	152.0	106.0
25-Apr			PN5244	PN5245			
21-Jun	WC18600	PN5245			989001006601612	140.0	108.0
13-Apr	VC1443			PN5201	989001005109692	159.1	115.2
4-Jul	VC1443	PN5201				158.0	112.0
5-Jul	VC1443	PN5201			989001005109692	158.0	113.2
12-May	AP0145	AP0146			989001005109656	155.4	113.5
9-Jul	AP0145	AP0146				152.0	111.0
10-Jul	AP0145	AP0146			989001005109656	153.6	112.9
23-Apr	VC6271	VC6272			989001005109768	151.3	112.1
4-May	VC6271	VC62			989001005109768	150.4	111.5
17-Apr	PM0643	VC6009			985121020515566	154.2	105.4
10-Jun	PN0693	VC6009			985121020515566	155.8	103.0

29-Apr			PN2979	PN2980		158.0	116.0
22-Jun	PN2979	PN2980			133259370A		
22-Jun	PN2979	PN2980			133259370A	158.0	115.3
13-Jun	VC5855	VC5856			989001006601610	152.2	112.5
22-Jun	VC5855	VC5856			989001006601610	153.5	110.5
14-Apr			PN5202	VC1929	151545413A	145.6	104.7
12-May	PN5202	VC1929			151545413A	146.1	104.5
25-Jun	PN5202	VC1929			151545413A	144.0	103.0
9-Jun	WC18575	WC18552				143.5	103.5
24-Apr		VC6015	PN5225		989001001695088	159.5	112.8
25-May	WC18895	WC18894			989001006601642	158.0	111.5
14-Mar		VC1949				149.0	
29-May	ELT2617	ELT2618			989001006601625	144.5	107.6
2-May	PN3591	PN3592				143.0	103.7
11-May	PM0700			PN5209	989001005109642	155.5	115.5
29-Mar	VC5969	VC5970			13249762A		
12-May	WC18419	WC18418			989001005109645	156.8	115.5
29-Mar	VC4153	VC4154			989001005109675	151.5	112.4
27-May		VC6258	PN5249			143.7	105.5
5-Jun	AP0128	WC18562			989001006601581	145.1	108.0
4-Apr	PN3988	PN3987			900118001503130	159.5	108.3
29-Apr		PN3642	PN3959		989001005109627	146.5	107.3
29-Apr		PN2571	PN5150		AVID*068*867*532	148.3	107.2
29-Apr	WC18545			PN5195		155	110.5

6-Apr					989001005109962		
3-May	VC2021	VC2017				150.5	107.4
6-Apr	VC4542	VC4539					
8-Apr		V4095					
8-Apr	CH1565						
12-May	WC18697	WC18698			985120009985969	143	102.6
19-May	PN3981	PN3982			900118001507235	150.3	111.5
21-May	VC4530	PN2302			989001005109760	149.5	107.7
28-May	WC18583	WC18561				141.5	100.0
4-Jun	AP0156	AP0157			132139733A	140.5	107.2
24-Jun	VC6164	PN2099			985120010023866	153.3	109.4
15-Apr			VC5975	AP0040			
31-Mar	PN1447	PN2812			989001005109654	145.7	101.4
11-Apr			PN5105	PN5028		144.0	103.0
27-Apr	PN2455			PN5017		151.4	111.6
1-May	WC18864	PN2637			985120009242154	157.5	106.6
11-May	VC5890	79150			985121020517830	150.2	113.5
14-May	VA4885				989001005109775	151.2	118.0
17-May	VC6281					149.7	111.0
24-Apr		AP0141	PN5154		989001005109651	148.0	108.6
28-May	VC5997			PN5008	985120009247439	147.3	105.3
29-May	WC18649	WC18598			985120008741353	134.0	104.0

25-Apr	WC18885	WC18887					
26-Apr	VC0228	VC6204				148.0	107.8
4-Jun	AP009	AP0151			989001005109618	167.5	109.0
22-Mar	WC16715	WC16566			151545362A	152.0	112.0
2-Apr	PM0778	PM0779			989001005109700	150	106.4
9-Apr		VC3180	PN5019			150.9	104.5
18-Apr			PN5165	PN5166	989001005109620	152.5	111.2
22-Apr	VC6216	ASVO-062			989001005109695	153.0	109.2
23-Apr	WC16237	WC16238				146.2	103.0
24-Apr		PN3996	PN5106		900118001506279	145	109
27-Apr	PN2330	PN2331			151603467A	153.5	110.4
27-Apr	VC4498	VC4492			989001005109655	147	103.3
30-Apr	VC5599	VC5598				159	114.5
2-May	CH11062	CH11063			989001005109639	155.3	113.5
7-May	VA0765	V1908				145.3	106.2
9-May	VC1909	79168				161	117.3
30-Apr	VC4090	VC4004			985120009986473		
22-May	VC7092	VC7093				142.0	107.0
28-May	PM0605	VA1895				155.0	113.0
2-Jun	AP0001	AP0022			989001005109648	150.2	108.5
6-Jun		WC16914	PN4527		989001005109743	151.2	108.5

2-May	PN2648	PN1709					
25-Jun	VC5834	VA5492			985120009247228	162.8	118.5
27-Jun	VC6247	VC6248			989001005109739	150.0	113.0
2-May					900118001507130	158.2	109.7
26-Jun	VC1293	WC18674			900118001504441	152.4	112.0
25-May	VC6299	VC6300			989001006601630	150.0	109.0
7-Jun	PN1682	PN1683				150.0	112.0
5-Mar	PN2966	PN2967			989001005109669	158.0	114.0
11-Mar	WC18064	VC0332			151616265A	147.4	108.4
12-Mar		PN2557	PN5156		133257256A	160.0	107.8
5-May		AP0163			132853345A		
1-Apr	PN3867			PN5006	989001005108690	156.3	108.2
7-Apr	VC6199	VC6200			989001005109621	162.1	111.1
5-May	VA1125	VA2181					
9-Apr	PN3543	VC6181	PN5129	PN5130	989001005109680	150.5	106.6
15-Apr	VC4173	VC1380			989001005109632	154	107.5
5-May	VC3410			PN5238	989001005109678	154.0	114.3
7-Jun	CAN430	VC6254			132274696A	155.0	119.5
11-Jun	VC6163	VC3366			989001006601677	149.5	111.7
7-Jul			PN5267	PN5268	132163516A	148.5	111.2
23-May	VC6233	VC6234			989001006601597	146.5	104.1

20-May	AP0057	AP0058					
20-May		PN1003					
20-May		VC3068				160.3	110.6
23-May	WC18406	WC18407				141.0	103.0
27-May	WC18416	VC5715			989001006601618	153.3	108.9
9-Jun	VC3509	VC3510				142.9	103.5
27-Mar	PN1878	VC2098		PN4512		156.0	114.5
28-Mar	PN3848	PN3847			151544123A	148.5	104.2
31-Mar	VC2061			PN5184	985121020471365	144.2	101.6
5-Apr	79826		PN5181	PN5182	900118001503757	156.2	114.4
13-May		VA3237			989001001695097		
21-Apr	PN3999	PN4000			900118001505924	153.2	106.7
22-Apr	VC5696	VC6603			989001005109657	141.5	109.4
30-Apr	V4825	V4826			AVID*084*596*563	147.0	115.0
30-Apr	VC6138				989001005109671	156.5	114.3
4-May	WC18591	WC18592				150.6	110.3
22-Jun	AP0126	VC6264			989001005109625	147.5	120.1
23-May	WC18597	WC18810				154.5	105.7
15-Apr			PN5215	PN5216	151608200A	157	113.5
16-Apr			PN5217	PN5218	989001005109612	148.0	105.0
25-Apr	PN2937			PN5210	989001005109681	152.4	110.2
29-Apr	PM0767		PN5246	PN5247		142.8	103.5

2-May	CH11503	CH11504			989001005109604	152.6	109.2
25-May	PN2928	PN2929				142.0	104.1
12-May	WC18835	VC5561				147.7	109.5
31-Mar		VC0177	PN5183			158.0	117.9
5-Apr			PN5127	PN5128	989001005109641	150.1	109.0
29-May	VC1450	VC6539					
31-May	WC18877	WC18842				147.1	108.0
5-Apr		WC18912	PN5120		989001005109784	145.2	108.5
26-Apr	V2242	VC5984			989001001536943	141.3	109.7
2-Jun	VC3199	WC18841			1327670974	157.0	105.5
29-Apr	PN2447	PN2448			900118001508333		
13-Apr	VC6203	PN3908			151548291A	159.8	109.5
15-Apr	VC5315			PN5101		146.8	108.0
17-Apr	VC4506	VC4505			989001001695108	153.3	106.5
24-Apr		VC5764	PN5110		989001001695102	146.3	104.0
21-Apr	PN3861	PN3870				138.5	101.1
3-May	VC3349	VC3350			900118001508022	140.0	108.0
27-May	WC18497						
31-Mar	VC6127	VC6130			900118001508205		
15-Jul	PN2669	VA8680				165.0	117.0
7-Jun	VC3460			PN5275	989001006601661	164.0	114.2

22-Jul	AP0158	AP0159			126147364A	159.0	119.4

Appendix B. Hard Shell Tag Catalog

FECHA	OLD PI	OLD PD	NEW PI	NEW PD	SPECIES	LCC	ACC
12-Mar			PN3002	PN3001	CM	106.3	94.4
25-Mar	PN3002	PN3001			CM	104.3	94.2
5-Apr	PN3002	PN3001			CM		
6-Apr	PN3002	PN3001			CM	106.3	94.3
19-Apr	PN3002	PN3001			CM	106.5	95.0
29-Jun			PN3230	PN3231	CM	99.0	87.9
9-Jul			PN0956	PN0993	CM	101.1	97
11-Jul			PN3155	PN3156	CC	95.5	87.5
21-Jul			PN3190	PN3191	CM	101.9	92.5