2009 Sea Turtle Monitoring and Research Report, Reserva Pacuare

Submitted to the Endangered Wildlife Trust and the
Ministry of Environment and Energy (MINAE)

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TABLE OF CONTENTS

This report complies with the research permission 008-2009-INV-ACLAC given by the Ministry of Environment and Energy across the area of conservation of La Amistad Caribe.

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

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Firstly we would like to sincerely thank the EWT Directors John Denham & Carlos Fernandez for inviting us back to the Pacuare Reserve for our second season as coordinators of the project, which made an unforgettable, challenging and fulfilling experience. Thank you also to all of the San Jose office staff, Zaida, Francini, Arturo, Andreas and David for the management of the EWT project funds, and supplying us with all of the necessary equipment and information to ensure that the season continued smoothly.

All of the research and data presented in this report was collected throughout the Leatherback and Green turtle nesting seasons thanks to the commitment of a great hard working team of Project Coordinators and Research Assistants at both Pacuare South and North Stations.

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We highly commend you all for your hard work and commitment to protecting the sea turtles and rainforest habitat at the Pacuare Reserve.

2009 DATA SUMMARY

- There were 1957 Leatherback activities constituting 1171 nests and 768 false crawls and non-nesting activities.
- Pacuare nesting density across 6km of beach was 195.1 nests per KM.
- The most favoured emergence times for Leatherbacks between 21:00 – 02:00, constituted 77.6% of all nesting activities.
- 600 individual females were identified by their tags of which 149 were identified as new-recruits to the population and 451 as re-migrants.
- New-recruits constituted 25% of the 2009 nesting population.
- 56.8% of females nested only once, 22.1% nested twice, and 21.1% either zero or between 3 and 6 times.
- The overall mean Leatherback CCL was 151.2 cm, CCW was 110.2 cm, nest depth was 75.4 cm, mean quantity of yolked eggs were 79.1, and yolkless eggs were 34.8.
- 35% of all activities were false crawls, 5% non-successful ovipostion, 46% were confirmed successful ovipostion, and 14% were nesting activities where ovipostion was not witnessed.
- 57% of all successful nesting activities were relocated.
- 838 (71.6%) nests were exhumed, and 58 (4.9%) were confirmed lost to erosion, bad triangulations or poached. 275 (23.5%) remained unexcavated as they were non-triangulated, “uncertain” nests.
- Relocated nests overall mean eclosion success was 62.1%, emergence success 56.8%, liberation success 58.6%.
- In-situ nests overall mean eclosion success was 63.8%, emergence success 60.3%, liberation success 60.9%.
- 62,705 eggs were exhumed from 838 Leatherback nests, 39,233 hatched and 23,472 non-hatched eggs, with 2253 hatchlings not survived.
- 24% of non-hatched eggs showed no signs of embryonic development, 3% with phase-1 dead embryo, 3% phase-2, 5% phase-3 and 3% at phase-4 embryonic development.
- Using the mean emergence success and mean clutch size, Pacuare could have produced a maximum of 54,232 Leatherback hatchlings.

- There were a total of 235 Green turtle activities, resulting in 88 nests and 147 false crawls or non-successful nesting incidents.
- Green turtle nesting density was 11.7 nests per Km, (to Pacuare river).
- Overall mean Green turtle CCL was 103.7 cm, CCW was 92.7 cm, nest depth was 58 cm and mean clutch size was 114.2 eggs.
- Overall mean Green turtle hatching success was 95.5% producing a possible 9253 hatchlings.

- There were only 3 Hawksbill nests and 1 false crawl.
- Overall mean Hawksbill CCL was 90 cm, CCW was 82, and mean clutch size was 191.3 eggs per nest.
- Overall mean Hawksbill hatchling success was 86.3% producing a possible 495 hatchlings.

1. INTRODUCTION

The Endangered Wildlife Trust is an English NGO which has been committed to sea turtle and wildlife conservation in Costa Rica since 1989. The trust started when the proprietor John Denham sought to buy a small piece of land to build a holiday home. Upon noticing the alarming sea turtle egg harvest, money was raised and 800 hectares of beachfront farmland with small pockets of forest was purchased to allow for natural rainforest rejuvenation and habitat protection for the hundreds of species of flora and fauna which were seriously under threat in the local area.

As the forest naturally and quickly took back the farmland, the wide array of wildlife could begin to flourish as it once had years ago before the area was cut back for local farming purposes. The forested area between the canal and the beach then made beach access more difficult and served as a deterrent for local sea turtle egg poachers.

Various efforts were made with MINAE (the government environment ministry) to protect the sea turtles during the nesting season as the poaching of nests was estimated to be as high as 95% on the Reserve, which was then a widespread and common problem throughout Central America. By the start of the 1994 nesting season, a comprehensive sea turtle monitoring and conservation program was under way, started by John's daughter Alexandra and with the help of a few volunteers.

The project has grown enormously since then and now operates research stations at each North and South Reserve limit which is separated by 5.7km of beach and 800 hectares of protected rainforest. The rich diversity of wildlife comprises of some 211 species of birds, 20 mammal species, 44 species of reptiles and 21 species of amphibians. With countless species of trees and plant life, the reserve is also a home for thousands of species of insects and many aquatic species that inhabit the surrounding canal and Pacuare Reserve shoreline.

Some of the treasures found at the Reserve are the endangered migratory Chestnut-Throated Agami Herons, 3 species of monkey, anteaters, deer, wild boars, both species of sloth, kinkajous, poison dart frogs, venomous snakes and American Crocodiles just to name just a few.
An additional 200 hectares of land were recently purchased on the opposite side of the canal to act as a barrier from the extending banana farms.

The Reserve attracts many biologists, conservationists and researchers as well as student organisations, independent volunteers and tourists, to experience and learn about the amazing biodiversity, now protected and flourishing in the area.

In 2002 the EWT responded to an alarming turtle slaughter on bordering Panamanian beaches by teaming up with Cristina Ordoñez and started community sea turtle conservation projects on 4 neighbouring beaches.

2009 marked the 20th anniversary of the Endangered Wildlife Trust.

1.1 PROLOGUE

The 2009 sea turtle nesting season started with much uncertainty, as during the months of November 2008 to March 2009, the Caribbean coastline was heavily affected by one of the worst rainy seasons during the past few decades. Also during these months the moon was the closest to earth since 1993, (14% closer than normal) causing huge tides and heavy waves. The coastline suffered massive erosion spanning from Nicaragua and into Panama, eroding almost the entire sea turtle nesting zone, leaving a beach of just a few metres wide at the best of places.

As we arrived at March 1st, the official start of the nesting season, it was still raining hard, the moon was still at its closest and the nesting beach at Pacuare barely existed. Across the 6km of monitored beach, the first 3km were non existent, with tides coming above the vegetation line and into the forest. The south station was very close to being swept away by the strong tides, the waves swept away the beach fringing palm trees and the water was coming under the station cabins. A 3km walk through the forest was necessary in order to reach the first stretch of patrolable beach. From this 3km point to the North Station (another 3km), the remaining nesting zone was narrow and almost completely covered in large logs and debris making it difficult for the turtles to find a suitable nesting area.

Fortunately by mid March the Leatherbacks were starting to nest on the wider parts of the beach but their nests were completely flooded, either by the incoming tide or the extremely shallow water table due to the extent of beach erosion. These nests would have all been completely destroyed if the nests were not relocated to higher ground.
As the beach slowly widened and the moon became more distant, the turtles began nesting in huge numbers, which later became the highest quantity of nests on the Pacuare beach in the 20 year history of the Reserve.

The transition between the Leatherback and Green turtle season was slow. With the Leatherback nesting at an end by the start of July, there were several more weeks of heavy rain, high tides and a rough Caribbean sea discouraging potential Green turtles from nesting. By the 1st week of August the sea had calmed a little and finally the Green turtles began to appear. Although Green nesting numbers were small compared to that of the Leatherbacks, there was more than double the nesting density of the 2008 season.

Figure 1. Extensive beach erosion at the South station.

Figure 2. Erosion and total beach flooding at sectors 1-28.

Figure 3. Narrow beach covered with logs and debris from sectors 28-60 (North Station).

1.2 Location of the Pacuare Reserve

The Pacuare Reserve is located on the Carribean coast 30km North West of the port of Limon, and 45km South East of Tortuguero. The Reserve is separated from the mainland by the Tortuguero canal, which was principally made for transportation purposes and linking a network of drainage canals from the extensive banana plantations to nearby river mouths.
The Pacuare river mouth is 1km from the Reserve's northern limit (10°13′17″ N, 83°16′39.″ W), and the Mondonguillo lagoon situated is at the south station, (10°10′00″ N, 83°14′00″ W).

Figure 4. Map of Costa Rica and location of the Pacuare reserve.

1.3 Sea Turtle Species

3 species of sea turtle nest in this region of the Caribbean coastline and on the 6km monitored beach at the Pacuare Reserve.
The largest of all sea turtles, the Leatherback (*Dermochelys coriacea*) migrate from their foraging grounds as far north as Nova Scotia in Canada, to begin their nesting season from late February or early March. They lay between 8-12 nests on various beaches along the coastline between Tortuguero (Costa Rica) and Playa Chiriqui (Panama) and even into Columbia, with approximately 10 day nesting intervals. This population of Leatherbacks is considered to be the 4th largest in the world.

Green turtles (*Chelonia mydas*), which are the largest of the hard shelled sea turtles and the only one which is vegetarian, nest on the Pacuare beach between July and September. Although the nesting density is relatively low compared to that of the Leatherback, Tortuguero National Park, just 45km North of Pacuare, hosts the second largest population of Green turtles in the world.

Each year a small number of Hawksbill turtles *(Eretmochelys imbricata)* nest at Pacuare. The closest major Hawksbill nesting site is just 36km south of Limon in the National park of Cahuita. The national park is host to the regions only coral reef system which is abundant in the Hawksbill's preferred food, sponges. It is also lush with grass beds making it a popular nesting and foraging ground for both Hawksbills and Green turtles. Pacuare receives only a handful of Hawksbill turtle nests per season, between the months of July – September.

2. MATERIALS AND WORK METHODS

2.1 Preparation

At the Pacuare Reserve the EWT operates the sea turtle monitoring, research and education programme from 1st of March until the 30th of September. As project coordinators we arrived at the reserve 1 week before the official start date in order to prepare the stations. The scientific equipment was delivered from the San Jose office and all equipment was cleaned and any missing parts were purchased in order to start the season fully equipped.

When the Leatherback season's Research Assistants arrived they were given a 4-day intensive training course to ensure that they were suitably equipped with enough knowledge to start the nesting season. The course included lessons on sea turtle ecology and biology, species identification, safe working practices, use of equipment, data collection, tagging, nest relocations and triangulations, beach patrol ethics, dealing with student groups and health and safety practices. We were also given a basic one day first aid course by the Bataan Red Cross to deal with basic first aid issues.

Between the 2 stations there are marker posts dividing the area into 100m sectors. Post 0 is situated near the middle of the Mondonguillo lagoon in the south station and Post 57 is directly in front of the North Station. Between the 100m sectors are sub-sector posts positioned every 25m, ie from post 0 follows: 0.1, 0.2, 0.3, and then continuing to the post of sector 1. Due to the severity of beach erosion leading up to the season, nearly all of these posts from the previous season were lost. It took 3 days to successfully measure each 25m of the 5.7km, dig holes about 75cm deep and erect new sector marker posts. At head height they were then painted white and numbered in black in order to be identified easily during night patrols. All night patrols were conducted from the South Station to the North Station until the 10th of March, when the North Coordinator arrived with all relevant equipment and a team of Research Assistants to commence patrols.

Between the stations, the patrol dividing point was set at sector 35 due to a historically higher density of nesting on the North side of the nesting zone, and due to an intensively eroded south side beach up to sector 28 that was constantly flooded up to the tree line until late March.

2.2 Beach Patrols and Nesting Surveys

Nightly beach patrols were conducted from the 1st March until the 30th September, covering the 6km Pacuare beach to accurately monitor all sea turtle activities and to help keep the egg poaching rate to an absolute minimum. Beach patrols were led by either a project coordinator or a research assistant, accompanied by small student groups, volunteers or tourists. Each group patrolled for a minimum of 4-hours and started from each station at 20:00, 22:00 and 00:00. It is during night patrols that turtles are encountered, tagged, measured and nests relocated.

This ensured that the entire beach was covered until almost sunrise, and with several hours during the night with 4-patrols on the beach at the same time, optimising turtle encounters. A rest of 10-15 minutes was taken at sector 35 before returning back to the station. If a turtle was still not encountered then 2 laps were necessary in order to complete the 4-hour minimum patrol time.

Due to an intensified Leatherback nesting season it was common that patrols were extended to at least 6 or sometimes 8 hours when nesting was in high numbers. The success of the night patrols was gained by the commitment of the project coordinators and the research assistants to relocate and protect as many nests as possible from the local poachers, and ensure that as many turtles were worked with as possible, maximising data collection.

The Pacuare Guards patrol independently of the groups in order to maximise beach coverage and protection. If a turtle was encountered by guards, they were able to alert a beach patrol either by radio or an intermittent red headlight flash which optimised turtle encounters. If a patrol couldn't arrive on time before the end of oviposition, the nest chamber was marked with a stick and the guard would wait for the patrol. It was then the decision of the patrol leader whether to relocate the clutch of eggs or triangulate the nest in-situ. The guards would also note tag numbers if the turtle returned to sea before the patrol arrived.

For each nesting activity, data is methodically recorded in a waterproof "Write in the Rain" data book as listed below:

- **Patrol leaders name,**
- **Date:** which is "the night of", meaning that if your patrol started at 22:00 on the 1st April and you encounter a turtle after midnight, it is still the night of the 1st, until sunrise. This is essential in order to effectively calculate nightly nesting activities. Otherwise, one night's nesting activities will be separated into 2 different dates.
- **Time A:** Noted in 24-hour clock the minute you encounter the turtle.
- **Time B:** Noted in 24-hour clock the minute she lays the first egg.
- **Turtle species:** **DC** = *Dermochelys coriacia* (Leatherback, Baula)
  CM = *Chelonia mydas* (Green, Verde)
  EI = *Eretmochelys imbricata* (Hawksbill, Carey)

The nesting activity when the turtle is first encountered is noted as either:

- **Sa**liendo – Just emerging from the water.
- **Su**biendo – Above the tide line and climbing the beach.
- **B**uscando – Searching for a suitable nesting area.
- **H**ueco **C**uerpo – Making a body pit, or nesting bed with her front flippers,
- **C**amará – Digging her nest chamber with her rear flippers.
- **P**oniendo – Laying her eggs.

- **T**apando – Filling in her nest chamber and "tapping" it with her rear flippers.
- **Cam**uflando – Camouflaging her nest by again flicking sand everywhere with her front flippers.
- **R**egresando – Returning to the sea.

The nesting zone is noted as either:

- **A** – Lower than the high tide line,
- **B** – Between the high tide line and the grassy vegetation,
- **C**– Between the grassy vegetation and the tree line.

Figure 5. Beach nesting zones.

The turtles nesting status is noted as either:

- **SF**- (salida falsa). When the turtle leaves the water to begin climbing the beach or even reaching the nesting area but makes no attempt at even making a body pit. This is a false crawl.
- **NP**- (no puso). This is noted when a turtle attempts to make a body pit or nest chamber but is aborted and oviposition does not take place.
- **NS**- (no se).The turtle clearly attempted to nest, a large body pit and camouflaged area present but oviposition was not witnessed.
- **IS**- (in-situ). If oviposition was witnessed and the egg clutch was left in its original natural state.
- **R**- (reubicado). When a clutch of eggs was removed from its original nest and relocated to a nearby area safely away from erosion, flooding from the high tide or the threat of poaching.

After working with a turtle, all nesting evidence was erased, (including false crawls and relocated nests), body pits were filled in and flattened, and tracks were wiped clean using logs or other beach debris. This greatly reduced the possibility of nests being poached as recent nesting activities were then hard to distinguish. Leatherbacks especially leave behind evidence of nesting that would remain for weeks and is obvious to poachers. With a group of volunteers or students nesting evidence flattened and can be wiped clean within a matter of 5-10 minutes. This was a lot of hard work but proved to be extremely successful as there were few incidents of nests being poached from the reserve.

2.3 Morning Nesting Census

At dawn, a final patrol left the stations in order to asses the nights nesting activities. Nests that had already been encountered during the night patrol should already have been erased, but if necessary, they were given a final camouflage to ensure that they would not be detected by poachers. Relocation sites were also further disguised if necessary. Any new nests or false crawls that may have occurred behind the final night patrol were also noted and fully erased.

No attempts were made at locating the eggs from these new nests as the eggs may have been buried many hours before and may have started their delicate development process. Moving the eggs may cause more harm than good so they were left to hatch naturally. All new nests are recorded as "No Se" (uncertain) and not "In-situ" as it is not known if successful oviposition occurred. The date is recorded as being that of the previous day (the *night* of nesting activity). During the hatching season it is the morning census patrol person's responsibility to notice and mark any hatched nests that were also missed during the night patrols, and guard any new hatchlings making their way to the sea. The nests that were noticed during the night patrol would already have been marked with a stick 50cm behind the nest and with flagging tape stating the hatching date and quantity of hatchlings emerged.

2.4 Tagging

When a new turtle is encountered for her first time, she is marked with a metal flipper tag which has a unique number to identify her. Each turtle is tagged in both her left and right flippers, which is carried out after oviposition to minimise unnecessary disturbance to her nesting process. Leatherbacks are marked with monel tags in their rear flipper pits and Green turtles and Hawksbills are marked with the smaller inconel tags on their anterior flippers in the centre of their 2nd scale. The lowest number of the pair is always tagged in their left flipper.
Evidence of a previous tag is normally quite clear. As turtles are always tagged in the same area, if one has been torn out, fallen out, or removed, then there will be a clear hole or puncture wound in her skin. These are noted as "Old Tag Hole" (OTH) or Old Tag Notch" (OTN) accordingly.
Any tags that were infected, causing the turtle some pain or encrusted with barnacles, were removed and new tags were applied.

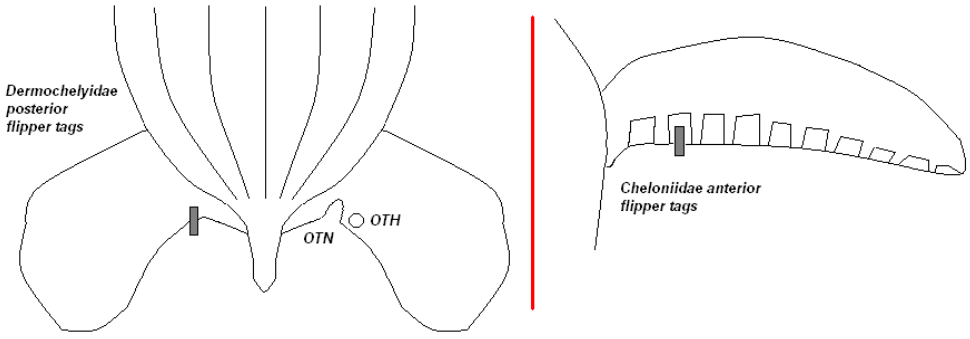


Figure 6. Tag positions and evidence of previous tags.

The Leatherback monel tag series used at the Pacuare Reserve in 2009 ranged from PN1005 – PN1772 with the addition of VA9136, VA9137, and VC0441 which were from last years kit.
The inconel tags for Greens and Hawksbills ranged from PN0301 – PN0674.

PIT tagging (passive integrated transponder) was not carried out at the Pacuare reserve in 2009, as equipment was not available.

2.5 Biometric Data

During oviposition (if the nest is to be left in-situ), or during nest relocation, the eggs are carefully counted. Leatherbacks also lay smaller yolkless eggs after the fertilised eggs, which are counted separately. When working with turtles, especially handling the eggs, latex protective gloves are always worn to protect both parties from any contamination and bacteria.

The length of Leatherback carapaces (CCL) were measured along one side of the central ridge from the neck notch following the shape of the curve to the tip of the caudal. The caudal is also noted as complete or incomplete. (Sometimes during mating or from possible predation attempts, the caudal may be broken or entirely missing.) CCL measurements with an incomplete caudal are removed from the data when calculating the average CCL.

The curved carapace width (CCW) is measured across the widest part of the carapace from the most outer carapace ridges. This measurement requires 2 people as you should never stride over a Leatherback.

Green turtles and Hawksbills are measured in the same manner, CCL and CCW at the central and widest points respectively as shown in the diagram below. Curved carapace measurements are always measured 3 times to ensure that an accurate and consistent measurement is recorded.

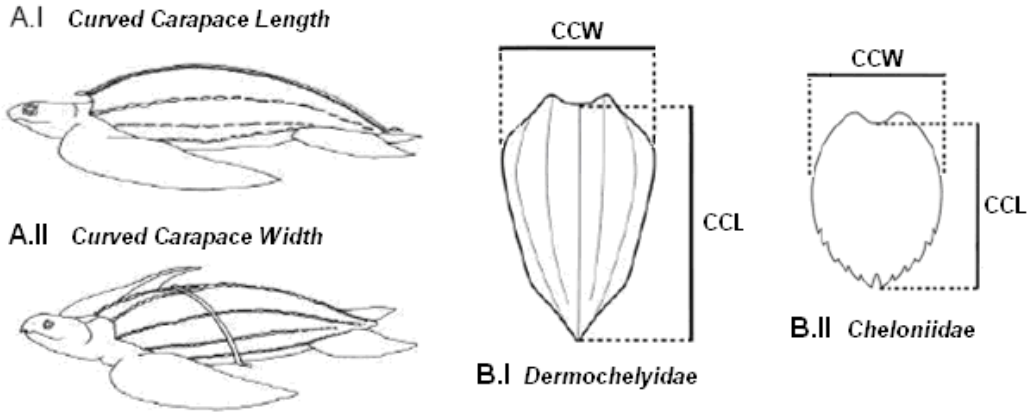


Figure 7. Curved Carapace measurements.

2.6 Nest Relocations and Triangulations

Due to the beach conditions of 2009 and also to minimise the level of egg poaching at the Reserve, it was agreed that all nests were to be relocated whenever possible, if we arrived at the turtle before she started filling in the nest chamber. Exceptions were made only if the nest did not seem susceptible to erosion or flooding and was very close to the station and therefore had a much lower risk of poaching. On these occasions, full body pit and track erasing were still carried out. If turtles were found camouflaging a nest in a "danger zone", i.e. below the high tide line or in an area heavily affected by erosion and susceptible to flooding, then attempts were made to recover the nest and relocate the eggs to safer ground.

Eggs were relocated close to the original nest in order to minimise the effects of movement and temperature loss within the clutch, which could possibly affect hatching success and skew hatchling sex ratios. A suitable relocation site was chosen within 100m or so from the original nest area, avoiding areas of beach erosion and possible flooding. New nests were made at the average 75-80cm depth and slightly boot shaped like the original nest. The sand removed was piled neatly to avoid excessive temperature loss and great care was taken when carrying the eggs to the relocation site. To make the new nest site less obvious, excess sand was deposited away from the nest area. Relocation sites were always left flattened and well camouflaged (including our footprints) to deter detection by potential poachers.

All relocated and in-situ nests were triangulated, which is essential in order to be able to find the exact location of the nest after hatching, especially for nests when hatching evidence is not found after the full 80-day incubation period has lapsed. This is done by carefully measuring from the centre of the nest which is marked with a stick, to the 2 closest sector marker posts using a 30m tape measure. A third marker is also needed somewhere close to the centre for accurate nest recovery.

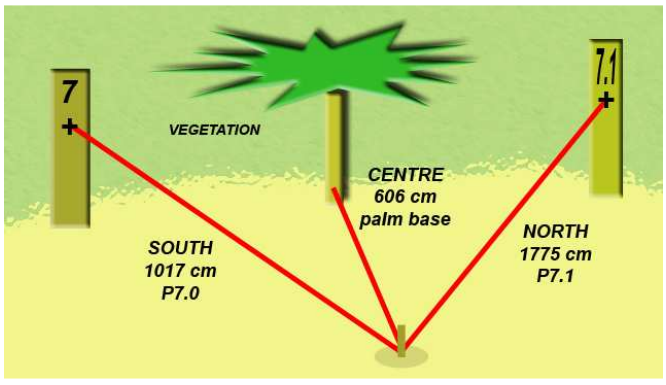


Figure 8. Nest triangulations.

These 3 measurements are noted as SOUTH, CENTRE and NORTH and they are recorded in centimetres.
A description of the exact point of measurement for the centre was noted to avoid using flagging tape which could attract poachers to the general nest area.

2.7 Post Hatching Nest Excavations

After the nest has hatched, it is important to exhume the contents of the nest in order to determine the hatching success, which will ultimately enable us to calculate beach productivity. It is expected to be able to retrieve data from all triangulated nests whether they were successfully hatched or not, along with excavating all nests where we have found hatching evidence and that were marked with sticks and flagging tape accordingly.
Thick rubber gloves are always used during nest excavations to avoid contamination from the decomposing nest material. When excavating the nest, the width and depth is exaggerated to ensure that all contents are removed and accounted for.

The contents are separated between:

- Hatched empty shells
- Whole un-hatched eggs
- Small yolkless eggs
- 'Pipped' alive or dead hatchlings, (where the hatchling pierced the shell but didn't completely emerge),
- Alive or dead hatchlings that had left the shell.

All contents are counted and noted accordingly and all un-hatched eggs are opened to determine if the embryo had terminated during a phase of its development, or if the egg was undeveloped.

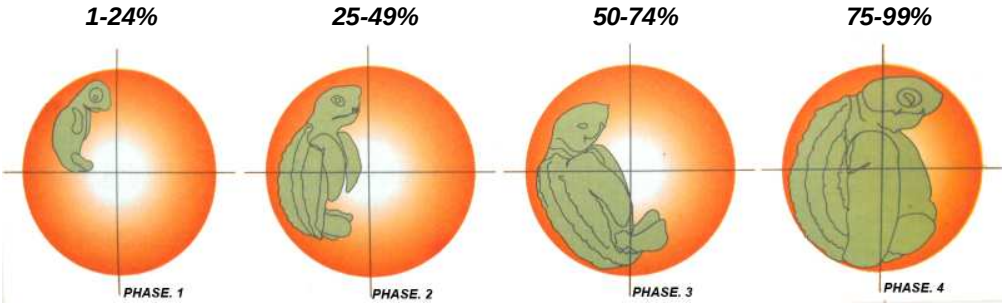


Figure 9. Embryonic development stages. (diagram from Inter-American Convention manual).

Undeveloped eggs will contain just the yolk and albumen and no signs of embryonic development. Early 1st phase embryos may be so small that only tiny black eyes are present, up to final 4th quarter phase where the embryo seems fully developed and containing only a small yolk sack.

Egg predation is common in sea turtle nests and is evident during nest excavations. Crabs will bury deep into the nest and feast on several eggs. Flies will then enter the nest via the tunnels and lay their eggs in the decomposing remains of shells and embryos and the maggots eat their way through the nest. Also worms, ants and fungus may enter the nest and cause damage. All shells, eggs and embryos are noted according to its depredation.

3. RESULTS

3.1 Temporal Distribution of Leatherbacks

During the 149 day Leatherback season, from the 1st March to the last Leatherback activity recorded on the 27th July, there was a total of **1957** Leatherback activities. **1171** were nests and **786** were recorded as either false crawls or confirmed non-successful nesting incidents.

The nights with the highest nesting activities were:

- 2nd April with 28 nests and 8 false crawls,
- 20th April with 24 nests and 25 false crawls.
- 19th April with 24 nests and 13 false crawls.

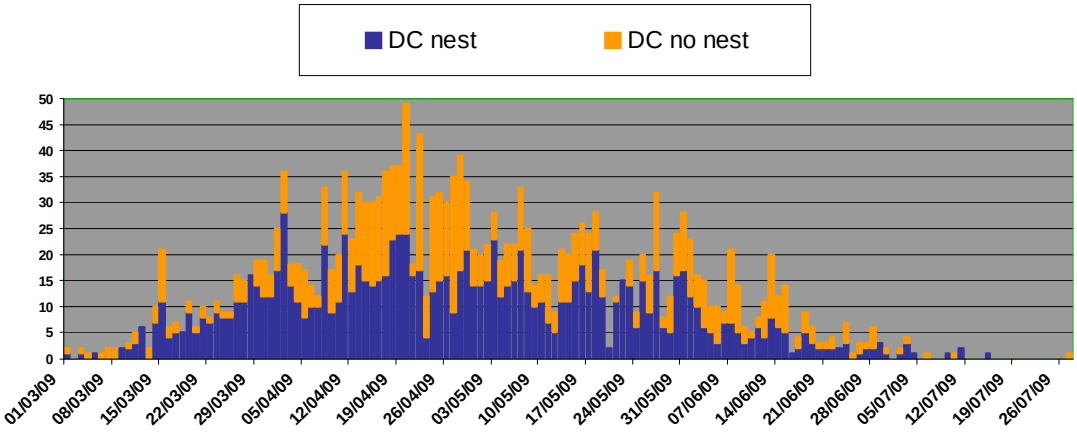


Figure 10. Daily temporal distribution of Leatherbacks.

When comparing a monthly breakdown of nests to that of the previous 9 years figures, it is evident that 2009 was an exceptionally high nesting season. April alone received close to twice as many nests as the past average. The month of April had the highest nesting density of the season, but in previous years May was the busiest month.

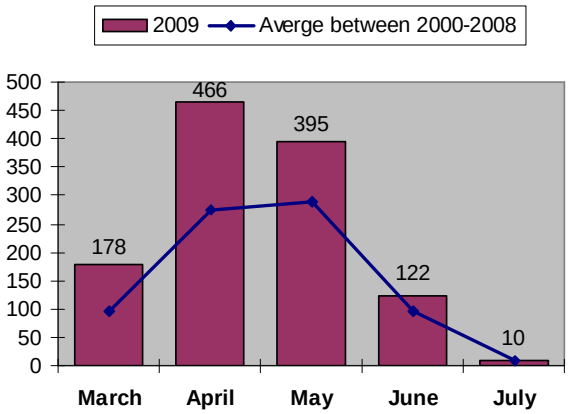


Figure 11. Leatherback nests per month.

With the nesting season divided into weeks, we can see that weeks 7-10, (12th April – 09th May) received the majority of activities with **441** nests and **364** false crawls, resulting in **41%** of the entire season's Leatherback activities and **38%** of the total quantity of nests.

Week	From	To
1	01-Mar	07-Mar
2	08-Mar	14-Mar
3	15-Mar	21-Mar
4	22-Mar	28-Mar
5	29-Mar	04-Apr
6	05-Apr	11-Apr
7	12-Apr	18-Apr
8	19-Apr	25-Apr
9	26-Apr	02-May
10	03-May	09-May
11	10-May	16-May
12	17-May	23-May
13	24-May	30-May
14	31-May	06-Jun
15	07-Jun	13-Jun
16	14-Jun	20-Jun
17	21-Jun	27-Jun
18	28-Jun	04-Jul
19	05-Jul	11-Jul
20	12-Jul	18-Jul
21	19-Jul	25-Jul
22	26-Jul	01-Aug

Table 1. Weekly time range.

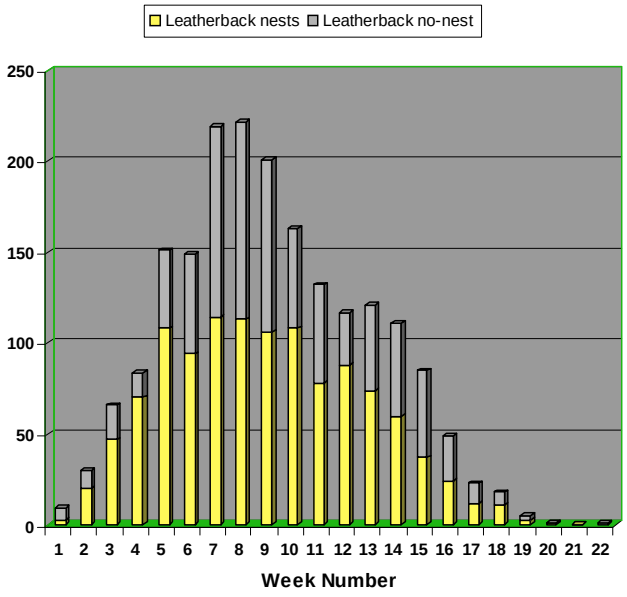


Figure 12. Weekly distribution of Leatherbacks activities.

3.2 Spatial Distribution of Leatherbacks.

The 1171 nests and 768 false crawls were distributed unevenly along the 6km of monitored beach. Up to sector 25 the beach was heavily eroded and very narrow and as a result was a less preferred nesting area with a higher rate of false crawls compared to nests. The most favoured nesting sectors were between **28-36**, with a total of **294** nests. This is an average of **32.7** nests per 100m sector, which is **25.1%** of the entire 6km nest total. Sectors 41-45 were the second preferred area with 151 nests, which is 30.2 nests per 100m sector.

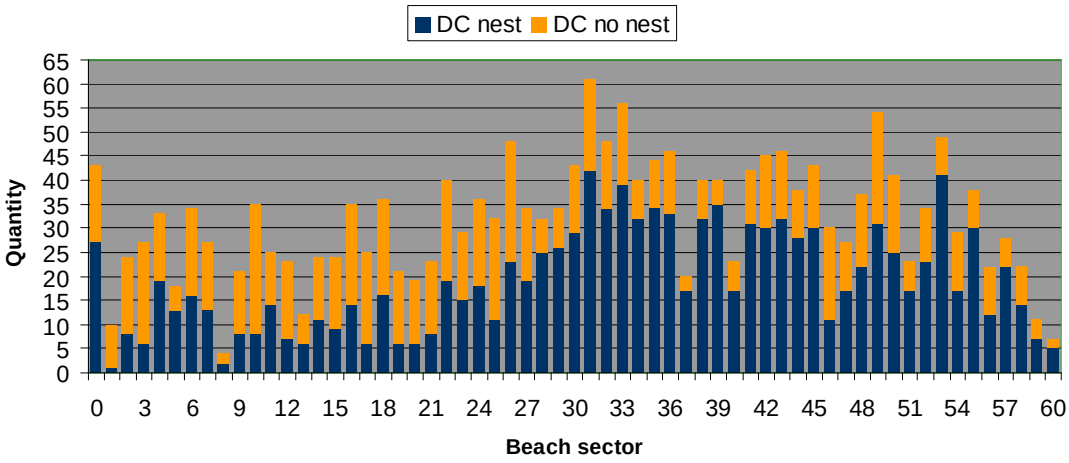


Figure 13. Spatial distribution of Leatherbacks.

The overall Pacuare beach nesting density in was **195.1 nests per km**.
South sectors 0-29 received a total of 380 nests which is 126.6 nests per km.
North sectors 30-60 received a total of 789 nests which is 263 nests per km.

3.3 Nesting Activities

938 Leatherbacks were captured during nightly beach patrols displaying either of the 7 nesting activities, and 233 nesting activities were missed.
235 Leatherbacks were captured making a false crawl or resulting in non-nesting activities, and 551 were missed.

80% of all nesting turtles were found by a night beach patrol.

84% of all encountered turtles were in nesting stages where nest relocation was possible.

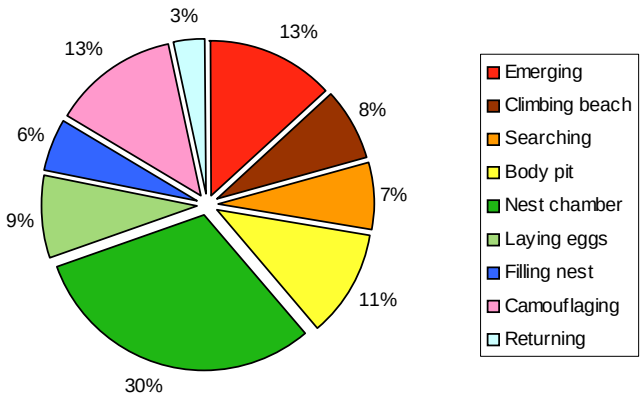


Figure 14. Encountered turtles nesting activities.

3.4 Estimated Emergence Times

By timing the entire nesting process of a sample of Leatherbacks, a breakdown of accumulated duration time can be calculated per nesting activity. For any given turtle encountered relating to her nesting activity when originally found, we can then estimate the time she may have emerged by deducting the relative duration time.

Activities			Accumulated duration
Type	ref	total	
Emerging	Sa	133	00:00
Climbing beach	Su	75	00:05
Searching	B	70	00:10
Body pit	Hc	110	00:20
Nest chamber	C	304	00:40
Laying eggs	P	85	00:55
Filling nest	T	57	01:05
Camouflaging	Cam	129	01:20
Returning	R	33	01:30
	total	996	

Table 2. Accumulated duration of nesting activities.

A total of 996 Leatherback nesting activities were accurately recorded with both the nesting activity and correct time when he turtle was first encountered. Inaccurate data entries and false crawls were not included in the estimated emergence times.

	Time Range
1	Before 18:00
2	18:00 - 18:59
3	19:00 - 19:59
4	20:00 - 20:59
5	21:00 - 21:59
6	22:00 - 22:59
7	23:00 - 23:59
8	00:00 - 00:59
9	01:00 - 01:59
10	02:00 - 02:59
11	03:00 - 03:59
12	04:00 - 04:59
13	05:00 - 05:59
14	After 06:00

Table 3. Emergence time range.

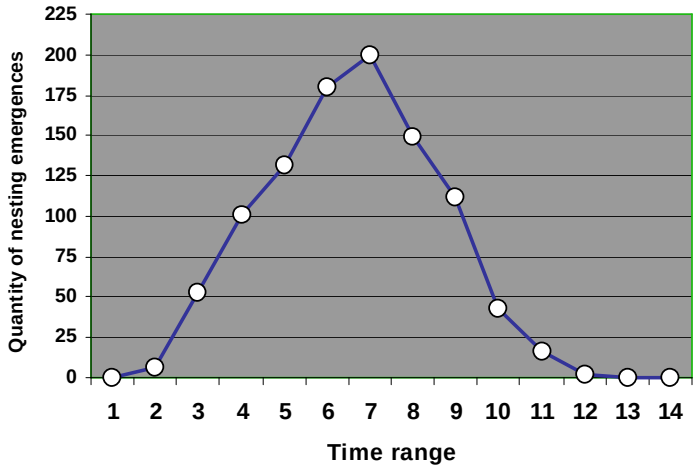


Figure 15. Estimated emergence times.

It is evident that the hours between 22:00 – 00:00 were the most favoured emergence times, with **380** emergences representing **38.1%**.
77.6% of all turtles emerged between 21:00 – 02:00.
19 Leatherbacks emerged between the hours of 03:00 – 05:00 which provided groups the amazing experience to witness Leatherbacks during daylight hours.

3.5 Tagging Data

The total Pacuare Leatherback nesting population of 2009 consisted of 600 individual females that were identified as re-migrants by their present tags or as neophytes. Neophytes are new recruits to the population that were tagged for the first time and showed no evidence of any old tags in the form of notches or holes in the flippers.

131 turtles were given both tags and identified as new-recruits to the population as they had no PTE (Previous Tag Evidence).
25 turtles were given both tags but showed signs of PTE or a previous tag was removed, which were recorded as re-migrants.
18 turtles had no PTE, identified as new-recruits but could only be tagged once due to time restrictions.
71 turtles were given 1 tag and showed signs of PTE, which were recorded as re-migrants.
317 turtles were found with both tags and no signs of PTE which indicates that she may still have her original tags.
38 turtles were found with both tags but with additional signs of PTE indicating that she had lost her original tags.

Given Both tags		Given 1 tag		Original Tags		TOTALS	
New Rec	Re-mig	New Rec	Re-mig	No PTE	With PTE	New Recruits	Re-migrants
131	25	18	71	317	38	149	451

Table 4. Tags given to new recruits, and re-migrants.

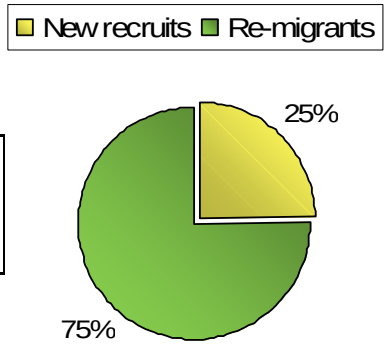


Figure 16. Population stock

From 600 individual turtles, **341** turtles were recorded as nesting only once within the Reserve. **133** turtles were recorded as nesting twice. Of all nesting females observed, turtles with the tags V4865 and VA1602 showed the highest nesting site fidelity, nesting on 6 occasions during the 2009 season.

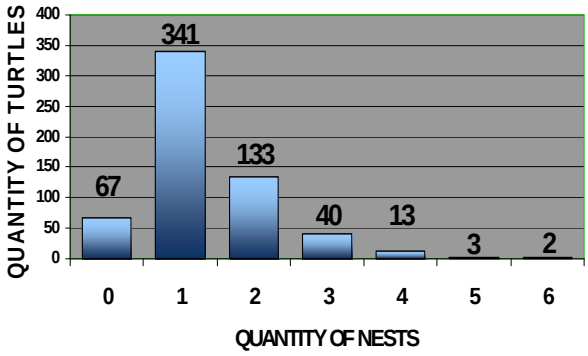


Figure 17. Nesting frequency per turtle.

Turtles that were recorded as having a nesting frequency of zero were turtles that were identified as individuals but were only encountered during non-successful oviposition activities. The turtle may later have nested, un-witnessed by ourselves or may have nested outside of the reserve boundaries.

3.6 Biometric data

801 carapace measurements (CCL and CCW) were recorded from **529** individual female Leatherbacks. **71** individual females were identified by their tags but could not measured due to time restrictions. **13** turtles were measured that either didn't have tags or could not have been tagged as they were too close to entering the sea. 21 Inconsistent measurements were removed from the dataset and not included in the averages. 19 carapace length measurements were removed due to the presence of a confirmed incomplete caudal, but 23 incomplete caudal measurements were not removed due to previous recaptures of the same female and same measurements stating the caudal was complete on more occasions than incomplete.

Overall mean CCL was **151.2** cm, the mean CCW was **110.2** cm. 247 individuals measured below the 151 cm (CCL) average, and 47 of the 600 individuals measured 140 cm (CCL) or less.

On **342** occasions it was possible to accurately measure the depth of the original nest chamber. Eggs were counted either during oviposition or when the clutch was relocated from a total of **605** nests.

	CCL	CCW	Nest depth	# Yolked eggs	# Yolkless eggs
Minimum	126.0	86.0	30.0	12.0	0.0
Maximum	178.0	133.0	95.0	136.0	110.0
Mean	151.2	110.2	75.4	79.1	34.8
STDEV	7.5	5.7	8.4	17.9	15.2

Table 5. Leatherback biometric data.

3.7 Nest Destiny

Of the 1957 Leatherback activities recorded at Pacuare in 2009, **35%** were false crawls, **5%** non-successful oviposition, **46%** were confirmed successful ovipositon and **14%** with nesting evidence (large body pit and camouflaged area) but unconfirmed successful ovipostion, as the turtle was encountered either camouflaging, returning to the sea or missed altogether.

	In-situ	Uncertain	Relocated	Didn't lay	False crawl
March	30	36	112	12	53
April	97	115	256	49	329
May	83	84	227	20	189
June	29	34	59	14	115
July	1	2	6	0	5
TOTAL	**240**	**271**	**660**	**95**	**691**
	1171			**786**	

Table 6. Monthly nest destiny.

By excluding all false crawls and confirmed non-successful nesting activities, we can breakdown all remaining nesting activities.
660 nests, **(57%)** were relocated, **240** nests **(20%)** were confirmed in-situ, **271 (23%)** were uncertain nests where actual oviposition was not witnessed, and there was no clear evidence of the nest hatching.

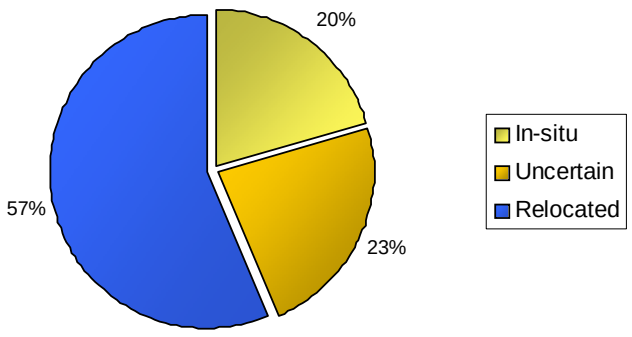


Figure 18. Nest destiny.

3.8 Nest Survivorship

Of the 1171 registered nests, 756 nests were triangulated (64.5%).
838 (71.6%) were recovered and exhumed to determine hatching success. 23.5% of nests were "uncertain", these were not triangulated and could not have been recovered for data analysis. These uncertain nests might possibly have hatched but evidence was not witnessed due to a storm or a high tide erasing the hatchlings tracks. There is also the possibility the nest was lost due to poaching, erosion, flooding, or may have even been a non-successful nesting incident. The remaining **4.9%** were confirmed as either lost or destroyed nests as they were triangulated and the exact location of the nest was possible.

	Total	%
Relocated nests, exhumed	612	52.3
In-situ nests, exhumed	226	19.3
Uncertain nests, not found	275	23.5
Eroded by tides	20	1.7
Poached	24	2.0
Lost, bad triangulation	14	1.2
	1171	

Table 7. Nest survivorship

92.7% of all relocated nests were recovered and exhumed.

94.2% of all in-situ nests were exhumed.

76.5% of all recorded nesting activities were exhumed or accounted for, leaving **23.5%** as uncertain nests.

3.9 Hatching Success

Successful eclosion, **(EC)**, signifies that the hatchling had fully developed and had hatched from its egg. Turtles found in the process of hatching (i.e were 'pipped') whether they were found alive or dead, are also included as successfully eclosed.

Successful emergence, **(EM)** signifies that the hatchling had fully eclosed and emerged from the nest. Upon nest excavation, if eclosed hatchlings were found either alive or dead still in the nest chamber, then these were not included as emerged. Dead hatchlings that were found on the beach surface are included as successfully emerged.

Successful liberation, **(LIB),** includes all hatchlings that made it to the sea, whether by themselves or found by ourselves alive during nest excavation. Even weak or disabled hatchlings, if they made it to the sea they are included.

Relocated nests	**Incubation period**	**EC%**	**EM%**	**LIB%**	*Quantity of nests at the min/max*
Minimum	52	0.0	0.0	0.0	61
Maximum	79	100.0	100.0	100.0	9
Mean	63.3	62.1	56.8	58.6	
STDEV	3.7	30.2	29.4	29.7	

Table 8. Relocated nest incubation period and hatch success.

In-situ nests	Incubation period	EC%	EM%	LIB%	Quantity of nests at the min/max
Minimum	56	0.0	0.0	0.0	16
Maximum	76	100.0	100.0	100.0	4
Mean	63.0	63.8	60.3	60.9	
STDEV	3.2	32.1	28.6	28.7	

Table 9. In-situ nest incubation period and hatch success.

There was only a maximum of 3.5% difference when comparing the hatching success of in-situ and relocated nests and the incubation period difference between the 2 is only 0.3 days.
A total of **61** relocated nests were destroyed due to severe beach conditions and excessive flooding of many nests, resulting in a zero% hatching rate. As these nests were triangulated we were able to retrieve this data which was included when calculating the averages, showing a more accurate figure compared to only excavating successfully hatched nests.

Taking the overall mean combined emergence success of **58.5%**, the **1171** nests containing an overall mean of **79.1** eggs per nest, Pacuare beach could have produced a maximum of **54,232** Leatherback hatchlings.

3.10 Post Hatching Nest Excavations

A total of **62,705** eggs from **838** Leatherback nests were successfully exhumed, either 3 days after the nest's hatchlings first emergence, or after the full 80-day incubation period if evidence of hatching was not witnessed.
39,233 hatchlings successfully hatched but **2253** of them died either during their climb to the beach surface, on the surface cooked by the sun, or were depredated by either birds of prey, racoons or other mammals.
23,472 eggs did not successfully produce a hatchling, consisting of **15,364** eggs showing no sign of embryonic development, and **8108** dead embryos at one of the 4 stages of embryonic development.

Quantity of exhumed nests	Quantity of eggs	Total non hatched	Total hatched	Total hatched but not survived
838	**62705**	**23472**	**39233**	**2253**

Table 10. Egg/hatchling quantities from exhumed nests.

An average nest contained **62%** successfully hatched eggs, **24%** showed no signs of embryonic development, **3%** of the eggs resulted in terminated phase-1 embryos, **3%** phase-2 embryos, **5%** phase-3 embryos, and finally **3%** of the eggs that terminated during phase-4.

Hatched eggs	**39233**
No **E**mbryonic **D**evelopment	**15364**
Embryo Phase-1	**2031**
Embryo Phase-2	**1588**
Embryo Phase-3	**2913**
Embryo Phase-4	**1576**

Table 11. Egg development totals.

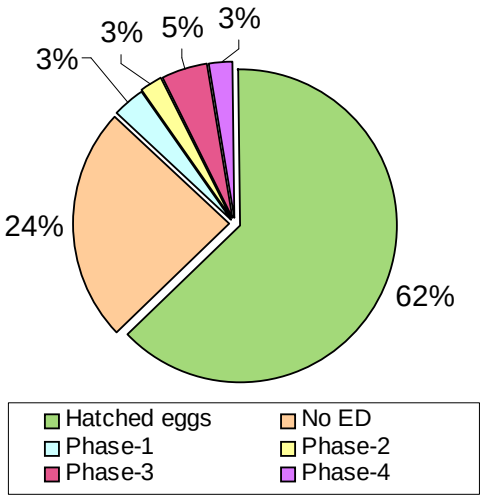


Figure 19. Average nest content.

Upon nest excavation, any eggs with clear evidence of depredation by either maggots, ants, crabs or fungus were noted accordingly.
Of the **23,472** non-hatched eggs, **8,847** were depredated inside the nest and during the nest incubation period.

The table below shows the totals of all non-hatched eggs from "No Embryonic Development" to "Phase-4" and relating to each form of depredation. Each percentage is correspondent to the quantity of eggs affected by each predator relating to only that specific egg development phase.
The "total eggs depredated" is correspondent to that specific egg phase and is also represented as a percentage of its total.
The final totals are relating to each specific predator and as a percentage of the total number of non-hatched eggs.

	TOTAL	MAGGOTS		ANTS		CRABS		FUNGUS		TOTAL DEPREDATED	% From total
No ED	15364	508	3.3%	164	1.1%	1270	8.3%	4291	27.9%	6233	**40.6%**
Phase-1	2031	29	1.4%	7	0.3%	36	1.8%	287	14.1%	359	**17.7%**
Phase-2	1588	63	4.0%	20	1.3%	124	7.8%	270	17.0%	477	**30.0%**
Phase-3	2913	285	9.8%	34	1.2%	332	11.4%	561	19.3%	1212	**41.6%**
Phase-4	1576	204	12.9%	6	0.4%	164	10.4%	192	12.2%	566	**35.9%**
TOTAL	**23472**	1089		231		1926		5601		8847	
TOTAL %			**4.6%**		**1.0%**		**8.2%**		**23.9%**		

Table 12. Egg depredation

The bottom "TOTAL %" on the table refers to the actual percentage of all depredated eggs by that specific predator, i.e fungus destroyed 23.9% of all depredated eggs.

122 hatchlings were found hatched but in the process of being consumed by maggots internally, most were already dead but a handful were still alive.

Many holes on the beach were identified as being dug from armadillos and coatis but there was no clear evidence that nests were depredated, nor any broken egg shells near the vicinity of any nests. **5** nests were confirmed excavated by the Reserve dogs with a total of **10** dead hatchlings around some of the nests. It is not known if the dogs ate any or if they were killed by just playing with them.

Hatchlings were witnessed being depredated by crabs, vultures, birds of prey and mammals. Although exact figures of depredated hatchlings are impossible to calculate, a total of **66** Leatherback hatchling carcasses were found on the surface near **5** different nests, and **10** hatchlings were witnessed being taken by a hawk.

3.11 Green and Hawksbill Turtles

In total there were **234** Green turtle nesting activities. **88** of these activities were nests and **147** were false crawls or where the turtle demonstrated nesting behaviour but did not lay. There were only **3** successful hawksbill nests and **1** false crawl during the season.

60% of all Green turtle nesting activities occurred during August alone, including **61.2%** of all false crawls.

68% of all nesting Green turtles were found, and **32%** were missed. 13% of all false crawls and non-successful nesting incidents were found and 87% were missed.

	CHELONIA MYDAS					ERETMOCHELYS IMBRICATA	
	In-situ	Uncertain	Relocated	Didn't lay	False crawl	Relocated	False crawl
March	0	0	0	0	0	0	0
April	0	0	1	1	4	0	0
May	0	1	0	0	1	0	0
June	0	1	0	0	2	0	0
July	0	0	2	0	8	1	0
August	4	23	25	5	85	1	1
September	5	20	6	6	35	1	0
TOTAL	**9**	**45**	**34**	**12**	**135**	**3**	**1**
	88			**147**			

Table 13. Green & Hawksbill nesting totals.

Although there were a few random sporadic nests between April and July, the Green turtles only started nesting frequently from the 3rd August and the last recorded Green nest was recorded on the 30th September, making a nesting season of only 58 days. There were 42 days between the first and last Hawksbill nests.

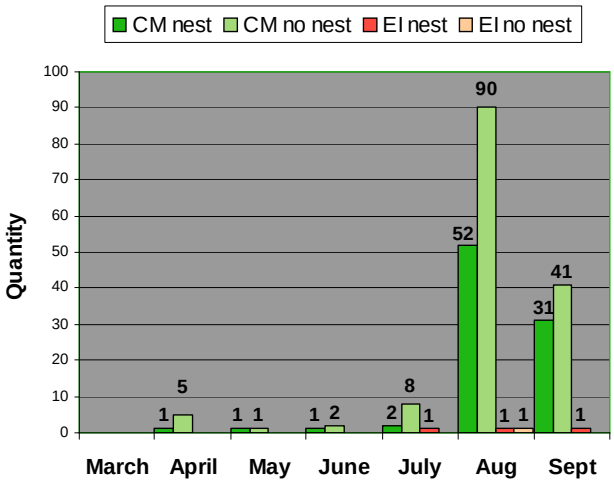


Figure 20 Green and Hawksbill monthly distribution.

Spatial distribution of Green turtles was more even spread than that of the Leatherbacks, favouring slightly more southern sectors.

- Between sectors 0-29 there were **45** nests and **70** non-nesting activities, which is **51.1%** of the total number of nests and 15 nests per Km.
- Between sectors 30-60 there were **36** nests and **65** non-nesting activities.
- Between sectors 61-75 which is the beach limit of the Pacuare river mouth there were an additional **7** nests and **12** non-nesting activities. From sector 30 this resulted in **48.9%** of the nesting total and 9.5 nests per Km.

Total Green turtle nesting density at Pacuare was **11.7** nests per Km.

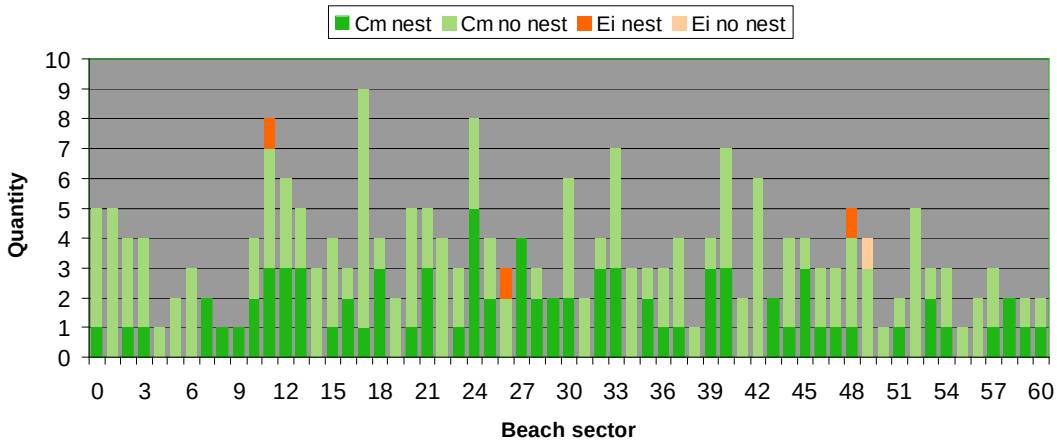


Figure 21. Green & Hawksbill spatial distribution.

In total **46** individual Green turtle females were identified.
34 were given tags and showed no signs of being tagged previously, so were registered as new-recruits to the population.
9 females were given tags that had evidence of being tagged previously and that had lost either 1 or both tags.
Only **3** females were recaptured with both of her original tags, so these **12** were registered as re-migrants.

40 Green females nested only once, and only **3** females nested twice, and **3** females came to Pacure and produced only non-successful nesting activities.

A further 41 nesting activities were recorded as "uncertain" as we arrived after the turtle had returned to the sea.

47 Green turtle carapace measurements were used to calculate the average and only 1 was removed as unreliable. Egg clutches were counted **34** times from relocated nests, and nest depth was successfully measured **17** times.

CHELONIA MYDAS	CCL	CCW	Nest depth	# Yolked eggs
Minimum	95.0	67.0	49.0	13.0
Maximum	114.0	102.0	68.0	177.0
Mean	103.7	92.7	58.0	114.2
STDEV	4.4	5.6	4.3	31.4

Table 14. Green turtle biometric data.

All 3 hawksbill nesting turtles were captured. **2** were given tags and registered as new-recruits to the population as they showed no evidence of being previously tagged.
1 female came to Pacuare after being tagged previously on another beach and there was **1** false crawl incident where the female was not identified.

ERETMOCHELYS IMBRICATA	CCL	CCW	Nest depth	# Yolked eggs
Minimum	88.0	80.0		154.0
Maximum	92.0	83.0		213.0
Mean	90.0	82.0		191.3
STDEV	2.0	1.7		32.5

All 3 hawskbill females were measured and clutches counted but nest depth was not possible to record for either activity.

Table 15. Hawksbill turtle biometric data.

Of the 88 Green nests it was only possible to retrieve hatching data from 3 nests, as the remaining 85 nests full incubation period extended beyond the project closure date of 30th September.

The first nest of the season was triangulated and was exhumed after the full incubation period as hatching evidence was not witnessed.
Of the 80 eggs within the clutch, 77 successfully hatched leaving 3 eggs without signs of embryonic development. 1 of these egg contained fungus.
This is a hatching success of **96.2%**.

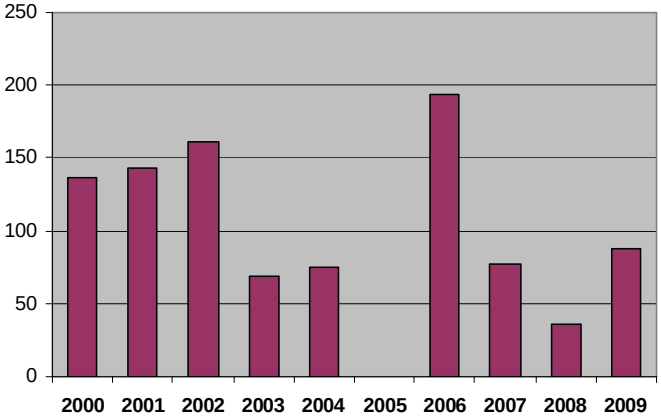
The second nest was relocated in sector 21 which suffered from severe erosion and flooding. Sadly all 123 eggs were destroyed by the extremely high tide that flooded the nest and a possibility that it was not relocated sufficiently high enough into the vegetation like the Greens prefer. The zero % hatching rate was most likely caused by human error and therefore was excluded when calculating the average.

The third nest only lost 6 eggs, 3 without embryonic development and 3 with embryos. 93 of the 98 eggs successfully hatched resulting in **94.9%**.

Due to the low sample size it is not possible to estimate an accurate hatch success, but between the 2 nests we have it is **95.5%**.
The remaining **85** Pacuare Green turtle nests contained some **9690** eggs. Using this mean hatching success it is possible that Pacuare beach produced a maximum of **9253** Green turtle hatchlings.

The only Hawksbill nest that was able to be excavated hatched **86.3%**. 18 non-hatched eggs had no signs of embryonic development, 11 eggs contained dead embryos, 6 were pipped and alive and there were 7 dead hatchlings found near the nest surface. Our 3 Pacuare Hawksbill nests could have produced a maximum of **495** hatchlings.

During the season of 2009 there were no witnessed sea turtle killings by local fishermen, nor evidence of a single live female or nest being taken from the reserve.



Nesting numbers have been historically varied over the past 10 years, but even though 2009 was the most productive over the past 3 seasons, Pacuare received only half the nesting quantity as of 2006.

Figure 22. Historic Green turtle nesting figures.

4. DISCUSSION

4.1 Nesting Trends

Despite the additional challenges at the beginning of the season with severe flooding, erosion and loss of suitable nesting sites, 2009 was a highly successful nesting season at the Pacuare Reserve. Results from the season indicate that 2009 resulted in the highest Leatherback nesting density on record since the monitoring program began in 1994.

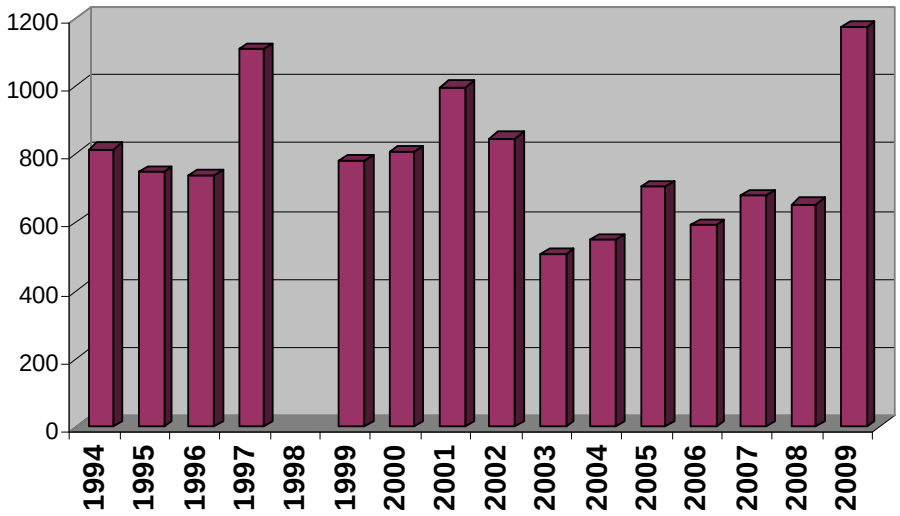


Figure 23. Historic Leatherback nesting figures.

The nesting figure from 1997 was exceptionally high due to the fact that the project coordinator at the time was investigating an additional 1km south of the Mondonguillo lagoon. Although accurate nesting data is not accessible for this 1km, it is known that the nesting density per Km is equal to that of Pacuare. Taking this into account the nesting density per Km was calculated across the 7km range and re-calculated for 6 Km producing a more accurate nesting figure. It was altered from 1293 to 1108 nests.

Also the previous nesting total for 2007 of 907 nests was inconsistent when studying the season's monthly totals and we feel an error was made. This total was also identified by David Melero in 2008 and was altered in his report to 678 nests which proves more realistic to that of the monthly nesting figures, we have used this figure also.

During each 4-year cycle, there is a distinct peak in the final nesting season, as the seasons of 1997, 2001, 2005 and the greatest peak of 2009 show. These peaks may be related to the population's nesting cycles and the variable use of other nesting beaches. Weather cycles and climatic changes in foraging and nesting zones may also be causing this 4-year peak but real conclusions can only be drawn about the population with the use of accurate

and comparable weather and nesting data throughout the region of this Leatherback population.

There was a distinct reduction in the annual nesting total between the nesting seasons of 2002-2003. This may be due to a shift in natural trends or a change in preferred nesting sites. It is speculative to suggest that this slump may have been caused by the excessive egg poaching level up until the early to mid 1990's when the conservation of Leatherbacks was first recognised in the region. The level of egg poaching would have caused a serious gap between the adult-juvenile population which only would have been noticed when older females started to fall out of the population, and due to the direct slaughter of females on neighbouring Panamanian beaches.

If Leatherbacks mature to be reproductive at the age of between 10-15 years, then we now may be seeing the start of an increase to the population thanks to the many years of conservation efforts, both at the Reserve and other regional sea turtle conservation projects.

4.2 Beach Patrols

Nightly beach patrols during Leatherback season yielded a high degree of success in encountering nesting turtles (80%). This success was achieved by instead of just waiting for long periods for an encountered turtle to start nesting, 1 or 2 members of the patrol would continue patrolling for 5 minutes or so checking if there were any more nesting turtles close by, ensuring that a maximum number of turtles were encountered.

The participation of the guards by alerting us when they had found a turtle and marking nests for later triangulation or relocation, proved to be very successful.

Effective management of the patrol groups is essential in ensuring that the beach is covered evenly between patrols and guards, ensuring that large areas of beach are not left uncovered for long periods of time, and that breaks are short and timed accordingly. Also such a high level of commitment to extend patrols up to 6 or 8 hour duration ensured that a high amount of turtles were worked with.

All of these methods resulted on many occasions working with several turtles simultaneously, which greatly increased the quantity of data collected and ultimately increased the amount of nests protected.

4.3 Tagging and Population Monitoring

The nesting zone of this population is widespread, covering many beaches from Costa Rica to Columbia, which are all monitored by various independent NGO's or institutions. Even though Leatherbacks may nest 10 times during their reproductive season, they show minimal nesting site fidelity. In order to

be able to analyse localised nesting patterns it is essential to study all nesting sites data, or at least be able to identify varying tag series at all nesting sites.

The WIDECAST regional Caribbean database must be made available to all participating sites relevant to this population of Leatherbacks as the history of re-migrant turtles cannot be studied otherwise. The CD of the database was requested several times from WIDECAST in order to check re-migrant females tag numbers, but was not issued before the closure of the season by 30th of September.

The 2009 nesting season saw the highest density of nesting Leatherbacks for the last 15 years, as well as an incredibly high number of new-recruits to the population (25%). Although this seemed a common trend across the region, indicating large numbers of new females, what possibly could have affected this data is that of some projects were only PIT tagging their new-recruits and avoiding using monel tags to identify them. Most projects in the region are unable to PIT tag turtles or to scan nesting females for PIT tags, perhaps resulting in turtles being incorrectly identified as new-recruits. This problem can only be rectified by either looking at the entire regions nesting data to compare monel and PIT tagged females, or for each project who are able to use PIT tags to also continue using monel tags as well, until all projects are equipped with scanners and PIT tagging equipment.

It would be beneficial to Pacuare and all regional sea turtle conservation projects to reintroduce, or start PIT tagging as they are a more permanent identity tag, causing less pain to the turtle and less liable for infection or tag loss. In 2009 there was a batch of monel tags that were exceptionally oily which caused notable infections when the turtle was recaptured, even after thoroughly cleaning them with alcohol. We were advised by Didiher Chacón to soak tags in gasoline, dry them in the sun and burn off the excess with a flame. Also this batch of tags were slightly misshaped compared to the previous batch causing many tag teeth to bend forward or not hook correctly under the dimple bar. This caused unnecessary pain or discomfort and many turtles were tagged up to 3 times before one was correctly attached. On some occasions each flipper was tagged the maximum three times without a tag fixing correctly.

It is also essential that there is more communication between projects and is advisable that each site knows the tag series used at different nesting beaches. Bad tags were repeatedly encountered of the same series either in a bad location causing the turtle discomfort, embedded in the skin, too loose and even repeatedly upside down. Projects should be made aware of this and additional training given to repeat offenders as the tagging process is a delicate and sometimes painful operation that we need to ensure is carried out to the highest of standards and greatest of care.

4.4 Beach Security and Egg Poaching

During the week running up to the 1st March, human and dog footprints were found on the beach and 3 Leatherback nests were identified with clear evidence of nest poaching. As we started night patrols, it was clear that the project season had started and evidence of poachers stopped. Pacuare beach security consisted of 3 guards at each station working a 4-hour shift during the day and 4 hours at night which resulted in 24-hour beach coverage.

On several occasions poachers were found on the beach and chased off the Reserve, however there were only 2 accounts of confirmed attempted poached nests upon finding clear evidence of open egg chambers from in-situ nests. Luckily on these 2 occasions, nest had been relocated and they were excavating the original nest chamber.

With all the hard work erasing all nesting evidence, relocating nests and constant security patrols, it was upsetting to discover that one of our local beach security guards, Juan Mendoza, was liaising with other egg poachers in the forest and advising them of the locations of many fresh relocated nests. The nests were poached, filled in and perfectly camouflaged whilst burying the small yolkless eggs and nest identification tape back into the nest, displaying signs of not trying to attract our attention. These nests were only discovered as poached upon triangulation and excavation after the 80-day full incubation period. After hearing many rumors in Bataan and Matina and some suspicious incidents at the Reserve, Juan was asked to leave on 23rd of April.

Poached nests were confirmed by either discovering evidence of a freshly excavated nest or upon triangulation after the 80 day incubation period discovering only small yolkless eggs, and/or nest flagging tape confirming the exact location of the nest but with no large egg remains. If a triangulation met exactly and a definite soft nest chamber found without tape or egg remains, it was also noted as a poached nest.

A total of 25 nests were poached before the 23rd of April, mainly in northern sectors (as Juan had mainly been in the North station) or around sector 30. After his departure there were no suspicious circumstances, and not a single nest was confirmed as poached in Pacuare for the remaining 5 months of the season.

Taking this into account it is safe to say that erasing all nesting evidence and flattening all nests and tracks, constant 24-hour beach security and the high rate of nest relocation, there could possibly have been a zero % poaching rate in Pacuare if it wasn't for our employed beach guard / poacher.

4.5 Nest Relocations and Triangulations

Due to the extreme weather and bad beach conditions of 2009, it was decided that as many nests as possible should be relocated to safer parts of the beach. Even though the beach eventually widened, during each new and full moon phase, either erosion worsened, or the high tide flooded the entire

nesting zone almost into the vegetation along many parts of the beach. This means that the majority of zone B in-situ nests could possibly have been repeatedly flooded and even destroyed if they were not relocated. Although the turtles nesting zone was recorded during night patrols, the data was not included in the results as the high tide line was repeatedly up to the vegetation line eliminating zone-B for many parts of the season.

The hatching success showed only minimal variation between in-situ and relocated nests. This is probably due to the fact that all nests were relocated within close proximity to the original nest whenever possible and therefore spent less time being moved, avoided prolonged periods out of the sand, reducing the effects of temperature loss or excessive movement of the clutch of eggs.

It is always preferable to leave as many nests as possible in-situ, to be left to hatch naturally. Poaching levels in the Reserve in 2009 were only 2%, so if beach conditions are more favourable in subsequent seasons, a higher percentage of nests should be left in-situ. However, it is imperative that great care is still taken to fully camouflage all nesting evidence and to triangulate all in-situ nests in order to be able to retrieve hatching data of both hatched and non-hatched nests. This will show a more accurate survivorship figure to that compared to only excavating nests that were witnessed as hatched as in previous years.

64.5% of all nests were triangulated, allowing for a high percentage of nest recovery for excavations. The new method of triangulation used in 2009 (using 2 marker posts and a third point of triangulation without flagging tape) was very successful and makes nest identification by poachers much harder without the visual clues of the flagging tape in the vegetation guiding them to the nest area. This also eliminates the disadvantage of flagging tape, which can blow away, disintegrate, or be destroyed by insects. Care must be taken to note down this third point accurately, so it can be used for re-triangulation at a later date.

4.6 Eroded and Lost Nests

1.7% of all nests were eroded. Nests were confirmed as eroded by either discovering the remains of a nest inside a wall of erosion while all other eggs had already been washed away by the tides, or by means of a triangulation point meeting at the bottom of a wall of erosion of at least 80cm deep and not being able to find any nest remains.

1.2% of all nests were ‘lost to bad triangulation’. Nests were labelled as such when the nest chamber of a triangulated nest could not be located due to inconsistent measurements, even after extensive searching with a ‘chuso’ (egg poachers stick) and digging several large holes in the general area.
It is important that great care is taken during the triangulation process and data should be checked and confirmed by the RA before leaving the relocation site.

Some in-situ non-triangulated nests were lost when the stick indicating hatching evidence was washed away by high tides or kicked over. As there was no triangulation data to locate the nest, these nests were lost even though they had hatched

4.7 Green Season

Unlike during Leatherback season when poachers only collect their eggs, Green and Hawksbill turtles also face risk of slaughter due to the economic value of their meat and carapace. Due to this increased threat, guard patrols and night patrols were extended from the North Station to the river mouth to ensure that any nesting greens or Hawksbills were not taken from the beach for slaughter**.**

The 2009 Green nesting season was less brutal than that of the previous year. In 2008 we repeatedly witnessed local fishermen within 1km of the shore, capturing, harpooning and killing Green turtles in front of the Reserve. During witnessed attacks on sea turtles, phone calls to pressure the coastguards based at Moin and Limon to assist were made.

On two occasions Green turtles were found upturned by poachers, whom we assume were scared off by our night patrols. The extension in patrol area proved successful as during the season 8 nesting Green turtles were found in this 2km danger zone. Without this presence, it is certain that not only these nests would have been taken but the turtles also killed.

Overall, 2009 saw a reduction in the levels of Green turtle hunting, with no kills witnessed on the Pacuare beach. There was a greater coastguard presence resulting in more sea and canal patrols and regular visits to Pacuare. On numerous occasions the coastguards and local police caught fishermen with sea turtles on board their boats and local egg poachers were caught with sacks of eggs. We hope that the authorities can continue their good work in 2010 and beyond.

The 32% level of missed nesting Green turtles is much higher than Leatherbacks (20%), due to the increased threat of a green turtle being taken or killed, so turtles were not left until they had returned to the sea.

At the start of the Green turtle nesting season we were tagging between their first and second scales as this was historically practiced at the reserve. However the Inter-American Convention manual of 2008 states they are to be tagged on their second scale. Therefore our methodologies were brought in line with the IAC.

5. Recommendations

5.1 Beach Patrols

- Continue efforts to find additional nesting turtles within close proximity to an encountered turtle in order to maximise data collected and nests protected.
- Positions of groups on the beach during patrols should be carefully timed, based on current nesting patterns and the location of other groups and guards to maximise beach coverage. Excessive breaks should not be taken during patrols as this leaves areas of the beach uncovered and turtles may be missed.
- When needed, guards should be involved with the work of night patrols, taking any tag data and marking nests if patrol groups can not arrive on time.

5.2 Tagging and Population Monitoring

- PIT tagging should be reintroduced at the Reserve
- The WIDECAST database should be made available at the beginning of the season.
- Ideally, a Pacuare database, including historical nesting data should be established.

5.3 Security and Egg Poaching

- Continue with guard patrols covering the beach 24 hours a day.
- Construct a basic guard tower at sector 30 to provide increased beach visibility.

5.4 Nest Relocation and Triangulation

- Leave a much higher rate of nests 'in-situ' if beach conditions are favourable.
- Continue to triangulate as many nests as possible to allow for nest excavations of nests where no hatching evidence is witnessed. Producing a more realistic value of nest survivorship and hatching success
- Consider triangulating witnessed hatched non-triangulated nests to avoid loss of nest survivorship data if hatching evidence sticks are displaced.
- It is imperative that when working with groups or volunteers, RA's check the nest depth and shape of relocated nests before eggs are deposited, as sometimes the eggs were too close to the surface which would increase the chances of nest predation, or cook the eggs.

5.5 Green Season

- During Green season, patrols should be extended to the Pacuare river mouth to offer better protection to the nesting turtles and ward off poachers.
- Extending patrols to Stanley's project during Green season should also be considered, as after mid July the Estación de Tortugas is officially closed.
- Due to the late start of the nesting season, in 2009 the majority of green nests went unexcavated and therefore the overall success of the season in unknown. If possible, one of the local Ras should come back after the official end of the Green season to ensure that all nests are excavated and important data retrieved.
- Increased contact with the Coastguards is essential to ensure regular sea and canal patrols to help mitigate the Green turtle slaughter problem. They should also be invited to spend a night at the Reserve and patrol the beach, as this will be talked about in the local community and deter turtle poachers.

5.6 General

- Data collection methods must remain consistent across the seasons and ideally should follow a Pacuare Manual to allow for comparable data each year. Data collection should also be in line with methods conducted by the Inter-American Convention and those used by EPI.
- A basic weather station needs to be set up to record air temperatures, humidity level, rainfall, winds speed etc, to monitor how weather conditions may affect nesting patterns and hatching success.
- The use of I-buttons or similar equipment is recommended to record and monitor nest temperatures in selected nests to provide information regarding estimated hatchling sex ratios.

6. CONCLUSIONS

All sea turtles are listed between threatened and critically endangered by the IUCN. They have been hunted and exploited for hundreds of years across the globe and in many areas may face localised extinction within the next few decades. Government laws in many countries are now protecting sea turtles and there are many institutions and NGO's all working for their conservation. Education is the key to changing local attitudes within communities that exploit sea turtles and long term habitat protection and population monitoring is essential in the hope for increased population trends.

The Endangered Wildlife Trust has been committed to sea turtle conservation and rainforest habitat protection for 20 years in Costa Rica. The success of the project continues to increase, due to the ongoing dedication of the EWT team in England, Costa Rica, Panama and to the national and international team of project coordinators, research assistants, volunteers, EPI, other student groups and tourists that participate in the project each year.

2009 was one of the most successful seasons in the history of Reserva Pacuare, with the highest Leatherback nesting density since records began, perhaps a reflection of the dedicated and ongoing conservation work carried out by the EWT and other regional sea turtle projects over the past few decades.

Costa Rica is considered to be one of the world leaders in sea turtle conservation. The standardisation of working methods, effective population monitoring, collaboration between projects, enforcement and strengthening of conservation laws, increased education and raising of awareness are some of the key elements in increasing the level of protection and ultimate preservation of sea turtle populations in Costa Rica and across the globe.

Appendix.1 Leatherback catalogue

TAG LEFT	TAG RIGHT	CCL	CCW	NEST	NO-NEST	TAGS REMOVED.
0.6313	PM0371	164.0	115.0	1	1	
0.8022	**PN1634**	156.0	122.0	1		
0.9069	**PN1438**	140.0	104.0	4	2	
3662	**PN1254**	150.0	116.0	1		
65075	65074			1		
65108	65109	153.0	120.0	2		
69443	VA5119	161.5	118.0	2		
69489	**PN1249**	163.5	116.5	4		
69548	VA2991	154.5	107.5	2		
72036		161.0	119.0	1		
76184	PM0513	148.0	110.0	1		
76861	**PN1229**	166.0	114.5	3		
77001	77098	159.5	116.5	2		
77937	77936	150.0	103.0	1		
79282		154.0	111.0	1		
79283	79286	155.0	115.0	1	1	
79323	79401	157.0	106.0	2	2	
	79359	155.0	107.0	1		
79406	79407	158.0	117.0	1		
79675	79674		121.0	3	1	
79743	VC0080	149.0	116.5	2	1	
79754		150.5	111.0	1	1	
79809	79808	150.0	111.0	1		
79929	VA4163	161.0	114.0	1	1	
?4698	V2602	178.0	132.0	1		
	V2260			1		
CAN304	CAN398	151.0	109.0	1		
CH1040	VC				1	
CH1287	CH1287	134.0			1	
CH2165		146.0	110.0	1		
CH5226	CH5227	140.0	101.0		1	
CH5301	CH5302				1	
CH5321	CH5323	145.0	106.0	1		
D6107	PM0447	158.0	113.0	2	1	
D7970	D7971			2	1	
D7989	76889	154.5	111.5	2		
D7997	D7998	154.0	117.0	3		
PM0166	PM0431	156.2	110.0	1		
PM0359	VA7914	155.5	117.0	1		
PM0368	PM0367	142.0	101.5	1		
PM0389	PM0390	149.5	107.0	4		
PM0411	PM0410	146.0	111.0	1		
PM0418	PM0419	145.0	113.0	1		
PM0420	PM0412	135.0	110.0	2		
PM0428	PM0429	157.0	109.5	1		
PM0437	79198	150.0	110.0	5		
PM0448	PM0458	160.5	117.5	2		
PM0449	PM0450	147.0	106.0	1		

PM0453	PM0440	155.5	115.5	3	4	
PM0455	PM0460				1	
PM0461	PM1238			2		
PM0462	PM0464	162.0	107.0	4		
PM0469	PM0470	156.5	112.5	1	1	
PM0474	VA9043	154.0	110.0	1		
PM0477	PM0555				1	
PM0479	VA5472	156.0	111.0	1		
PM0498	PM0499	147.0	109.0		1	
PM0532	PM0533	159.0	118.0	1		
PM0537	PM0538	133.5	101.0	2		
PM0558	PM0560	137.0	105.0	1		
PM0563	PM0562	149.0	105.0	1		
PM0566	PM0567	140.0	101.0	2	1	
PM0569	PM0574	160.0	112.0	1		
		149.0	110.0	1		Left tag PM0572 but no new tag given.
PM0584	PM0585	149.0	112.0	1	2	
PM0605					1	
PM0731				1		
PM0735	**PN1362**	138.5	100.0	1	1	
PM0737	PM0738	148.0	108.5	2		
PM0743	PM0744			1		
PM0746	PM0747				1	
PM0749	VA5472	156.0	112.0	3	1	
PM1094	VA2757			1		
PM1530	PM1532				1	
PM1568		161.0	119.0		1	
PN0342	VA3898	151.0	111.5	1		
PN0361	PN0360	144.0	102.0	1		
PN0396	PN0369				1	
PN0399	PN0728	145.0	102.0	1		
PN1005	**PN1072**	152.5	114.0	2		
PN1008	**PN1009**	142.5	108.5	3		
PN1012	**PN1086**	156.0	114.0	2		
PN1066	PN0431	152.0	106.0	2		
PN1073	**PN1074**	134.0	96.5	2	1	
PN1079	**PN1424**	143.0	111.0	1	5	Right original tag VA9870 but lost.
PN1083		139.0	103.0	1		
PN1086	**PN1087**			1		
PN1093	**PN 1555**	153.0	105.0	2	1	
PN1094	VA2757			1		
PN1095	79172	151.0	116.0	1		
PN1107	PN1138	140.0	105.0	1		
PN1109	VA4421	146.5	112.0	1		
PN1113	PN1114	156.0	114.0	2		
PN1117	PN1118			1		
PN1129	PN1144	145.0	108.0	1		
PN1141	**PN1142**	141.5	111.0	1		
PN1149				1		
PN1161		153.5	113.0	2	1	
PN1169	V2994	154.5	113.0	1	1	
PN1174	**PN1175**			1		
PN1182	PN1183	146.0	104.0	1		

PN1184	VC0332	143.0	108.0	1		
PN1191		151.0	119.0	1		
PN1202	**PN1203**	160.5	114.0	4		
PN1204	**PN1205**	167.0	110.0	1	1	
PN1208		153.0	110.0	1		
PN1211	**PN1253**	153.5	114.0	2		
PN1216	**PN1217**	143.5	106.5	1		
PN1219		144.0	111.0	1		
PN1224	VA5915	154.0	113.0	4		Left tag PN1224 later removed but no new tag given.
PN1226	**PN1227**	147.0	112.0	1		
PN1230	**PN1278**	152.0	109.5	3		
PN1231	**PN1232**	147.5	109.0	4		
PN1233	**PN1234**	152.5	110.0	2		
PN1237	**PN1238**	164.0	118.0	1		
PN1240	VA5497	160.0	114.0	1		
PN1245	VA1213	158.0	114.0	1		
PN1250	VA5108	144.5	102.0	2		
PN1251	**PN1254**	138.5	103.5	2		Original Left tag PN1251 later removed, changed to PN1439
PN1255				1		
PN1258	**PN1259**	142.0	103.0	1		
PN1262	**PN1263**	147.0	110.0	2		
PN1264	**PN1210**		110.0	2		
PN1266		154.0	118.0	1		
PN1270	D8065	159.0	114.5	3		
PN1272	**PN1273**	152.5	111.0	3		
PN1280	**PN1281**	166.0	120.0	1		
PN1282	**PN1283**	143.5	110.0	3		
PN1289	**PN1288**	156.0	115.0	1		Original Right tag VA3230 removed,
PN1290	**PN1291**	135.0	108.0	1		
PN1292	**PN1293**	137.0	101.0	1		
PN1295	**PN1297**	165.0	119.0	1		
PN1300	VC0088	157.0	111.0	1		
PN1302	**PN1310**	152.0	107.0	3		
PN1303	**PN1401**	140.0	100.0	2		
PN1305	**PN1306**	157.5	108.5	2		
PN1323	**PN1394**	153.0	110.0	1		
PN1328	**PN1677**	158.0	112.0	1		
PN1330	**PN1331**	142.0	106.5	3		
PN1336					1	
PN1398	VC0226	152.5	112.0	4	1	
PN1342	**PN1343**	134.5	99.5	3	1	
PN1349		154.0	113.0	1		2 DIFFERENT TURTLES BADLY NOTED
VA9351	**PN1349**	169.0	120.0	1		
PN1351					1	
PN1352	VA3028			2		
PN1353	**PN1354**	148.0	105.0	1		
PN1356	**VC0462**	140.0	103.0	1		
PN1357	**PN1358**	146.0	100.0	1		
PN1363	**PN1364**	154.0	111.0		1	
PN1365		147.0	110.0	1		
PN1368	**PN1369**	150.0	109.0	1		

PN1374	**PN1375**	153.0	107.0	1		
PN1376	**PN1377**	154.0	109.5	1	1	
PN1382	**PN1383**	147.0	107.0	1		
PN1384	**PN1385**	142.0	109.0	1		
PN1386	**PN1387**	153.5	115.5		2	
PN1390	VA4671	149.0	113.0	1		
PN1392	**PN1393**	159.0	111.5	2		
PN1396	**PN1397**	151.0	116.0	1		
PN1401	**PN1402**	155.0	112.0	2	1	
PN1403	**PN1404**	142.0	99.0	1		
PN1405	**PN1453**	145.0	107.0	2	2	
PN1407	**PN1408**	138.0	98.0	2		
PN1411	**PN1412**	147.0	105.0	1		
PN1413	**PN1414**	152.0	113.0		1	
PN1415	76212			1		
PN1417	**PN1629**	161.0	120.0	3	1	RIGHT TAG PN1416 CHANGED FOR PN1629
PN1419	**PN1420**	142.5	106.5	2		
PN1422		136.0	98.0	1		
PN1425	**PN1446**	149.0	108.0	2		PN1425 LATER REMOVED
PN1426	PN1293	137.0	100.0	1		
PN1427	**PN1428**	150.0	108.0	1		
PN1429	**PN1430**	150.5	107.0	2		
PN1431	**PN1491**	146.0	105.0	2		
PN1433	**PN1434**	139.0	99.0	1	1	
VA5446	**PN1423**	153.0	107.0	1		
PN1435	**PN1436**	150.0	108.0	1		
PN1441	**PN1442**	157.0	110.0	1		
PN1443	**PN1444**	142.5	105.0	2		
PN1456	**PN1457**	149.0	13.5	4		
PN1458	**PN1459**	155.5	109.0	1		
PN1460	**PN1461**	139.0	104.0	2		
PN1462	**PN1463**	141.0	105.5	2	1	
PN1464	VA0746	147.5	113.5	2	1	
PN1466	V4822	155.5	108.5	2		
PN1467	VA0352	152.0	109.0	2	1	
	PN1469	145.0		1		
PN1471	79482	162.0	113.5	2	1	
PN1476	PM0371	157.0	113.0	1		
PN1477	**PN1478**			2		
PN1479	**PN1480**	147.0	103.0	2		
PN1482	**PN1484**	147.5	107.5	1		
PN1483		157.0	116.0	1		
PN1485	**PN1486**	151.0	113.0	1		
PN1487	**PN1488**	154.0	113.0	1		
	PN1335	158.0	110.0	1		
PN1490	PN1335	158.0	113.0	2		
PN1493	**PN1494**	144.5	103.0	2		
PN1497	**PN1498**	157.0	112.0	1		
PN1499	**PN1500**	140.5	110.0	3		
PN1501	**PN1502**	142.0	104.0	1		
PN1503	**PN1504**		109.0	1		
PN1505	**PN1506**	138.0	105.0	2		

PN1507		134.0	86.0	1	1	
PN1509	**PN1379**	152.0	113.5	2		
PN1511	V2508	164.0	119.0	1		
PN1513	**PN1514**	152.0	112.0	1		
PN1515	**PN1516**	142.0	106.0	1		
PN1517	**PN1518**	146.0	107.0	1		
PN1519	**PN1520**			1		
PN1521	**PN1522**				1	
PN1523	**PN1524**	156.0	108.0	1		
PN1525	VA2224	148.0	106.0	1		
PN1526	**PN1527**	154.5	108.0	2	2	
PN1528	**PN1529**			1		
PN1530	**PN1531**	162.0	114.0	1		
PN1532	**PN1533**	149.0	106.0	2		
PN1534	VA2807			1		
PN1536	VA3118	153.5	106.5	2	1	
PN1537	**PN1510**	160.0	119.0	1		
PN1539					1	
PN1540				1		
PN1541	**PN1542**				11	
PN1543	**PN1544**	147.0	101.5	2	1	
PN1545	61642			1		
PN1546	V2574	154.0	112.5	1		
PN1547	**PN1548**	140.0	104.0	2		
PN1549	**PN1550**	147.0	110.0	1		
PN1551	**PN1552**	142.0	104.0	2	1	
PN1553	**PN1554**	143.0	105.0	2		
PN1556	**PN1557**	153.0	111.0	2		
PN1558	**PN1559**	164.0	117.0	1		
PN1560	**PN1561**	146.0	109.0	2		
PN1562	**PN1563**		107.0	1		
PN1564	**PN1565**	148.0	107.0	1		
PN1566	**PN1567**	138.0	106.0	1		
PN1568		161.0	114.0	2		Left tag VC0254 was replaced with PN1590, then later replaced with PN1568, Right tag VA3769 removed.
PN1569	CH4387	153.0	106.0	1		
PN1570	**PN1571**	137.0	102.5	1		
PN1572	**PN1573**	145.0	113.0	1	1	
PN1576	VA4716	142.0	105.0	1		
	PN1578	152.0	114.0	1		
PN1581	**PN1582**	134.0	104.0	1		
PN1584	**PN1585**	143.0	98.5		1	
PN1586	**PN1659**	152.0	113.0	2		Original Left tag VA4779 replaced with PN1586.
PN1587	**PN1298**	176.5	126.0	1	2	OLD TAG LOST VA1511
PN1588	VA9415	162.5	112.5	2		
PN1589	VA9796	141.0	103.0	1		
PN1591		148.0	105.0	1		
PN1593	**PN1594**	142.0	108.0	1		
PN1597	**PN1598**	144.0	108.0	1		
PN1599	**PN1600**	152.0	114.0	1		
PN1603	**PN1604**	150.0	107.0	1		

PN1605	VA9046	160.0	118.0	1		Right tag VA9006 replaced with PN1605.
PN1607	**PN1608**	145.0	106.0	1		
PN1609	**PN1610**	141.0	100.0	1		
PN1611	**PN1612**	164.0	119.0	1		
PN1613	**PN1614**	136.0	100.0	1	1	
PN1617	**PN1618**	155.0			1	
PN1619	**PN1620**	138.0	105.0	1		
PN1621	**PN1622**	141.0	106.0		1	
PN1623	**PN1624**	146.0	107.0	1		
PN1625	**PN1626**	153.0	109.0	1		
PN1628	**PN1616**	144.5	102.5	2		
PN1630	VA9139	160.0	108.0	1		
PN1631	VA8370	140.0	104.0	1		
PN1632	**PN1633**	147.5	102.0	2		
PN1636	**PN1637**	157.0	116.0	1		
PN1638	???31	161.0	107.0	1		
PN1639	**PN1640**	143.0		1		
PN1641	**PN1642**	147.0	106.0	1		
PN1643	**PN1644**	148.0	108.0	1		
PN1645	**PN1646**	148.0	108.0	1		
PN1647	**PN1648**	144.0	101.0	1		
PN1649	**PN1650**	137.0	100.0	1		
PN1655	**PN1656**	154.0	108.0		1	
PN1657	**PN1658**	154.0	113.0	1		
PN1660	**PN1661**	153.5	110.5	2		
PN1662	VA4759	151.0	108.0	2	1	
PN1664	VA9704	150.0	110.0	1		
PN1666	**PN1667**	151.5	111.0	1	1	
PN1668	**PN1669**	147.0	107.0	1		
PN1670	**PN1671**	126.0	99.0	1		
PN1672	**PN1673**	158.0	111.0	1		
PN1674	**PN1675**	144.0	102.0	1		
PN1678	**PN1679**	147.0	101.0	1		
PN1680	**PN1681**	152.0	117.5	2		
PN1682	**PN1683**	145.5	110.5	3		
PN1686	**PN1687**				1	
PN1688	**PN1689**	144.0	107.5	2	1	
PN1691	**PN1391**	149.5	110.0	2		
PN1692					1	
PN1693	VA5866	157.0	112.0	3	1	
PN1694	**PN1695**	148.0	104.0	1		
PN1696	**PN1697**	140.0	109.0	2		
PN1698	**PN1699**	160.0	112.0	1		
PN1701	**PN1702**	154.0	111.5	2		
PN1741	**PN1742**			1		
PN1745	**PN1746**	160.0	115.0	1		
PN1772	**PN1773**	155.0	109.0	1		
V0661	**PN1676**	165.0	113.0	1		
V1039	D7739	163.0	115.0	2		
V1703	VC0292	151.0	111.0	2		
V1887		157.0	107.0	1		
V1888	PM0473	154.0	110.0		1	
V1939	V1829	155.0	108.5	2	1	

V2131	V2132	160.0	112.0	1		
V2202	D7388	160.0	119.0	4		
V2223	V2224			1		
V2511	PM0362	160.0	114.0	1		
V2544	VA9705	151.0	113.0	1		
V2817	V2818	157.5	116.0	2		
V2863	V2864	160.5	119.5	2		
	V2964	155.0	118.0	1	1	
V2979	VA9415	168.0	115.0	4	1	
V4080	VA5929	144.0	98.0	1		
V42181		156.0			1	
V4423	V4424	158.0	118.0	2		
V4634	V4782	143.0	104.0	1		
V4782	V4783			1		
V4805	VA5492	162.0	115.0	1		
V4825	V4826	143.0	114.0	2		
V4865	V4866	164.5	119.0	6	1	
	V4915	155.0	115.0	1		
V4968	PM0454	148.0	108.0	1		
V4977	VA8719	165	121	2		
VA3604	VA3628	168.0	122.0	2		
VA0350	VA1555	144.0	107.0	1		
VA0352		154.0	109.0		1	
VA0583	VA0584	143.0	110.0	2		
VA0595	VC0447	156.0	112.0	1	1	
VA0835	VA0834	151.5	110.0	2		
VA0987	VA0986			1		
VA0996	VA0453	153.0	112.5	2		Old right tag VC0112 not removed by Pacuare.
VA1054	**PN1489**	142.5	109.0	3		
VA1131	VA9276	146.5	106.0	1	2	
VA1201	VA1202	156.0	108.0	1		
VA1221	VA1220	152.0	113.0		1	
VA1232					1	
VA1407	VA1408	164.0	116.0	1	2	
VA1449	PN1057				1	
VA1452	VA1461	153.0	113.0	1		
VA1458	PN0454	150.0	108.0		1	
VA1469	**PN1651**			1	1	
VA1513	VA1514	154.0	112.5	1		
VA1573	VA1686	155.0	110.0	1		
VA1579	PM0526	159.5	115.5	3		
VA1602	D7918	145.0	111.0	6	2	
VA1618	V2708	141.0	109.0		1	
VA1627	**PN1579**	153.5	108.0	2		
VA1645	VA1646	150.0	109.0	1		
VA1673	VA1686	156.0	109.5	1		
VA1678	V2708	150.0	114.0	1		
VA1700	VA1701	165.0	118.0	1	1	
VA1756	VA1757			1		
VA1803	VA1812		113.0	1		
VA1924	VA1923	148.0	112.0	2		
VA1930	**PN1583**	145.0	104.5	2		

VA2033	VA2032	153.0	105.0	1		
VA2101	**PN1700**	155.0	111.0	3		
VA2149	VA9044	144.5	111.0	2		
VA2172	VA1680	157.0	110.0	1	1	
VA2181	PM0500	162.5	119.0	3		Right tag VA1125 either lost or removed by another project.
VA2182	**PN1575**			1		
VA2207	**PN1279**	154.0	114.0	1	1	
VA2213		155.0	121.0		1	
VA2217	VA2218	156.0	110.0	1		
VA2223	VA2224	150.0			1	
VA2303	VA2304	153.0	115.0	1		
VA2307	VA2308	157.0	113.0	1		
	VA2470	153.0	111.0	1		
VA2776				1		
VA2862	VA2861	154.0	114.0	1		
VA2990	VA2987	153.0	111.0	2		
VA3059	VA3058	157.0	115.0	1		
VA3062	VA3061	153.0	110.0	3		
VA3072	V4984	163.0	112.0		1	
VA3110	VA3516	156.0	109.0	1		
VA3122	PM0406	142.0	108.0	2		
VA3164	79241	158.0	108.0	3	1	
VA3171				1		
VA3190	VA3191	154.0	118.0	3		
VA3226	VA3227	150.0	109.0	1		
VA3236	VA3237	158.0	115.0	1		
VA3297	VA4651	150.0	103.0	1		
VA3320	V4768	151.0	116.0	2	1	
VA3374	VA3373	151.0	115.0	1		
VA3475	79225	156.5	115.0	2		
VA3476	**PN1200**	151.0	115.0	1		
VA3526	VA3527	153.0	110.0	2		
VA3561	VA3562	152.0	117.0	1		
VA3584	VA2337	160.0	113.0	1		
VA3589	VA3590	157.0	120.0	1		
VA3591	PM0375		106.0	2		
VA3611	**PN1366**	147.0	110.0	1	1	
VA3662						Right tag PN1257 removed but not replaced.,
VA3682	VC0020	163.5	116.0	2		
VA3697	VA3698	153.0	113.0	2		
VA3699	VA9500	154.0	112.0	1		
VA3714	VA3715	155.0	109.0	1		
VA3724	VA3729	156.0	113.0	1		
VA3733	VA5989	159.0	111.0	1		
VA3744	VA3745	154.0	111.0	1		
VA3774	VA3745	153.0	115.0	1		
VA3791	VA8640		109.0	1		
VA3823	**PN1222**	154.0	119.0	2		
VA3947	VA5948				1	
VA3963	VA3964				1	
VA4042	VA4041	147.5	110.0	1		

VA4053	VA4052	140.0	104.0	1	1	
VA4180	VA4968	150.5	107.5	2		
VA4222	VA4223	146.0	109.0	2		
VA4327	VA4328	145.0	102.0	1		
VA4352	VA4353	144.0	109.0	1		
VA4374	VA4395	144.0	105.0	3		
VA4376	**PN1601**	147.0	113.0		1	
VA4391	73911	171.0	133.0	1		
VA4394	VA4395	145.0	106.0	1		
VA4423	VA4424			1		
VA4523	VA4524	143.0	113.0	1		
	VA4539	151.5	107.5	1	1	
VA4610	VA4611	146.0	105.0	3		
VA4632	VC0157				1	
VA4644	VA4645	149.0	107.0	2		
VA4662	VA4663	154.0	110.0	1		
VA4666	VA4667	149.0	109.5	1		
VA4706	VA8910	156.0	115.0	1		
VA4715	VA4716				1	
VA4749	VA4750	149.0	107.0	2		
VA4769	VA4768			1		
VA4799	VA4800	142.0	103.0	1		
VA4801	VA4802	155.5	114.0	1		
VA4804	VA4803	161.5	113.5	2		
VA4812	PM0488	144.0	100.0	2		
VA4814	VA4805	159.5	113.5	2		
VA4818	VA2220	154.0	124.0	1		
VA4819	VA4820	157.0	110.0	1		
VA4831	VA5891			1		
VA4834	VA4835	144.5	106.0	1		
VA4835	VA4834	142.0	106.0	1		
VA4843	VA4844	150.0	110.5	3		
VA4846	**PN1635**	163.0	129.0	1		
VA4848	VA4754			1		
VA4914	VA4913	149.0	109.0	1		
VA4924	VA4923	148.0	124.0	1		
VA4931	79311				1	
VA4937	VA4939	140.0			2	
VA4953	VA4952	156.0	107.5	1		
VA4955	VA4954			1		
VA4970	VA4971				1	
VA4977	VA4775?				1	
VA5047	VA5048	146.0	105.0	1		
VA5101	VA5102	154.0	108.0	2		
VA5115	VA5116	158.0	112.0		1	
VA5368	VA5364	136.0	106.0	1		
VA5413	**PN1261**	153.0	117.0	3	1	
VA5415	VA8716	155.5	108.0	2		
VA5440	69578			1		
VA5448	VA5447	145.0	100.5	3		
VA5466	PN1437	153.0	106.0	2	1	
VA5468	VA5469	149.0	110.0	1	1	
VA5480	VA4364	154.0	115.0	1		

VA5485	VA9342	144.0	102.5	1	1	
	VA5568			1		
VA5640	VA5641	146.0	100.5	1		
VA5751	VA5752			1		
VA5759	VA59…..				1	
VA5850	VA5881	152.0	112.0	1		
VA5854	VA5942	141.5	104.0	1	1	
VA5893	VA5907	147.0	109.5	2		
VA5899	VC0150	156.0	110.0	2	2	
VA5936	VA5886	149.0	112.0		1	
VA5937	VA2633	147.0	107.0	1		
VA5947	VA5948	141.0			1	
VA5951	VA5952	148.0	102.0	1		
VA5955	VA5956	156.0	114.0	1	3	
VA5957	VA5359	154.0	112.0	1	1	
VA5960	VA5961	153.0	110.0		1	
VA5965	VA5935	138.0	101.0	1		
VA5970	D7552	156.0	113.0	2	1	
VA5971	VA5993	156.0	112.0		1	
VA5972	VA5973	134.0	106.0	1		
VA5983	VA5984	144.0	107.0	1		
VA5985	VA9342	153.0	103.0	1		
VA5990	VA6000	148.0	103.0	1		
VA5998	VA5999	146.0	101.0	1		
	VA6105				1	
VA6164	VA5700				1	
	VA1635				1	
VA6430	VA6431	165.0	118.0	1		
VA6445	VA6446	144.0	105.0	5	3	
VA6457	VA6458	153.0	108.0	1		
VA6595	VA6596	147.5	113.0	1	1	
VA6631	VA6632	142.0	112.0	1		
VA6717	VA5934	144.0	118.0		1	
VA6737	VA6738	146.5	108.0	1	1	
VA6842	VA9469	156.0	115.0	1		
VA7425	**PN1627**		96.0	1		
VA7681	**PN1492**	154.0	104.0	2		
VA7710	VA7709	138.0	106.0	1		
VA7748	PM0543	156.0	107.0	1		
VA7764	PN1299					
VA7764	PN1299	143.0	106.0			
VA7764						
VA7764						
VA7764	**PN1299**	146.0	109.0	3	3	
VA7764	PN1201	144.0	108.0	1		
VA8345	VA8344	146.0	107.0	1		
VA8361	VA8360	147.0	109.0	1	3	
VA8411	79386	145.0	108.5	2		
VA8639	79353	154.0	118.0	1		
VA8658	VA8659			2	1	
VA8710	**PN1371**	157.0	115.5	1	1	PN1371 removed 2 weeks later, no new right tag given.
VA8763	VA8764			1		

VA8789	VA9099	156.5	109.0	2		
VA8790	VA9637	158.5	115.5	3		
VA8799	VA8800	156.5	114.5	2	2	
VA8811	**PN1399**	147.5	108.0	1		right tag VA8892 removed, PN1399 given.
VA8813	VA8814	152.5	113.0	3		
VA8893	**PN1214**	159.5	114.0	2		
VA8941	VA0209			1	1	
VA8973	**PN1538**	147.0	108.0	2		
VA8993	PM0602	156.0	112.0		1	
VA8999	VA9000	153.0	114.0	3		
VA9021	**PN1512**	157.0	114.5	2		
VA9048	PM0435	155.0		1		
VA9125	VA9126	153.0	114.0	2	1	
VA9133	VA9134	146.0	107.0	1		
VA9136	**VA9137**	162.0	112.0	1		
VA9220	VA9219	156.0	111.0	1		
VA9221	VA9225	155.0	111.0	1		
VA9236	VA9237	140.0	109.0	1		
VA9245	**PN1058**	160.0	115.0	1		
VA9266	VA9392	161.0	119.0	1		
VA9271	VA9272	155.0	108.0	1	1	
VA9282	VA9283	153.0	110.0	1		
VA9299		151.0	122.0	1		
VA9343	76422	146.5	105.0	3	3	
VA9392	VA9266	161.5	114.0	3		
VA9413	VA9414	161.0	114.0	2	1	
VA9449	**PN1057**				1	
VA9464	PM0365	163.5	116.5	2		
VA9478	**PN1285**	160.5	115.5	5	1	VA9479 removed, PN1285 given
VA9486	VA9487	154.0	108.5	3		
VA9633	**PN1535**	147.0	109.0	1		
VA9645	VA9643	139.0	103.0	1		
VA9647	VA9650	142.0	107.0	1		
VA9648	VA9649		108.0	1		
VA9660	VA9080	147.0	102.0		1	
VA9706	VA9804	146.0	105.0	1		
VA9711	VA9712	145.5	105.0	3		
VA9713	VA9714	151.0	110.0	1		
VA9724	VA9724			1		
VA9733	VA9732	147.0	106.5	1	1	
	VA9745	149.0	107.0		1	
VA9770	VA9794	143.0	103.0	1		
VA9777	VA9778	142.0	107.0	1	1	
VA9780	VA9781	151.0	111.0	1	1	
VA9785	VA9786	154.0	107.0		1	
VA9787	VA9788	155.0	120.0	1		
VA9806	VA9836	153.0	106.0	1		
VA9832	VA9833	148.0	110.0	1	1	
VA9842	VA9843	145.0	106.0	1		
VA9861	VA9868	149.0	112.0	1		
VA9869	VA9860	148.0	104.0	1		
VA9882	VA9883				1	
VA9885	VA9884	148.0	119.0	1		

VA9977	VA9978	145.0	106.0		1	
VC0003	VC0004	146.5	111.0	4	1	
VC0011	VC0012			1		
VC0015	**PN1381**	156.0	105.0		1	
VC0019	VC0299	152.5	110.5	2	1	
VC0022	VC0023		107.0	3		
VC0044	VC0061	142.5	105.5	2		
VC0058	VC0059	140.0	106.0	1		
VC0099	VC0100	146.0	102.0	1		
VC0116	D6114	155.0	114.0	2		
VC0136	VC0137			1		
VC0142	VC0143	148.0	102.0	1		
VC0157	VA4652	153.5	116.0	3		
VC0205	VA9496	148.5	107.5	2	1	
VC0208	VA8755	146.0	112.0	1		
VC0228	VC0229	142.0	101.0		1	
VC0233	VC0198	143.5	101.0	2		
	VC0232	150.0	110.0	1		
VC0241	VC0242	150.0	110.0	2		
VC0278	VC0279	159.0	115.5	1	1	
VC0283	VC0282			1		
VC0304	VC0305	145.5	109.5	2		
VC0350	VA1555	154.0	108.0	1		
VC0351	VC0352	148.0	107.0	1	1	
VC0355	VC0377	152.0	107.0	3		
VC0424	**PN1167**	139.0		1		
VC0441		148.0	106.0		1	
VC0524	V43769	160.0	115.0	1		
VC0554	VC0253	142.5	106.0	2		
VC0560	VA7303	143.0	103.0	1		
VC0983	VC0985	151.5	112.5	2	1	
VC0988	VC0989	140.0	107.5	2		
VC0994	VC0159	161.0	116.0	1		
VN4367		147.0		1		
WC3185	VC0944	143.0	109.0	1		
	?4932	153.0	112.0	1		
		168.0	123.0		1	Right tag VA9807 removed but no new tag given.

Appendix 2. Green turtle catalogue

PM0840	PM0841	104.0	89.0		1	
PM0891	PM0192	108.0	89.0	1		
PN0301	**PN0302**	100.0	80.0	1		
PN0418	**PN0419**	106.0	95.0	1		
PN0425	**PN0674**	104.0	94.0	1		
PN0436		103.0	90.0	1		
PN0449	**PN0450**	104.0	93.0	1		
PN0451	96310			1		
PN0459	**PN0460**	100.0	96.0	1		
PN0478	**PN0479**	95.0	67.0	1		

PN0488	**PN0450**	98.0	89.0	1		
PN0501	**PN0502**	104.0	94.0	1		
PN0503	**PN0504**	103.0	94.0	1		
PN0505	**PN0506**	101.5	91.5	2		
PN0507	**PN0508**	100.0	90.0	1		
PN0510	**PN0541**	101.0	88.0	1		
PN0514		107.0	91.0	1		
PN0519	**PN0520**	105.0	96.0	1		
PN0521	**PN0522**	105.0	94.0	1		
PN0532	**PN0533**	114.0	102.0	1		
PN0536	**PN0538**	108.0	92.0		1	
PN0543					1	
PN0555	**PN0556**	104.0	96.0	1		
PN0559	**PN0666**	114.0	98.0	1		
PN0561	**PN0562**	102.5	95.0	2		
0900..?	**PN0569**	100.0	95.0	1		
PN0574	**PN0575**	109.0	99.0	1		
PN0578	**PN0580**	106.0	93.0	1		
PN0581	**PN0582**	95.0	83.0	2		
PN0583	**PN0584**	98.0	87.0	1		
PN0585	**PN0586**	104.0	98.0	1		
PN0587		110.0	99.0	1		
	PN0589	104.0	95.0	1		
PN0591	**PN0592**	102.0	93.0	1		
PN0593	**PN0594**	110.0	99.0	1		
PN0595	**PN0596**	109.0	98.0	1		
PN0597	**PN0598**	103.0	97.0	1		
PN0601				1		
PN0603	**PN0604**	98.5	88.0	1	1	
PN0608	**PN0609**	107.0	93.0	1		
PN0653	**PN0654**	98.0	93.0	1		
PN0655	**PN0656**	96.0	86.0	1		
PN0659	**PN0660**			1		
PN0669	**PN0670**	107.0	97.0	1		
PN0671		103.0	97.0	1		
V3418	V3419	102.0	92.0	1	1	

Appendix 3. Hawksbill catalogue

PM0185	PM0197	90.0	83.0	1		
PN0485	**PN0486**	92.0	83.0	1		
PN0613	**PN0614**	88.0	80.0	1		