Final Activities Report

Project

Understanding the relationship between abiotic factors and hatching success of *Dermochelys coriacea* in the Tayrona National Park, Colombian Caribbean: Implications for conservation

May-July 2009

Wooden sea turtle carved by Mr. Alonso, resident of Tayrona National Park, Arenilla Beach

Bogotá, August 2009

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Prepared by:

With the financial support of:

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ABSTRACT

As part of the research process begun on 2007, and the evident necessity of understanding the interaction among abiotic factors and hatchling success for *Dermocheys coriacea* in Tayrona National Park (TNP), Colombia Marina Foundation researchers and Park Officers from the area, developed the reproductive nesting assessment during 2009. Unfortunately, no nest from this specie was obtained in the patrolled beaches and so, there was no possible relation between biological and abiotics factors as was the initial goal. Nevertheless, the continuation of the night patrols and the tagging program allowed us to tag two more females, one nesting loggerhead (*Caretta caretta*) and one not nesting leatherback (*Dermochelys coriacea*). The abiotic data were analyzed in function of bibliographic information for the specie in the Great Caribbean Area, with the principal idea of give the local authorities the guidelines in the establishment of the relations between these two aspects. In the same way, an analysis was done about the critical situation of these populations in the area, as the result of decades of over-exploitation and the low quality in the conservation management inside the National Park.

RESUMEN

Como parte del proceso de investigación iniciado en el 2007, en el cual era evidente la necesidad de entender la relación existente entre los factores abióticos y el proceso de incubación de *Dermochelys coriacea* para el Parque Nacional Natural Tayrona (TNP), se realizó el monitoreo de la temporada reproductiva en el sector de Arrecifes durante el 2009, entre los funcionarios del área y los investigadores de la Fundación Colombia Marina. Desafortunadamente no se obtuvo ningún nido para la especie en el sector y los datos abióticos obtenidos no se pudieron relacionar con datos de eclosión e incubación como era el objetivo inicial. Sin embargo, la continuación del monitoreo nocturno y el programa de marcaje, permitieron marcar dos hembras, una *Caretta caretta* (caguama), la cual anido, y una *Dermochelys coriacea* (canal), que tan solo caracoleo. Los datos abióticos se analizaron en función de la bibliografía para la especie en el Gran Caribe, buscando dar una guía de lo útiles que pueden ser estos datos en el momento que se obtenga información biológica y abiótica para la misma temporada. Así mismo, se realiza el análisis de la situación actual de las poblaciones de tortugas en el TNP con una visión hacia el pasado que deja ver una clara tendencia a la disminución, como resultado de décadas de explotación y falta de decisiones de manejo y protección dentro del área protegida.

INTRODUCTION

Over the past three years, the Colombia Marina Foundation has been working jointly with the Special Administrative Unit of the National Park System (UAESPNN) specifically in the Tayrona National Park (TNP), strengthening the sea turtle monitoring program initiated by the protected area in 2006. Prior to this year, available information is vague, since there was no standardization in research, or methodologies, so it is hardly comparable with the data obtained in recent years (Pavia and Monterrosa, 2007).

For this reason, after performing the data analysis of the reproductive activity from 2006 to 2008, which showed an overall declining trend in the activities of nesting sea turtles in the Arrecifes sector, was clear the need for understanding the factors affecting the incubation process of *Dermochelys coriacea* (leatherback), which have been showing highly variable results for hatchling success previously (Monterrosa and Pavia, 2008). Colombia Marina researchers proposed for 2009, to conduct monitoring of the nesting season, taking particular attention to leatherback's nests and incubation results. The relation obtained between these and some of the abiotic factors that directly affect embryonic development and hatchling success, such as temperature, humidity, rainfall and water table level will allow understanding the local problematic. (Ackerman, 1980; 1997; Bustard and Greenham, 1968; Miller, 1985; Mortimer, 1990; Ralph *et al.*, 2005; Wallace *et al.*, 2004; Yntema and Mrosovsky, 1980).

The proposal was risky because as we stated in last year's report (Monterrosa and Pavia, 2008), 2009 will define the population trend of the different nesting species in the area. This year could have similar number of events as the one's obtained in 2006 (14 nests), as result of the re-migration periods or could also decrease, showing similar numbers as in 2008 (3 nests) or less, as a result of human pressure over previous decades. This last situation would not allow the data link between abiotic and biological processes for the specie, but because of the need for such data in order to make management decisions for the Park, the research was developed awaiting the results. Nevertheless, the continuation of the tagging program and nesting assessment had already shown significant results (Monterrosa and Pavia, 2008).

The present season (2009), was not a good year for sea turtles in the Tayrona National Park, and although the data handled in this report only involves one sector of the protected area, the tendency was the same for the complete area, so the decreasing pattern seems to be confirmed. This

situation, makes the responsibility of environmental authorities even bigger, they must seek more protection and better management decisions in the coming years to ensure that the few nests that are being placed have the greatest hatching success.

This report aims to provide a wider view of the current status of marine turtles in the TNP, some possible explanations for this scenario and our recommendations to improve habitat conditions for nesting females and to seek the best management decisions towards the survival of these threatened populations.

STUDY AREA

Project activities were carried out in the Tayrona National Park (TNP) (Figure 1.), which was declared a protected area by Resolution 191 of August 31, 1964 and Executive Resolution 292 of August 18, 1969. This is located north of the city of Santa Marta, between latitudes 11°16' - 11°21' N and 73°53' - 74°12' W, Department of Magdalena - Colombian Caribbean.

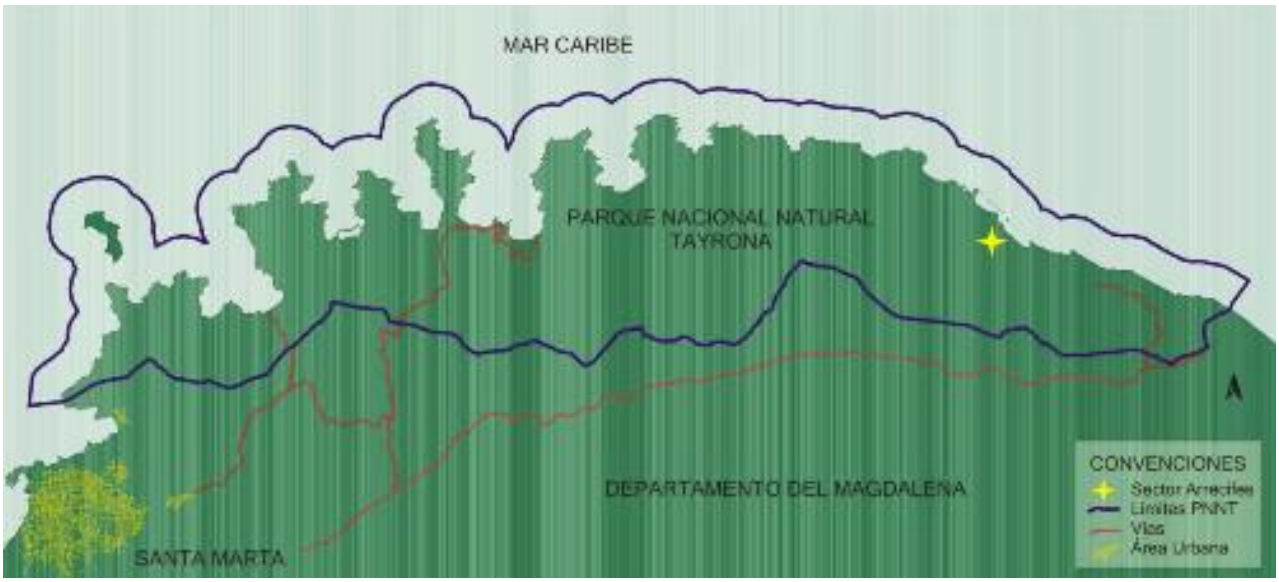


Figure 1. Study area localization map – Tayrona National Park (TNP). Modified from MAVDT (2006).

METHODOLOGY

Monitoring reproductive of sea turtles activities

The Arrecifes sector index beaches (San Felipe, La Gumarra and Arrecifes) (Figure 2.), were monitored every night from 20:00 hours to 04:30 hours from May 15 to July 15, 2009 by the Colombia Marina Foundation research team and during daytime by Tayrona National Park officials since the beginning of March. The main objective of night patrols was to intercept any nesting females, tagging and measuring them, recording any nesting events (nest or tracks) along these beaches. The research team walked the beaches at least once per hour using red lights and wearing dark clothing. When night monitoring were interrupted prematurely or were cancelled because of thunderstorms, patrols were conducted at 05:00 hours to record any event that occurred the night before.

Figure 2. Map of surveyed beaches in the Arrecifes sector – Tayrona National Park (TNP). Picture Google Earth (2009).

Marking and biometrics of nesting females

Considered one of the main activities in the conservation of marine turtles (Balazs, 1999), the tagging of nesting females in TNP started in 2007 and has continued over the years. Emerging females were intercepted only after they had completed oviposition in the case of successful nests, or they were preparing to return to the sea after crawling (Figure 3.). In each, two tags were placed, one on each front flipper in the case of the Chelonidae family and on the uropigial membrane for Dermochelidae family, following all the recommendations made by Chacon *et al.*, (2007). Additionally, to maintain uniformity in the data obtained so far (Pavia and Monterrosa, 2007;

Monterrosa and Pavia, 2008), measurements of nesting females included curved carapace length (CCL) and curved carapace width (ACC) following Bolten's recommendations (1999).

Figure 3. Females intercepted during the night surveys in the Arrecifes sector – Tayrona National Park (TNP).

Protection and management of nests

Since the starting of the work in 2007, the relocation of nests is taken very conservatively. Only those nests that were in imminent risk of loss, through erosion or washing of the sea, they were moved to safer places on the beach, which have been identified by researchers and officials during the previous years of work. If the relocation was necessary, the nests were protected from people passing by placing a plastic mesh or a wooden enclosure, to allow follow up until hatching.

Measuring abiotic factors

Environmental stations: Two stations were established, one in La Gumarra (EA GMR) and another at Arrecifes beach (EA ARF), which would be used as reference for comparison with the data collected under sand or false nests. These were located, in the case of La Gumarra (Figure 4.) in the middle of the beach and at Arrecifes (Figure 5.) in the middle where historically there has been much turtle nests events. In both cases, the stations were at the height of the vegetation zone, make sure no shade or protection of some sort. The temperature and relative humidity were measured with reading sensors programmed to record every six hours from the start until the last day of the project (Figure 6a.). Rainfall was measured using a small Styrofoam cooler with a funnel inserted into the cover, which collected the water, a volume that after each episode of rain was measured using a probe (Figure 6b.).

Figure 4. Localization of the environmental stations (red star) and false nest stations (yellow star) at La Gumarra. Picture Google Earth (2009).

Figure 5. Localization of the environmental stations (red star) and false nest stations (yellow star) at Arrecifes beach. Picture Google Earth (2009).

Figure 6. a. Datalogger used to measure temperature and humidity in the environmental stations. **b.** Set up used to measure rainfall.

False nests stations: Four stations were established resembling the shape of a leatherback turtle natural nest, two in La Gumarra (ES GMR 1 and 2) and two in Arrecifes beach (ES ARF 1 and 2), in those places where there have been nests recorded during previous seasons (Figure 4. and 5.). The false nests were built using plastic balls, which simulated the eggs. These balls, formed an air chamber under the sand needed for the sensors, which were placed at the centre of mass of balls (Figure 7a.). The temperature and relative humidity were measured in the same manner as in the environmental factors.

Additionally, adapting the methodology used by Furler (2005), the groundwater level was measured using a 115 cm tube, which was buried to a depth of 100 cm, at a distance of 50 cm from the false nest (Figure 7b.). The end tube remaining into the sand, was covered with a plastic membrane, to avoid the filling of sand, so we could take measurements with a wooden stick with a plastic tape measure attach to the side of it, these measurements were made every six hours in order to see if there was raised the water level from the bottom of the tube.


Figure 7. a. False nest elaborated using plastic balls. **b.** Set up used to measure water table level at both surveyed beaches.

Identification of threats affecting nesting habitats

In previous years have been identifying the different pressures that affect sea turtles in the TNP, making appropriate recommendations in each final report. During 2009, Colombia Marina assessed the progress in the correction of the threats mentioned before and continues the process of identification during night patrols, taking into account that at this time is when reproductive activity is altered.

RESULTS

Below are the results obtained during the nesting season of 2009 for the Arrecifes sector at Tayrona National Park, data were collected by TNP staff during their daily monitoring and the researchers from Colombia Marina in the night patrols focused on nesting events and tagging of intercepted females.

Surveys of marine turtles nesting assessment

In total during the 2009 season, there were five events reported on the Arrecifes sector. Three leatherbacks tracks, one on Arrecifes and two on La Gumarra and one nest and one track of loggerhead in La Gumarra. The data obtained, dates, codes and beaches are listed in Table 1.

Table 1. Events register of the sea turtle nesting activity in the Arrecifes sector (TNP) during the 2009 nesting season. Source: Source: Colombia Marina Foundation – Tayrona National Park Monitoring Program.

Fecha	Código Arribamiento	Playa	Especie	Código Anidación
09/03/2009	GMRAR09001	La Gumarra	*D.c.*	-
10/04/2009	ARFAR09001	Arrecifes	*D.c.*	-
28/05/2009	GMRAR09002	La Gumarra	*D.c.*	-
21/06/2009	GMRAR09003	La Gumarra	*C.c.*	GMRND09001
N/A	GMRAR09004	La Gumarra	*C.c.*	-

Nesting females tagging and monitoring

During the night patrols, there were only two events, a not nesting *Dermochelys coriacea* and a nesting *Caretta caretta*. The two females were tagged and only the loggerhead was measured. The tags and biometrics data are shown in Table 2.

Table 2. Tags applied and biometric data registered to both intercepted females during the night surveys at the Arrecifes sector.

Specie	Left Tag	Right Tag	LCC (cm)	ACC (cm)
Dermochelys coriacea	YCC 927	-	-	-
Caretta caretta	YYC 919	YCC 918	108	100

Protection and management of nests

The only nest obtained was from loggerhead turtle in La Gumarra. It was laid by the turtle in the vegetation zone and was not washing or erosion risk, so we decided to leave it *in situ*.

Measuring abiotic factors

After the sampling period, the dataloggers were removed and the collected data was downloaded using an interface called OneWire Viewer. From the data of temperature and relative humidity, obtained from the environmental stations (EA) and the false nest stations (EN) yielded the following results (Table 3. and 4.).

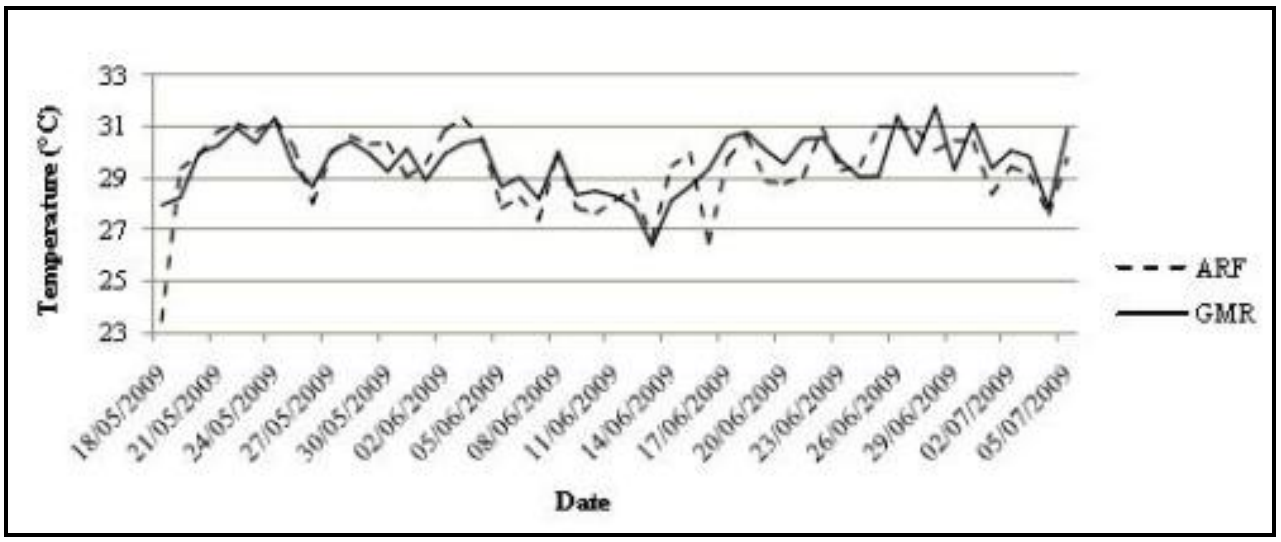
Table 3. Temperature (°C) registered at the environmental stations and the false nest stations in the Arrecifes sector during the field work (May 18-July 05). Environmental stations (EA) – False nest station (ES).

Statistical Data	EA ARF	EA GMR	ES ARF1	ES ARF2	ES GMR1	ES GMR2
Average	29,5	29,6	31,7	31,8	32,2	31,8
Standard Deviation	6,48	5,38	0,53	0,44	0,74	0,48
Minimum	22,2	22,4	30,5	30,6	29,7	30,6
Maximum	46,1	43,2	34,0	32,6	34,2	32,5
Mode	25,0	25,9	31,5	31,6	32,6	31,7
N	195	195	196	196	196	196

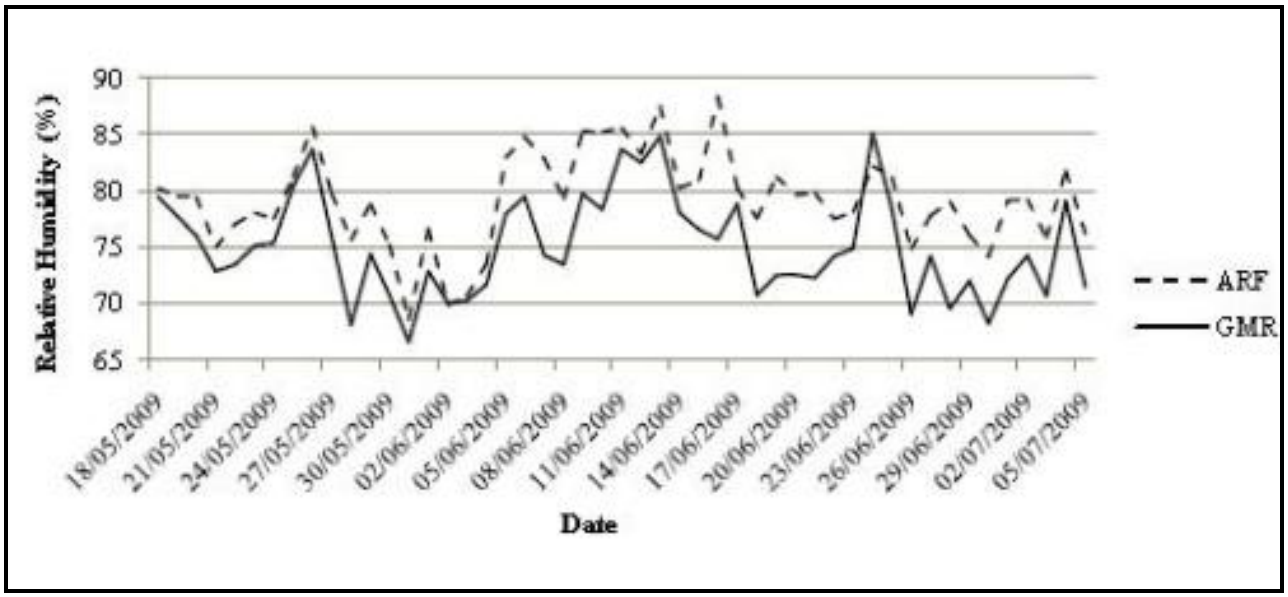
Table 4. Relative humidity (%) registered at the environmental stations and the false nest stations in the Arrecifes sector during the field work (May 18-July 05). Environmental stations (EA) – False nest station (ES).

Statistical Data	EA ARF	EA GMR	ES ARF1	ES ARF2	ES GMR1	ES GMR2
Average	79,1	75,1	94,4	97,6	97,6	97,4
Standard Deviation	17,62	18,08	2,51	0,92	1,12	1,08
Minimum	40,4	34,3	89,1	94,2	94,4	94,0
Maximum	100,0	100,0	99,1	100,0	100,0	100,0
Mode	80,8	75,8	96,3	98,3	98,3	98,1
N	195	195	196	196	196	196

Environmental stations: In addition, graphs were prepared with daily averages measured in environmental stations (EA), which correspond to the average temperature (Figure 1.), and average relative humidity (Figure 2.) at the two monitored beaches. They show that the variation of the average daily temperature for Arrecifes beach (EA ARF) was between 23.5°C-31.4°C and between 26.3ºC-31.8°C for La Gumarra (EA GMR). Moreover, the average daily relative humidity recorded for Arrecifes beach was between 68.5%-88.4% and for La Gumarra was between 66.6%-85.1%. Additionally, measurements of ambient precipitation at the station totalled 13.85 mm of rain water collected on Arrecifes beach and in the case of La Gumarra was 12.28 mm.

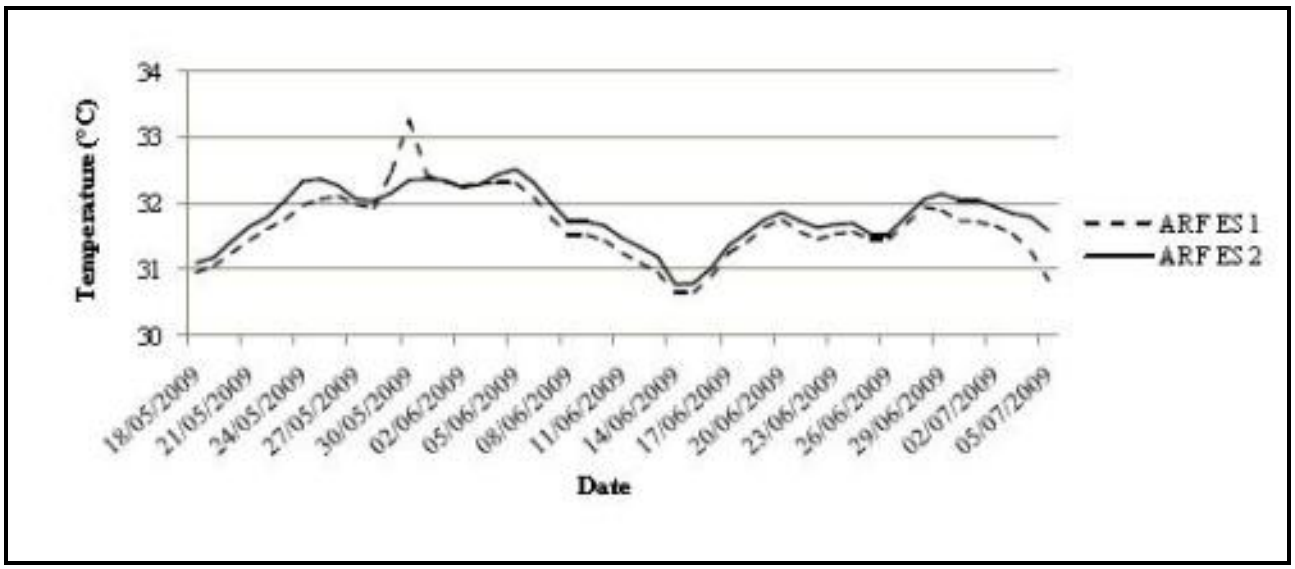


Graphic 1. Temperature registered at both environmental stations (EA ARF and EA GMR) used during the night surveys at the Arrecifes sector.

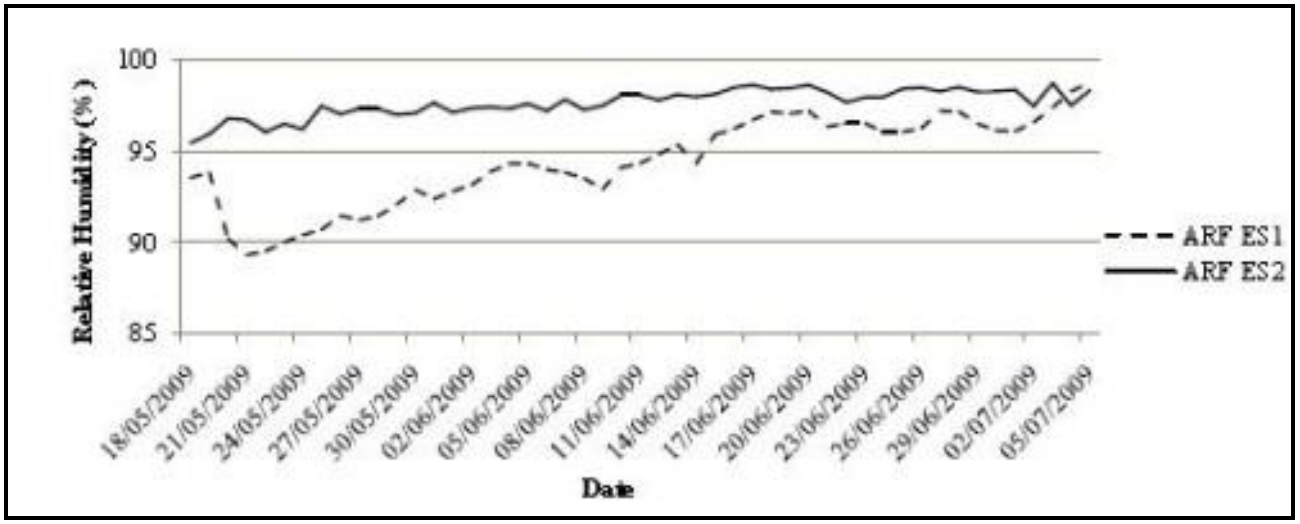


Graphic 2. Relative humidity registered at both environmental stations (EA ARF and EA GMR) used during the night surveys at the Arrecifes sector.

False nests stations: About the information obtained from dataloggers at the false nests in Arrecifes beach (ESARF 1 and 2), we obtained that the variation of the average daily temperature was between 30.6°C-33.3°C (EN ARF1) and between 30.8°C-32.5°C at EN ARF2, which can be seen in Figure 3. About relative humidity (Figure 4.), this ranged from 89.3%-98.8% (ES ARF1) and between 95.4%-98.7% (ES ARF2).

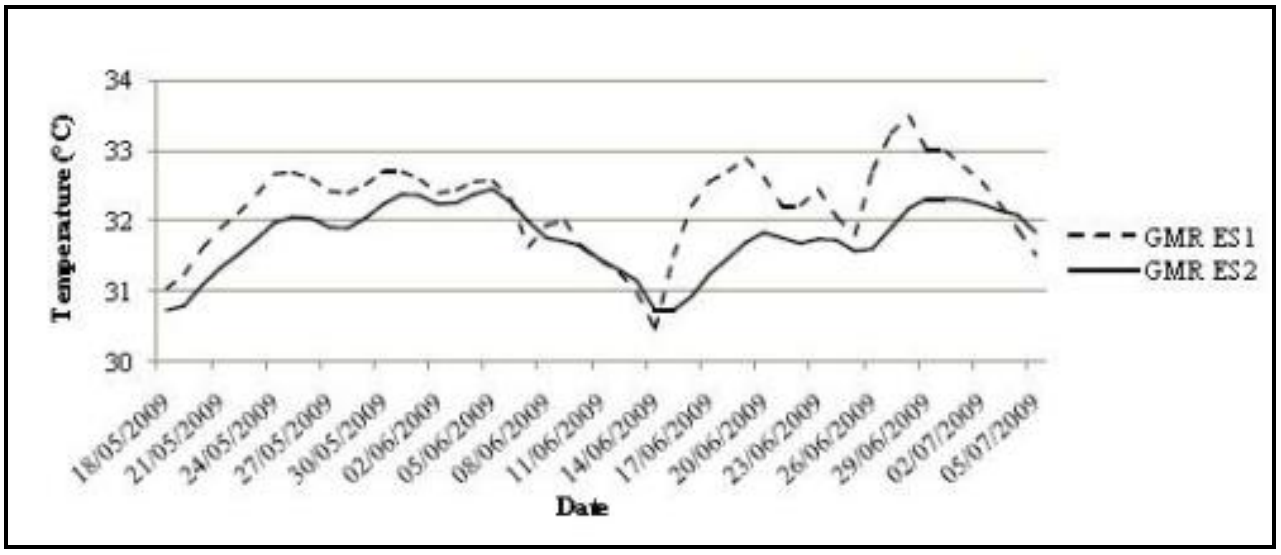


Graphic 3. Average daily temperature registered in the false nest station at Arrecifes beach (ES ARF 1 and 2).

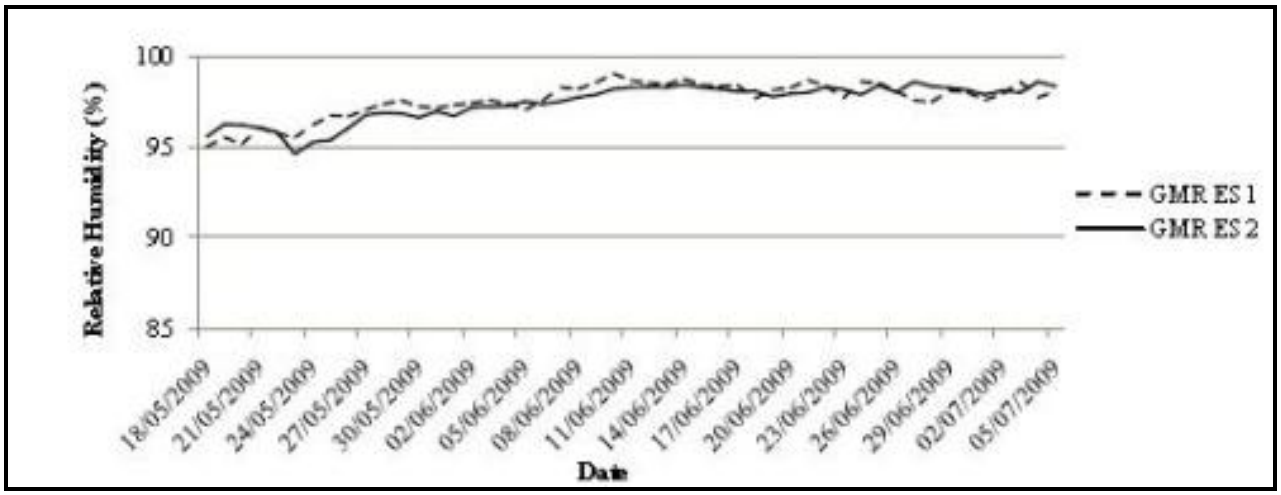


Graphic 4. Average daily relative humidity registered in the false nest station at Arrecifes beach (ES ARF 1 and 2).

Moreover, the false nests in La Gumarra showed that the average temperature ranges was between 30.5°C-33.5°C (EN GMR1) and between 30.7°C-32.5°C EN GMR2 (Figure 5.). About the relative humidity, results were between 95.0%-99.0% ES GMR1 and between 94.6%-98.6% ES GMR2 (Figure 6.).



Graphic 5. Average daily temperature registered in the false nest station at La Gumarra beach (ES GMR 1 and 2).



Graphic 6. Average daily relative humidity registered in the false nest station at La Gumarra beach (ES GMR 1 and 2).

During the sampling time water level readings were always 0, which implies that the ground water level during those days was no less than a meter from the surface of the sand.

Identification of threats affecting nesting habitats

During this year season, natural phenomena as the formation of slopes or driftwood were not present on the beaches of the sector. Nevertheless, the extension (width) of the monitored beaches was bigger than all the last seasons; the sea was far beyond what had been observed during previous years. On the other hand, the anthropogenic threats still exist, some with greater intensity, as is the case of artificial lightening (Figure 8.) at the major nesting beaches and artisanal fishing with trammel nets in front of them (Figure 9.).

Figure 8. Panoramic view of the Arrecifes beach in which the incidental lights of the eco-touristic infrastructure is easily observed.

Figure 9. Artisanal fishermen pulling fishing nest in front of the La Gumarra beach.

DISCUSSION

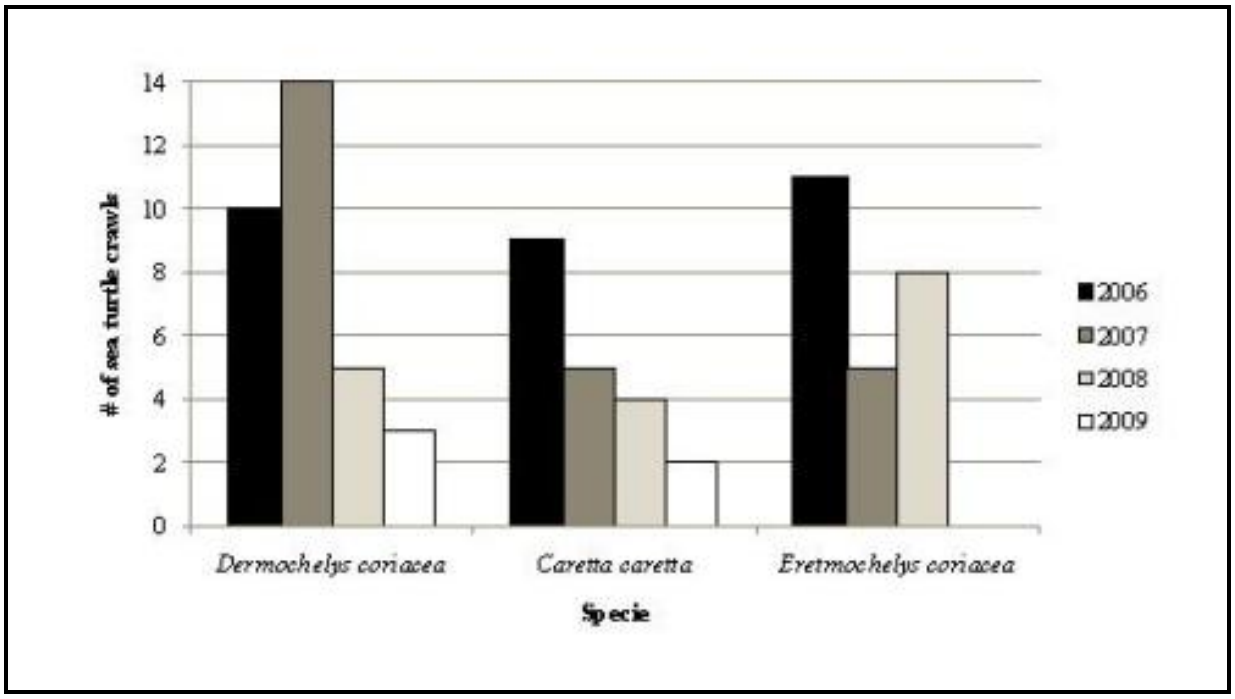
Monitoring reproductive activity of sea turtles

In time terms, the sea turtle conservation research involves long-term monitoring and evaluating the results annually, as well as clear and appropriate goals for each study, which over time should be reproducible and comprehensible to researchers. Due to its long life cycle, the work of some years may not be sufficient to achieve tangible goals, but undoubtedly years of accumulating information work and achievements during periods of a decade or more will get the expected results (Eckert, 1999; Schroeder and Murphy, 1999).

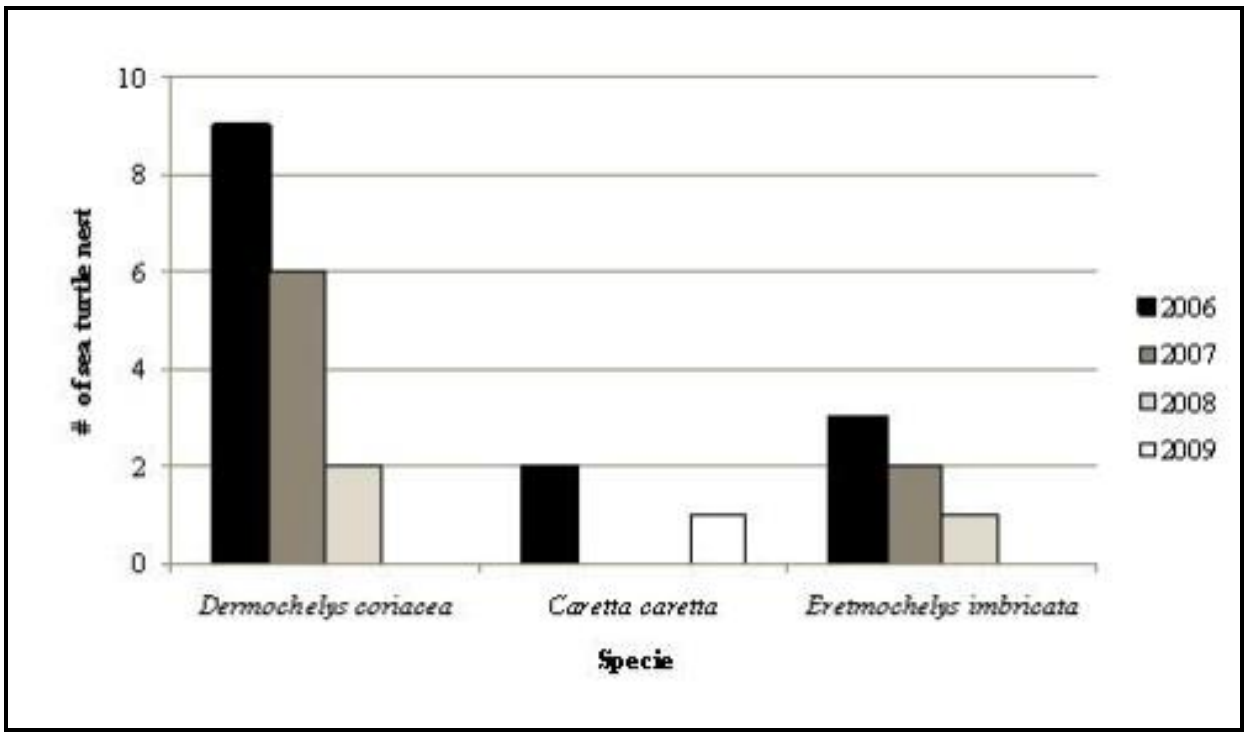
Authors such as Richardson (1999), state that one of the main knowledge that should have any draft for depleted stocks recover, is to understand the nesting activity and biology of each species for the study site. In TNP, happened what the author calls "*well-intentioned but misguided conservation efforts*", causing a period of seven years of losing valuable and indispensable information for understanding the situation facing these turtles in the area. During this time, *ex situ* incubation practices and management of nests and hatchlings that were used did not correspond with the little information that was available about the nesting populations in the area, so now there are no data of nesting females, total number of nests or hatchlings released.

It was only until 2006, when the TNP on an assessment of what had been happening established the daytime monitoring nesting program, which although avoids essentials procedures such as tagging, do achieve the registration of tracks and nests that occur, with the possibility of nests protection. In 2007, when Colombia Marina started working together with UAESPNN, the tagging program was begun for the Arrecifes sector, where it has been made along the night patrols, with methodologies that allow annual comparisons.

Data collected systematically by park officials, in their sea turtle monitoring program, and Colombia Marina Foundation researchers, during these four years of work, showed a trend in the reproductive activity of sea turtles. In a forceful way, both tracks and nests have been declining in the three index beaches at Arrecifes sector, as shown in Figure 7 and 8.



Graphic 7. Register sea turtle crawls by specie during surveys (day time and night time) of the nesting activity in the index beaches at the Arrecifes sector (San Felipe, La Gumarra, Arrecifes) during 2006-2009 seasons. Source: Colombia Marina Foundation – Tayrona National Park Monitoring Program.



Graphic 8. Register sea turtle nests by specie during surveys (day time and night time) of the nesting activity in the index beaches at the Arrecifes sector (San Felipe, La Gumarra, Arrecifes) during 2006-2009 seasons. Source: Colombia Marina Foundation – Tayrona National Park Monitoring Program.

The interpretation of these data should be done carefully, because as stated earlier is little time to conclude. But without doubt, it is possible to be less optimistic and conservative that in the analysis of the previous year (Monterrosa and Pavia, 2008) and the explanations needs begin to look more into the past. The first reports of sea turtle nesting in the Magdalena area (Mendihuaca, Guachaca, Buritaca) date from the 50's (Nicephorus, 1953), when confirmed nesting species. Over the years authors as Medem (1962) in the 60's and Kaufmann (1971; 1973) in the 70's refers to the area as a major nesting area for *Caretta caretta* in the Caribbean and also the presence of a significant number of females of *Dermochelys coriacea*, *Eretmochelys imbricata* and *Chelonia mydas* was reported (Amorocho *et al.,* 1999; Ocampo *et al.,* 2001).

However, since the 60's, the over-exploitation was evident and the killing of large numbers of nesting females and the poaching of nearly 100% of the nests, with data up to 70000 eggs of loggerhead in a season to be sold in the markets of major cities in the Colombian Caribbean coast (Medem, 1962) were reported. This situation of over-exploitation began to show results early and already in the 80's the population had decreased by 95% (MMA, 2002).

Since then, although the investigation has not been constant, there have been several inspections at these beaches (Amorocho *et al.,* 1999, Marquez, 1990; Marrugo and Vasquez, 2002; Muñoz *et al.,* 1989; Pinzon *et al.,* 1996), showing all the same downward trend. For TNP specifically, Sanchez (2002) states that the greatest threat to these species was the nests poaching and illegal fishing activities in front of the main nesting beaches, which adversely affected the already small number of nesting females.

After analyzing all these documents, it is not surprising the actual situation in the area, which in our concept is the generation gap caused by over-exploitation. Mortimer (1995) proposed two schemes that he strengthens in a very crude way in 2006 with the statement *"What is the easiest way to destroy a nesting population of sea turtles? The answer is simple: Over-exploitation of the females and their eggs on nesting beaches*" Mortimer (2006).

The first of the schemes mentioned (Figure 10.) depicts the situation faced in the Magdalena area (included in TNP) since the 60's, when most if not all the nesting females were slaughtered and eggs stolen, either for food or extra money, as versions of older fishermen who are now witnessing

the decline. Under this scheme, 25 to 30 years after the last hatchling were born, no nesting females arrive to lay their eggs, because during all that time there were not new generations of females maturing to reach breeding season, there are not adult females because there were not hatchlings born.

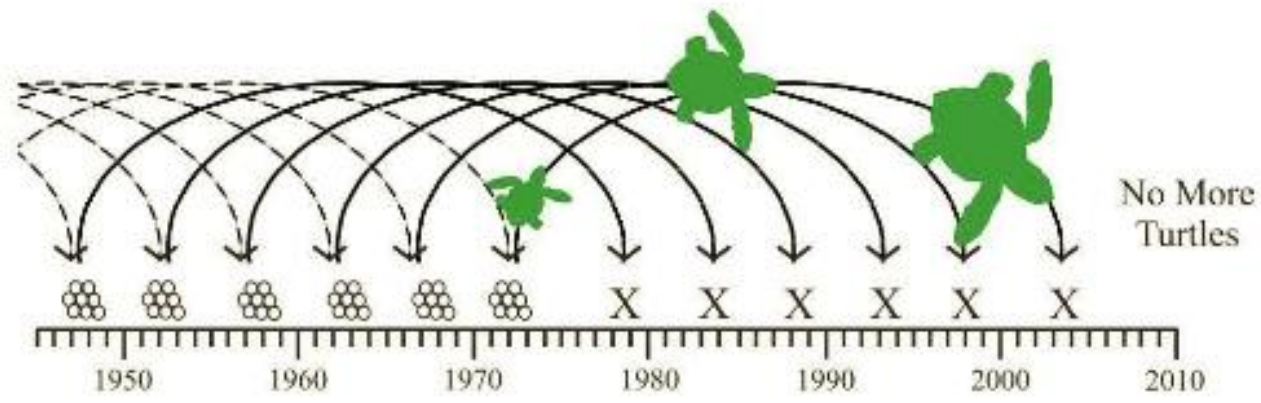


Figure 10. Model exemplifying the generational process and the effect of the eggs recollection on recruitment. Modified from Mortimer (1995).

Here we must keep in mind that surely, those vast numbers of nesting females that Medem recorded in the 60's, some females could be safe and lay their eggs for some other years, hopefully for the last 40 years. The few hatchlings which have been born in these decades are the few females still laying nests. However, we could be less dramatic and consider that according with the literature and based on our conversations with fishermen in the area, the greater pressure was made on the nests (almost 100%) leaving the sacrifice of the nesting females only for sporadic cases. In this way, we may assume that the picture is not so dark. And it is just that, as illustrated in Figure 11.

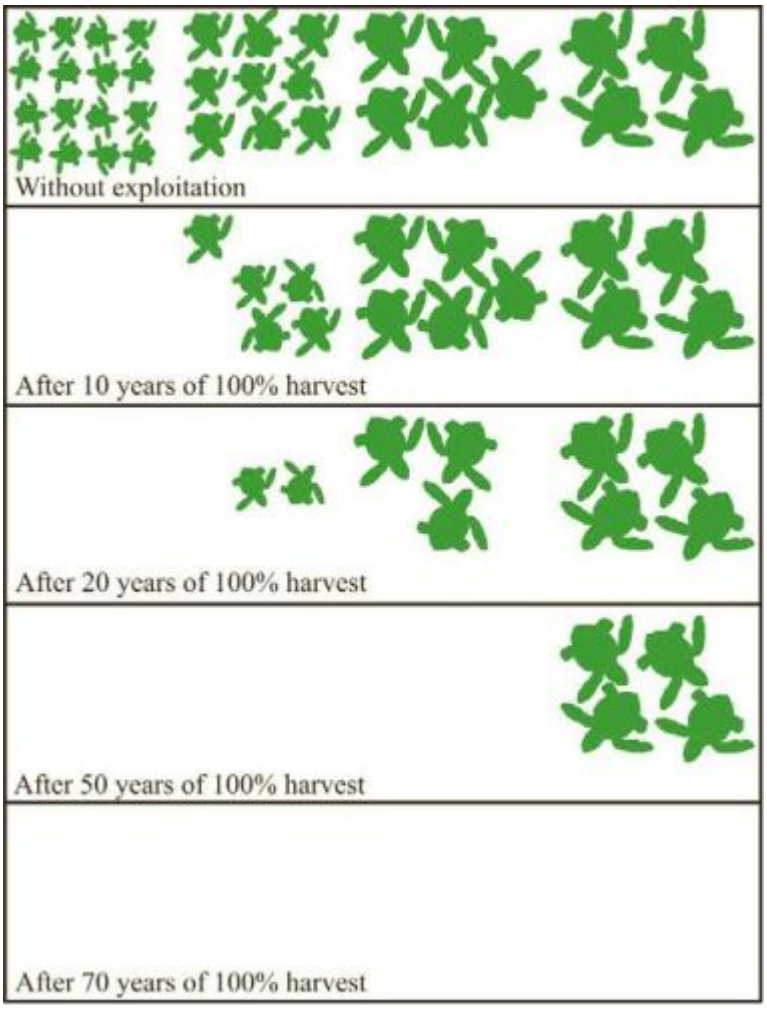


Figure 11. Graphic representation of the process of population reduction caused by human collection. Modified from Mortimer (1995).

This model is even more misleading. In it, 100% of the nests are poached, but the adult females protected. Thus, over time, no hatchlings are entering the pyramid, juveniles and sub-adults begin to decline until they are all adults. 50 years later the number of nesting females begins to decline because they are all at least 50 years old. During 50 years there were no hatchlings born and in 20 years the population will have disappeared completely.

Tayrona National Park is not at this situation yet and we think the population will not became extinct, because over the past ten years, the nests protection has been a fact and the poaching is really sporadic. We would expect that some of the hatchlings born inside the Park (hundreds, maybe a thousand) hopefully reach adulthood and will come to nest on the beaches in 20 or 25 years, which is the average time of sexual maturity (Marquez, 1990) for species that visit the area.

However, we must be careful with this statement, because it is assuming a scenario with no other pressures that exist in reality. This is why the consequences of current management decisions take great importance and will be the protagonists in the analysis of the situation in the medium term. From what we do now depends on the recovery of these populations in the future.

Well, is there still something to do? The answer has many conditions but we would think so. This reality of over-exploitation was a constant in most countries of Latin America and in the Caribbean islands; where there was poaching of 100% of the eggs in the main nesting beaches and many nesting females were sacrificed. These countries have incredible examples of populations near the brink of extinction that after a decade of continuous protection of nesting beaches, both female and hatchlings show significant recovery.

Such is the case of Playa Cuixmala (Mexico), where Garcia *et al.,* (2003) speak of less than 25 nests in 1988 and after 8 years of intensive protection in 1996 recorded more than 250 nests in a season. Meanwhile, Dutton *et al.,* (2005) in Sandy Point (Virgin Islands) reported 18-30 nesting females in 1980 and over 186 in 2001, after introducing in 1981 an intensive protection at beaches program. In Brazil, during the 1984 season, on the continental beaches less than 10 nests were protected, and with research and community work, in 2004 there were more than 4000 protected nests along the Brazilian coast (Projeto TAMAR-IBAMA, 2004). As such there are many other examples, and they all have in common an essential element: *Government commitment*.

And it is here where the challenge for Colombia is. Many conservation initiatives can take place in our country, NGO's in all activities can help collect the necessary information, but if this information is there, and national environmental authorities do not take conscientiousness in this matter, we never will able to establish a conservation program with such as results as the previous, in a medium term. Governments in Mexico, Brazil or Costa Rica, after hearing what private organizations determine and propose in its investigations, assumed state policies to protect these animals, they didn't stop in action plans, nor laws, they invested money and logistics to ensure their survival (Figure 12.). This is what Colombia has to do, because otherwise, the time delay will charge and there will be nothing to correct.

Figure 12. To help prevent the theft of eggs, armed federal agents patrol Mexico's Escobilla Beach during the olive Ridley nesting period. Source: Swot Report Volume I (2006).

Now, there is a very popular idea between environmental authorities and some researchers in the area of Magdalena, about sea turtle nesting in the TNP. Many say in oral arguments that the area has always been a "*sporadic nesting area*", and that its activity was never very high to be alarmed by the current situation. Faced with the contradiction of this version and the literature of the area to the 60's, Colombia Marina appealed the traditional knowledge of the inhabitants of TNP to ask them how it was the turtle activity before. Elaborating on oral interviews, which according to Tambiah (1999) are an inexpensive tool that saves time and saves information which is maintained only on oral tradition and supplement data in areas where they are scarce. We try to understand what was going on in the area at the 60's. So it was with the trust that we have earned in the three years of research among the residents, struck up casual conversations with them, during which they shared with us their experiences of the past and if they saw or not changes in the current situation of sea turtles in TNP.

The talks inquired about presence, species abundance, poaching, hunting of females, uses and sightings at sea. The results of these questions confirmed what is not written for the Park but is for beaches from Mendihuaca to the Guajira. The villagers, aged over 50 years old, say that "*there were turtles before, not like now that is one every month*". They say that for the decade of the 60's, "*On these beaches, five turtles could nest on every beach, and towards Boca del Saco* (a beach

located further west in the Arrecifes sector) *sector were more than five or seven*". They say that emerged very early, at six in the afternoon, "*we didn't have to walk like you all night, we wait until the end of the day and they were already there, and if we wanted to get out at five in the morning, also found one another*".

When we asked them if they exploited females and turtle eggs, they answered calmly, "*of course, was part of our food, they came and if we had not meat we peak up one, because the meat of one turtle was enough for the entire colony, we shared it*". And the eggs? "*Oh no, those were all, because if we leave them the people from La Sierra* (referring to the who come down from the Sierra Nevada de Santa Marta) *came and poached them. They did kill the females and took the meat in plastic containers to La Sierra*". And did you sell the eggs? "*No, we ate them like the meat, but other people they did sell them, they earn money to take them to Santa Marta, Barranquilla and Riohacha, but to go up there it was so much trouble, so we better ate them ourselves*".

And in the sea, did you ever saw them? "*Sure, we began to look them in March, if you overlooked the beach, at the ocean you could see entire lines of little heads that suddenly breath hard*", "*they began floating on the surface in order to heat the eggs before come to the beach to nest, so we knew they were going to start nesting*", "*when we were fishing they approached to the boats and occasionally we caught them with hooks, we saw a lot of the loggerhead and leatherbacks, hawksbill was not seen in the sea*". And apart from these, ever saw a different one? "*Yes, there was one with a white belly, white, but that almost never went out, it was very strange to see it, people say that that one came out more towards the La Guajira, the meat was good*".

And now what is happening, why we don't see them any longer? "*We got a lots of eggs, many*" also say "*no, with that many people on the beaches at night, and the walking of the sand in the day, they do not like that*", "*the artificial lights alarm the turtles, before it was dark, not like now, but I do not know why they don't nest where there is no light*", "*It's so hot, they do not like this, before it was cool, it rained, the sand was not so hot, there were more fish to eat, but now, it's hot and they should no longer find what to eat, if we do not fished they do not eat, they are leaving to elsewhere"*. Well, when did you stop taking the nests and turtles? "*The turtles since 1990, but eggs, we didn't stop until 2000, what happens is that now in order to find a nest we would have to do what you do, walk all night, every day , and that is not worth it*".

This approach was the most enriching experience in these years of research, listening to oral tradition than anyone have written about, is for us the possibility to be sure that the number of turtles in the TNP, was higher, the nesting were continuous and abundant and the threats were identical to those from around the Magdalena, which largely explains the current status of sea turtles in this "*protected area*".

Nesting females tagging and biometrics

The tagging program for marine turtles is one of the greatest advances made in the TNP during these three years. Overall 8 females have been marked since 2007, all the ones that were nesting and some of those which only made tracks at Arrecifes sector, the data are listed in Table 5.

Table 5. Relation of applied tags during the night surveys carried out by the Colombia Marina Foundation in the Arrecifes sector (2007-2009).

Season	Specie	Event	Left Tag	Right Tag
2007	*C.c.*	Crawl	YYC 901	YYC 902
2007	*E.i.*	Nesting	YYC 954	YYC 956
2008	*D.c.*	Nesting	YYC 909	YYC 910
2008	*D.c.*	Crawl	YYC 911	YYC 912
2008	*C.c.*	Crawl	YYC 913	YYC 914
2008	*E.i.*	Nesting	YYC 915	YYC 917
2009	*D.c.*	Crawl	YYC 927	-
2009	*C.c.*	Nesting	YYC 918	YYC 919

While the low number of females coupled with the lack of night patrols in other beaches of the Park, makes difficult to obtain data as re-migration intervals, the program has already shown interesting results, as a re-nesting leatherback the last year, 11 days after the first nest, on the same beach and in places very close between them (Monterrosa and Pavia, 2008). This data has no scientific value by itself, but it reveals the validity of the tagging and all information that may be collected, if the program was instituted in the whole area. Only in this way, it will be actually determined the population size and other important data of the reproductive biology of sea turtles in Tayrona.

Protection and management of nests

Since the beginning of our work in TNP, Colombia Marina has been very conservative regarding the management measures taken to nests and hatchlings. For us, there is not information that allow to take decisions on *ex situ* incubation or alternative methods of incubation like Styrofoam boxes or hatcheries, like stated in 2008 (Monterrosa and Pavia, 2008). So we always opted for *in situ* protection, and only those nests that were at imminent risk of loss were transferred, on the night of the oviposition to a safer location on the same beach, this was one of the biggest gains in the night monitoring. Under this standard, the nest of loggerhead turtle was left where turtle placed it, and park officers were awaiting the hatchling and make the exhumation process.

Under this scenario and observing the results of hatching and emergence of loggerhead and hawksbill on several beaches of the Park (Escobar, 2007; Pavia and Monterrosa, 2007), we believe that the *in situ* protection, should be the first protection option inside the area, and once protected to ensure the release of all hatchlings born. Only in that way, would be possible to have turtles nesting in the next decades. The situation for leatherback is different, their hatchling results are very low and park authorities should understand this situation, before take relocations decisions without knowing what is what is affecting the nests.

Measuring abiotic factors

This need for information and the results of these two years of research, made evident the necessity to understand the relationship between leatherback hatchling success and abiotic factors such as relative humidity and temperature. So this year, the research part of the project, was focused on this aspect. Unfortunately we didn't obtain a nest of this specie in the area, and the data obtained at the stations could not be compared to results from hatchling, leaving abiotic information without value. However, it was interesting to see that the methodology works, that is a viable and accurate temperature reading of the nests in the sand and hence, at the time there will be real nests an important comparison could be make.

In the absence of biological data, abiotic information was analyzed according to the literature of incubation for the species in the Wider Caribbean, for example, Costa Rica and Surinam. This comparison made solely with the intention of make clear the aspects, which in our opinion, would begin to reveal the doubts existing in the leatherback incubation process. This information will help to explore options for improving the hatching success. Be clear on how many are the factors that literature said could affect embryos survival and how little is known about the influence of each

one and their interaction (Bell *et al.*, 2003; Houghton *et al.*, 2007; Runemark, 2006; Wallace *et al.*, 2003) so this study was or would be only the beginning of a long way in the TNP.

Ackerman (1997), states that the environmental tolerance survival range for embryos of *Dermochelys coriacea* must be between 25°C-35°C, so one would think that during the time that temperature measurements were made, there were moments in which the two stations located in Arrecifes beach (EA ARF 1 and 2) and station 1 of La Gumarra (EA GMR1) were very close to the lethal limit (Table 6.). If to this values we aggregate 0.5°C from the metabolic heat inside the nest, that would be generated by embryos Godfrey *et al.*, (1996), it might had caused low hatchling rates but not necessarily the death of the entire clutch, according with Wallace *et al.*, (2003), who state that the position of eggs within the clutch may influence their involvement with abiotic factors.

Table 6. Temperature (°C) register at the false nest stations in the Arrecifes sector during the night surveys at Tayrona National Park (May 18-July 05).

Statistical Data	ES ARF1	ES ARF2	ES GMR1	ES GMR2
Average	31,7	31,8	32,2	31,8
Standard Deviation	0,53	0,44	0,74	0,48
Minimum	30,5	30,6	29,7	30,6
Maximum	34,0	32,6	34,2	32,5
Mode	31,5	31,6	32,6	31,7
N	196	196	196	196
Second Third Average	32,0	32,0	32,6	32,0

Now, we know the sex of embryos is defined during the second third of the incubation period, this means that the average temperature during days 20 to 40 determines the predominant gender of the hatchlings (Desvage *et al.*, 1993; Spotila *et al.*, 1987). Within this framework and again thinking about when collect biological data can be possible, temperatures measured this year would have generated 100% females (Table 6.), according to research conducted in nesting populations inside the Wider Caribbean, like Surinam and Costa Rica, which has a pivotal temperature of 29.5°C (Chacon and Arancibia, 2007; Hilterman and Goverse, 2002).

With regard to the relative humidity, it has been argued that influences embryonic survival, especially because of its effect on gas exchange (Runemark, 2006). Nevertheless, Houghton *et al.*, (2007) studying the effect of the rain as contributor of humidity, said that in extreme conditions it can cause high embryo mortality, but in normal or average rainfall regimes, the effect on the nest is

"*refreshing*", which means lower temperatures and so, it can divert to male sex determination, a trend that nowadays with the current temperatures is becoming less common. The authors are also clear in stating that to determine what is a regime of high or normal rainfall in relation to hatchling, it should be local approaches. Godfrey *et al.,* (1996) suggest that the sex ratio of hatchlings in Surinam is largely influenced by the rainfall regime changes throughout the years.

Another event that brings moisture into the incubation process is the flooding of nests by sea washing or groundwater level rise. Runemark (2006) argues that these situations are among the main causes of embryonic death for leatherback in Tortuguero (Costa Rica); she said that for that beach, relocation of nests at risk of flooding is a strategy that increases the recruitment of hatchlings. It is therefore important to measure the water level of the sites where nest are present, then get the results after hatchling, and be able to analyze its influence on the incubation process. These procedures, may provide the best areas of the beach where would be possible relocate the endangered nests.

All this research and the results have been obtained from the strategies adopted, make clear the need to deepen the understanding of these aspects for TNP, and in our concept would be ideal to establish the measurements of temperature and humidity as part of the baseline information of reproductive activity. Be able to relate abiotic and biological data is going to allow generate valuable knowledge for the conservation and management decisions and raise possibilities for improving productivity in the area, we need to understand what it happens in the TNP in order to take international examples and apply them to local needs.

Identification of threats affecting nesting habitats

Colombia Marina Foundation wishes to acknowledge the disposition of UAESPNN for conducting research in the area, and all the support received from managers, professionals and officials of the Tayrona National Park, during the three years of research. This collaboration and the effort has made progress in the conservation of these species within the area and what they have learned in this time can be very useful in the future. However, this process has barely begun and the low nesting activity in recent season's that becomes a lack of reasons to seek international funding, the responsibility for the continuation and implementation of recommendations made through these three years of work, rests with the park authorities and indeed the national authorities.

The persistence of anthropogenic threats in protected areas is perhaps the most disturbing element for Colombia Marine in the entire process in the TNP. Since 2007, the threats from human activities are the same and don't improve. Issues such as the absence of night patrols and the tagging program all over the park beaches, the lack of absolutely protection of nests and hatchlings, fishing with trammel nets in front of the index beaches and increased disorganized tourism is the common denominator for TNP beaches. We are well conscious of social problems that protective measures can generate, but those are problems that need to find a solution without putting the environment in a second level. However, since the presence of communities is a reality, policymakers should consider a strategy of community-based conservation, which get the people involved in these conservation needs, in exchange for benefits for them.

CONCLUSIONS

The reproductive activity of sea turtles in at Tayrona National Park is showing the result of decades of over exploitation and lack of protection measures in the area. The number and intensity of anthropogenic threats affecting sea turtles in the Arrecifes sector, is worrying and requires prompt and effective attention of the authorities to correct them. The investigation and understanding of the incubation process for *Dermochelys coriacea* inside the area, is essential to improve hatching success of this species and Tayrona's National Park productivity. Faced with diminished reproductive activity of sea turtles in the area, which makes it harder for international sponsorship for research, national authorities must take responsibility for the issue and attempt to continue the efforts made so far. To ensure the permanence of sea turtles populations at Tayrona National Park, it is needed total protection on females and nests, and the release of the greatest numbers of hatchlings that may occur in the area.

RECOMMENDATIONS

Read carefully each of the researches made in the area, and all the recommended literature, as these texts have the strategies that Tayrona's National Park authorities must take to ensure that these populations do not disappear. The establishment of monitoring and tagging program in the index beaches of Tayrona National Park is essential to protect and understand the populations present in the area. Involve the community in conserving these animals may have beneficial effects for both groups in Tayrona National Park. All research undertaken in the area must have a close and constant monitoring by program managers to avoid situations that go against the policies of the Park. Research reports, should reach the hands of park officers, they have so much information that helps them improve their daily management and conservation activities.

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