Beach profile correlated to nest site selection of Green turtles (*Chelonia mydas*) at Playa Norte, Tortuguero, Costa Rica

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hogeschool

CANADIAN ORGANIZATION FOR TROPICAL EDUCATION AND RAINFOREST CONSERVATION

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16/11/2012 – Tortuguero, Costa Rica

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Acknowledgements

This report about the correlation between beach profile and nest site selection of the Green turtle is commissioned by COTERC and HAS hogeschool. As a student of Applied Biology we have to do an internship abroad. I ended up in Costa Rica, at Caño Palma Biological Station. My goal for doing this research was learning how to participate in a real company and setting up my own research.

This research is to the accompaniment of Aidan Hulatt of COTERC and Lotte Bakermans of HAS hogeschool, completed by Ilse Leemans.

I want to thank Aidan Hulatt for being my supervisor and helping me figure out how to set up this research, Lotte Bakermans for being my supervisor in the Netherlands and giving me useful feedback, Charlotte Foale for giving me the best experience at Caño Palma Biological Station, Kymberley Snarr for giving me the opportunity to do my internship at Caño Palma Biological Station and everyone who helped doing my beach profile field work (Khristina Bonham, Jessica Bradford, Mark Groen, Emma Lehmberg, Sophia Merritt, Jessica Kunz, Saoirse Pottie and Rejean Cotes).

List of contents

Summary

Playa Norte, the beach on the north east coast of Costa Rica is the study site of this research. It is close to Tortuguero National Park. Four species of sea turtles nest on the beach, and the Green turtle is one of them. They are recognized internationally as endangered by the World Conservation Union, but still common in the Tortuguero area. To restore the population it is an option to establish a hatchery. To find out if the hatchery is going to be the best solution to restore the population, it is necessary to know where the Green turtle nest. Important factors for a nest site are the distance from high tide line to nest site, the distance from vegetation line to nest site, the zone where they nest and if there is a correlation between beach profile and the nest site selection.

The ocean will make the beach steeper near the water line, those big slopes can make it more difficult for the turtles to crawl further up to the beach, because it costs more energy to drag themselves up the beach. As a result they will tend to nest closer to the ocean. How steep the beach is, how less far they crawl. If the nest is too far away from the high tide line and too close to the vegetation line it will be too hard for the hatchlings to go to the ocean. But if the nest is too close to the high tide line the nest might get eroded. There was no clear expectation about the zone where the Green turtle nests, because the Green turtle tend to nest in open, border and vegetation zone.

The distance from ocean to nest site, from high tide line to nest site and from vegetation line to nest site were measured by using the beach profile methodology for every new nest. The angle of inclination to measure the steepness of the beach is been measured by using the same methodology. The zone where the Green turtle nested is been recorded for every new nest.

The results were as expected. The Green turtle crawls less distance up the beach if the beach is steeper. There is a negative correlation between the distance from ocean to nest site and the angle of inclination. The distance from high tide line to nest site was bigger than the distance from vegetation line to nest site. For the last three years, 2010, 2011 and 2012, the highest number of nests was in the border zone. However, there was no statistical difference between them.

It can be concluded that there is a negative correlation between the distance from ocean to nest site and the angle of inclination. The Green turtle nests were further away from the high tide line than from the vegetation line. As last there was no statistic difference between the open, border and vegetation zone.

1. Introduction

Caño Palma Biological Station is one of the conservation organisations that is fighting for the future of sea turtles. It is owned and operated by the Canadian Organisation for Tropical Research and Rainforest Conservation (COTERC). Caño Palma Biological Station has been running a marine turtle monitoring program since 2004 with guidance from the Sea Turtle Conservancy (STC). There are four aims of the marine turtle monitoring program:

- Improved scientific understanding of local marine turtle nesting abundance and patterns;
- Increased awareness of human threats and disturbance to nesting marine turtles through active outreach and education of children, adults, and businesses. Practical stewardship actions are needed to diminish these threats to nesting turtles and integration of conservation and socio-economic benefits;
- Reduce the human-induced mortality and disturbance to nesting females and their nests;
- Establish a cooperative and collaborative network of contact organizations and an inventory of monitoring and research information that can be shared and accessed by all people and conservation organizations (e.g., STC, Association ANIA and WIDECAST) (Bonham, 2012 unpublished)

The community of San Francisco has raised the possibility of building a hatchery on Playa Norte with COTERC but research is necessary to determine the nesting behaviour of Green turtles on Playa Norte before recommendation about hatchery location can be made.

There are seven sea turtles species; Leatherback (*Dermochelys coriacea)*, Green (*Chelonia mydas)*, Loggerhead (*Caretta caretta)*, Hawksbill (*Eretmochelys imbricata)*, Olive Ridley (Lepidochelys olivacea), Kemps Ridley (*Lepidochelys kempii)* and Flatback (*Natator Depressus*). The Green turtle is the most abundant species on Playa Norte (table 1.1), but the Leatherback, Hawksbill and Loggerhead nest on Playa Norte as well, but in lower abundance. The Green turtle nesting season is between March and November on Playa Norte (table 1.2). The Leatherback nesting season is between March and June (Philips, 2001) and so was outside of this research. Because of the amount of Green turtles and the time of the nesting season, this research will be focused on the Green turtle.

Table 1.1 Amount of Green, Loggerhead and Hawksbill turtle nests in 2010, 2011, 2012

Species / Year	Green	Loggerhead	Hawksbill
2010	955	1	31
2011	186	0	55
2012	768	10	44

Table 1.2 Start and end of green turtle season in 2010, 2011, 2012

Season / Year	Start Green season	End Green Season
2010	17-03-2010	25-09-2010
2011	03-04-2011	19-10-2011
2012	03-05-2012	15-11-2012

Green turtles are recognized internationally as endangered by the World Conservation Union (IUCN) (www.iucnredlist.org). The Green turtle population has declined from between 48 -67% worldwide (www.iucnredlist.org) and even in Costa Rica, with its laws and active protection, it suffers significant losses from poaching. Tortuguero is still the largest nesting site in the world for Green turtles, with 22,500 nesting females per year (Spotila, 2004).

Sea turtles live in tropical and subtropical oceans all around the world. The female will spend most of her time in the ocean. The only time she leaves the ocean is to nest on the beach, but every sea turtle will start their life on the beach as a hatchling. All seven species are declining and human impacts are the biggest threat to sea turtles (Sea Turtle Conservancy, 2011). These threats include the poaching of eggs and meat and habitat destruction in their feeding grounds. The potential loss of Green sea turtles to wider marine environment could have far reaching impact. The Green turtle is one of the few animals to eat sea grass, which needs to be eaten for their growing process. Sea grass beds are important for the breeding and developmental grounds for a lot of fish, shellfish and crustaceans species. If the Green turtle populations further decreased this would have consequences for other species that are supported by the sea grass habitat. Another important factor that is influenced by the sea turtle is the low amount of nutrients on the beach. Without any nutrients the vegetation on the beach will not survive (Sea Turtle Conservancy, 2011). The sea turtle lays around 100 eggs in a nest on the beach. Only a small percent of the eggs will hatch and the other part will provide the beach of nutrients. With these nutrients the dune vegetation will grow stronger and it will help to hold the sand in the dunes. The stronger dune vegetation will protect the beach from erosion and this will save some turtle nests from getting eroded (Sea Turtle Conservancy, 2011).

There are different effects that influence the Green turtle population. Egg collection occurs at 45% of all nesting beaches and harvesting of nesting females occurs at 27% of all beaches. Intentional fishing of adults and juveniles 47%, accidental capture in fishing trawls, nets and longlines affects 49%, habitat loss on nesting beaches and sea affects 25% and diseases, particularly fibropapillomatosis affects 42% of the Green turtle population (Spotila, 2004).

Green turtles tend to nest in vegetated areas behind open sand (Wang & Cheng, 1999). Green turtles in Australia tend to nest on platforms of sand that were 1–3 m above the mean high-water line on beaches with lower salinities in surface sand and at nest depth (Wood & Bjorndal, 2000). According to Phillips (2001) the Green turtles nest along open sand beaches up to the dune grass or beach vines. In contrast to this Diez & Ottenwalder (1999) the Green turtles tend to nest in open habitat. There are different results of the area where the Green turtle will nest. To be sure where the Green turtles will nest at Playa Norte, and to know where the hatchery could be built, it is important to do a study to nest site selection of the Green turtle.

The ocean will make the beach steeper near the water line (Wood & Bjorndal, 2000), those big slopes can make it more difficult for the turtles to crawl further up to the beach, because it costs more energy to drag themselves up the beach (Coudert, 2009). As a result they will tend to nest closer to the ocean (Wang & Cheng, 1999).

There are two considerations for a turtle before she will start laying eggs. The eggs should be faraway enough from the high tide line, otherwise they may be eroded, secondly the eggs should not be placed so far from the ocean that the hatchlings can crawl to the ocean without being eaten by predators or that they are unable to find the sea due visual obstructions (Miller et al., 2003). In a study by Brown and Macdonald (1994) they found that 67% occurred 30 – 60 metres from the high tide line and 80% of nests occurred within 20 metres of the vegetation line. If the turtles will nest close to the high tide line and far away from the vegetation line, the nest will be eroded. To know where the hatchery could be placed, the distance from nest to high tide line and vegetation line should be studied.

To measure the distance from ocean to nest site, from high tide line to nest side and from vegetation line to nest site for every new nest, the standard beach profile monitoring method of Fish (2011) will be used. The zone where the Green turtles nested will be recorded for every new nest.

2. Material and method

2.1 Study site

Caño Palma Biological Station is located in National Park Tortuguero at the northeast coast of Costa Rica . 300 meters to the east is the beach; Playa Norte. The study site will be the first two miles of the turtle survey transect at Playa Norte (figure 2.1). It will not be the whole transect (3.12 mile) because the beach profile will be measured in the afternoon and the measurement will not be finished before dark if there are a lot of nests to measure. Starting earlier is not possible because the morning patrol does not come back before 11:00hr. It is not possible to do the beach profile during morning patrol, because there is other scientific data what need to be collected.

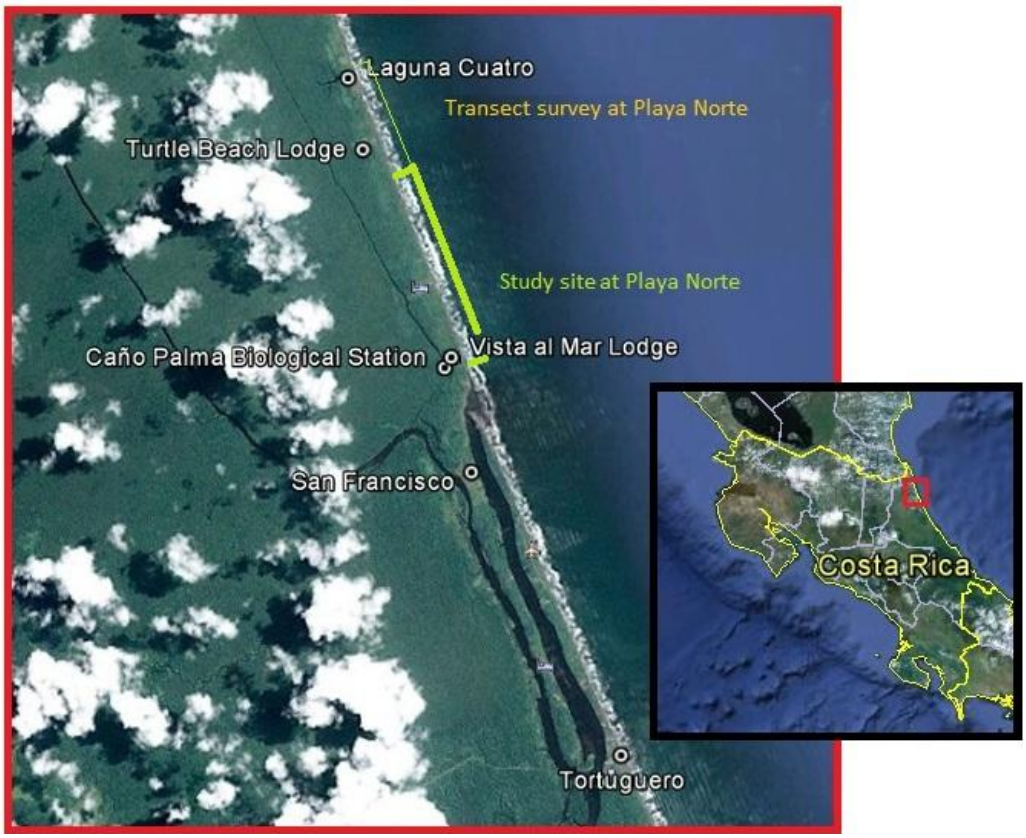

Figure 2.1 National Park Tortuguero in Costa Rica (Google Earth)

2.2 Green turtle

The Green Turtle has an average carapace length of 80 -l 122 **cm** and weigh between 65 and 204 kilogram. They have a light or dark brown carapace, it is sometimes shaded with olive, with bold streaks or blotches of brown. Their plastron is yellowish-white. You can recognize them on their four costal scutes, five vertebral scutes and one pair prefrontal scales on their round face (figure 2.2) (Lagueux, 2001). They are called Green turtles because of the greenish colour of their fat which is due to their diet of sea grasses (Spotila 2004, Lagueux 2001).

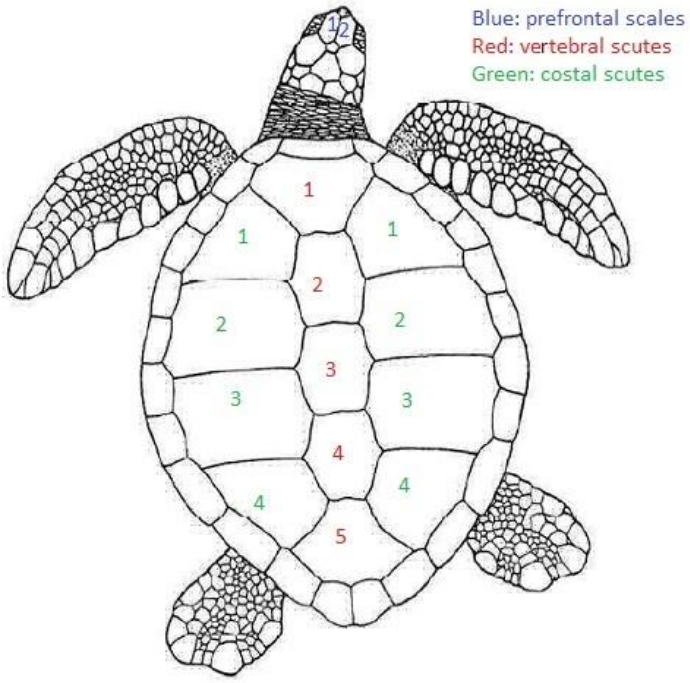

Figure 2.2 Green turtle with 5 vertebral scutes, 4 costal scutes and 1 pair prefrontal scales

2.3 New nest

Every night and morning the new Green turtle nests will be recorded by the team that is working on the beach. Night patrols will start between 20:00 and 23:00 and will take at least 4 hours. Morning patrols will start at 5:30 and will take between 2,5 and 7,5 hours. During the morning patrols and night patrols all the new nests and half moons will be recorded. During night patrols turtles will be encountered and if it is possible the eggs will be counted, the turtle will be tagged and the nest will be marked by using triangulation. If a turtle laid a nest and the team has tagged the turtle it will be a REC. If a turtle laid a nest and the turtle was already tagged and the tags will be read it will be a REM. It will be a NST if there is a nest and the turtle wasn't seen, or it was seen but had no tags or unable to tag or read the tags.

A new nest can be recognized by tracks going up to the beach, a body pit, lots of sand spray, soft sand on one site of the body pit and the down tracks are going straight back into the ocean (not searching for another nest site) (appendix 1). For each new nest the GPS coordinates and mile will be recorded. Mile markers are placed on the beach every 1/8 of a mile. The first mile marker north is the mile marker that will be recorded.

2.4 Beach profile monitoring

Data collection will start on the 13th of September until the 13th of October and 20th of October. Once in two days the beach profile will be measured for each new nest of the last two days. The beach profile is divided in five parts:

- The angle of inclination and distance from ocean to nest site
- Distance from high tide line to nest site
- Distance from vegetation line to nest site
- The place of nesting (open, border or vegetation).

The standard beach profile monitoring method of Marianne Fish will be used (Fish, 2011). For measuring the beach profile two poles of 1.50 metre will be used. The poles will need a flat piece of hard plastic on the bottom, so they will not sink in the sand. Pole one will need a measuring tape on the side, from top to bottom, of 1.50 metre.

The first pole from 1.50 metre with the measuring tape starts at the nest site, the ocean side of the nest, and the second pole from 1.50 metre starts at the first slope. Standing behind the first pole and looking to the top of the second pole, by using a finger as a line next to your eye, the difference in height can be checked on the measuring tape. The top of the second pole should be in one line with the horizon and a finger. If the height is checked, the distance from nest site to ocean can be measured by using a triangulation tape or a measuring laser at the measured height and on top of the second pole (figure 2.3) (Fish, 2011).

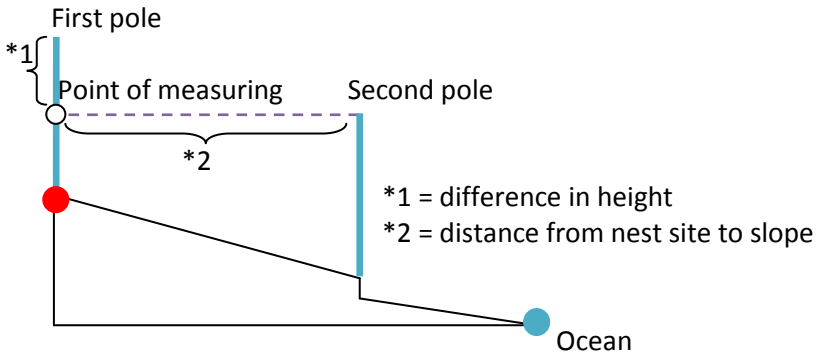

Figure 2.3 Method of measuring distance from nest site to slope (Leemans)

2.5 Angle of inclination and distance from ocean to nest site

The angle of inclination (figure 2.4) and distance from ocean to nest site (figure 2.5) will be measured, by measuring the difference in height and the distance from nest site to first slope, from first slope to second slope, etc. The last part is from the last slope until the ocean, where the wave is crashing (figure 2.6). The total of all the slopes is the distance from ocean to nest site.

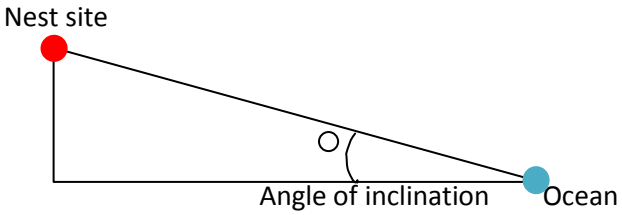

Figure 2.4 Angle of inclination from ocean to nest site (Leemans)

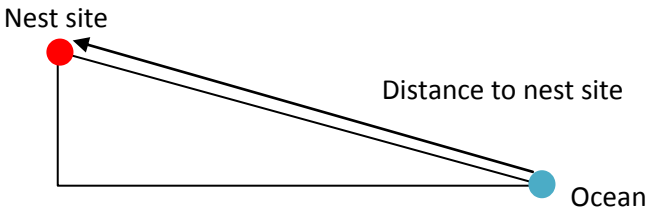

Figure 2.5 Distance from ocean to nest site (Leemans)

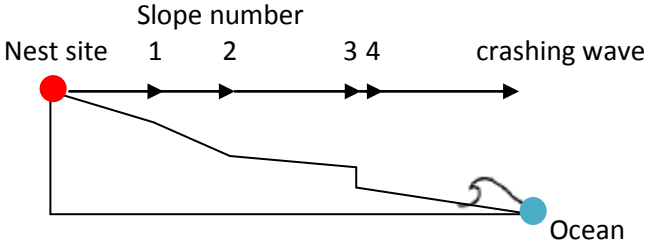

Figure 2.6 Slopes on the beach and the crashing wave in the ocean (Leemans)

By using the total of all the difference in height of all the slopes, the angle of inclination can be calculated. The distance from ocean to nest site will be calculated by using the Pythagoras formula (WisWijzer, 2012): $M = \sqrt{H^2 + L^2}$. H is the difference in height, L is the difference in length and M is the length the turtle actually crawled. The angle of inclination will be calculated with the next formula:
$D = Arctan(\frac{H}{L})$. H is the difference in height, L is the difference in length and D is the distance from the ocean to the nest site.

2.6 Distance from high tide line to nest site

The distance from high tide line to nest site (figure 2.7) will be measured by using the same method with the two poles. By using the measuring laser (Sonin Multi-Measure combo PRO) or triangulation tape at the first pole at the nest site in one line with the horizon and the top of the second pole at the high tide line.

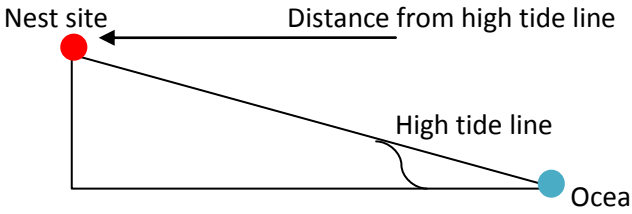

Figure 2.7 Distance from high tide line to nest site (Leemans)

2.7 Distance from vegetation line to nest site

The distance from vegetation line to nest site (figure 2.8) will be measured by using the same method with the two poles. By using the measuring laser or triangulation tape at the first pole at the beginning of the vegetation line in one line with the horizon and the top of the second pole at the nest site.

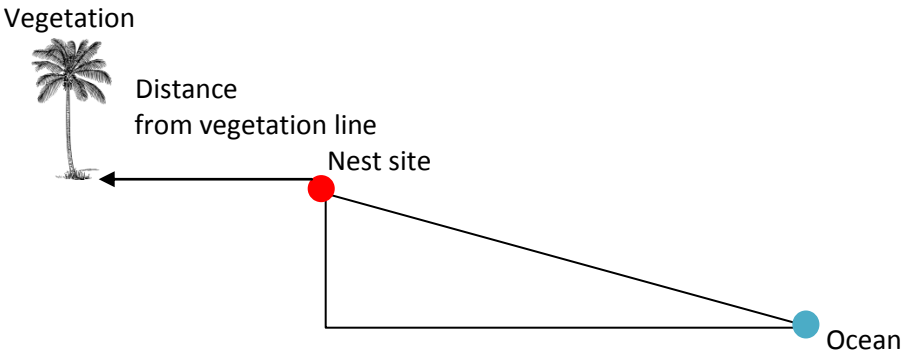

Figure 2.8 Distance from vegetation line to nest site (Leemans)

2.8 Vegetation, border and open

There are three zones on the beach, open zone, border zone and vegetation zone (figure 2.9). The open zone is the zone with just sand, without any vegetation. The border zone is the zone with the lower vegetation. The vegetation zone is the zone with the trees and shadow. The zone will be recorded for each new nest.

Figure 2.9 Open zone, border zone and vegetation zone at Playa Norte (Leemans)

2.9 Analyses

The average of each part of the results will be calculated and the results will be described in words. The zone where the nest was laid will be tested with the One-Way ANOVA to make sure there is no coincidence by the observed data. The correlation between angle of inclination and distance from ocean to nest site will be calculated with a Pearson correlation test to see if there is a relation between the distance and the angle of inclination.

3. Results

During this research, 89 nests were laid and in the total season of 2012 were 768 nests laid. In 2010, a lower year, were 955 nests laid and in 2011 were 186 laid. Number of nests every 1/8 of a mile in table 3.1. During this research the highest amount of nests is at mile 4/8 and the lowest amount of nests is at 1 4/8. Highest amount of nests in 2012 was at 3/8 and the lowest amount of nests was at 2 4/8. Highest amount of nests in 2011 was at 3/8 and the lowest amount of nests was at 1 4/8. Highest amount of nests in 2010 was at 1 2/8 and the lowest amount of nests was at 3 1/8.

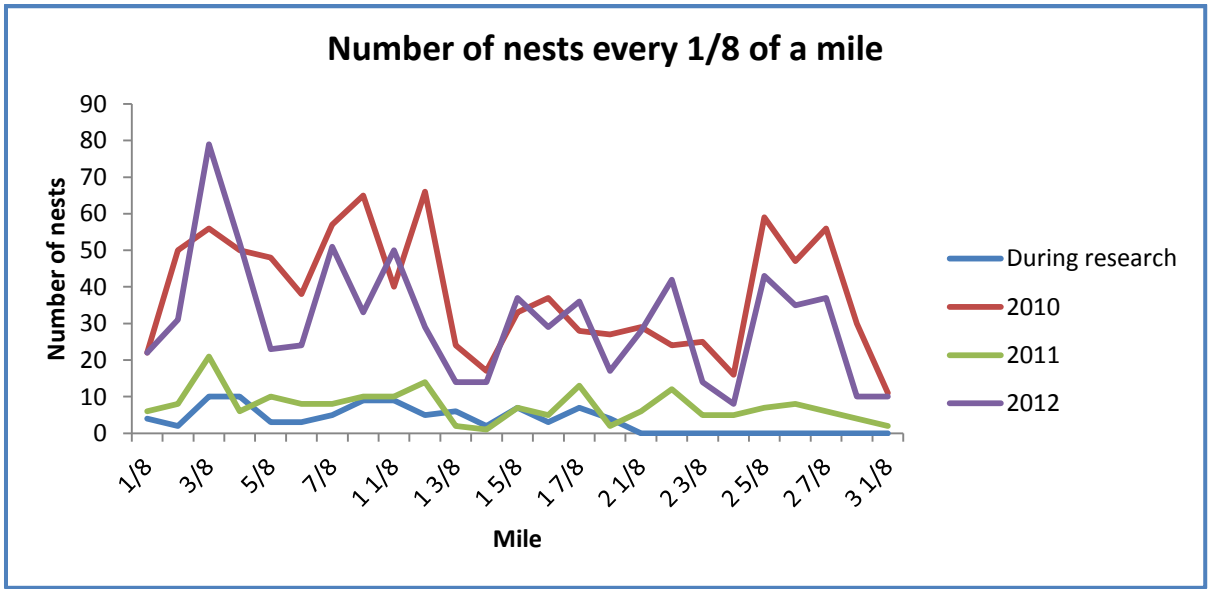

Figure 3.1 Number of nests every 1/8 of a mile in 2010, 2011, 2012 and during this research

3.1 Distance from ocean to nest site and angle of inclination

Crawled distance (figure 3.2) and angle of inclination (figure 3.3) is been measured for every nest from 13th of September until 13th of October and 20th of October. The furthest the turtle crawled is 70.42 metres and the shortest is 14.82 metres. 91% of nests were laid between 20.01 and 50 metres away from the ocean. The highest number of the angle of inclination is 7.0375 degrees and lowest 0.2856 degrees. 84% of the nests had an angle of inclination between 2.01 and 4 degrees.

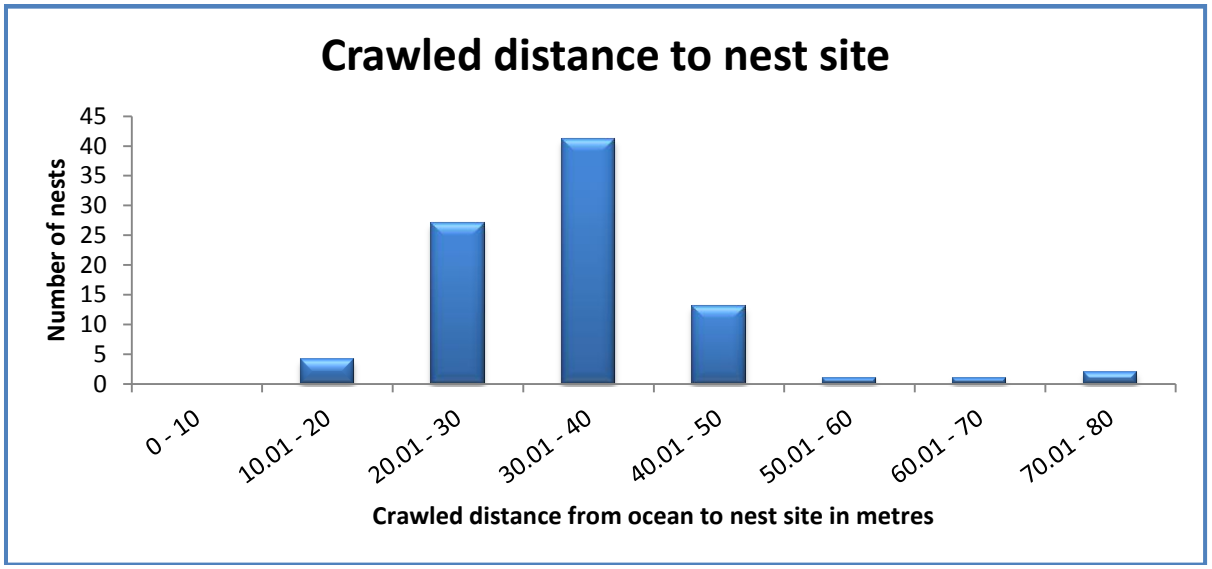

Figure 3.2 Number of nests per 10 metres crawled distance from ocean to nest site

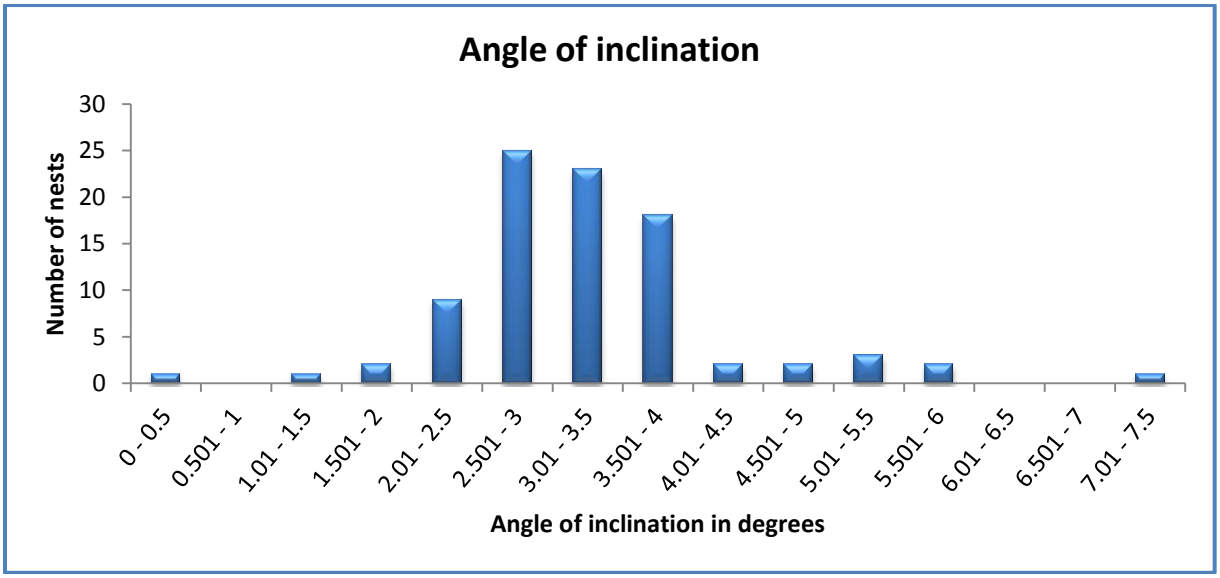

Figure 3.3 Number of nests per 0.5 degrees angle of inclination from ocean to nest site

A Pearson's correlation was run to determine the relationship between angle of inclination and crawled distance from ocean to nest site (figure 3.4). There was a negative correlation between angle of inclination and crawled distance from ocean to nest site ($r = 0.7$, $N=89$, $p < 0.001$) (appendix 2).

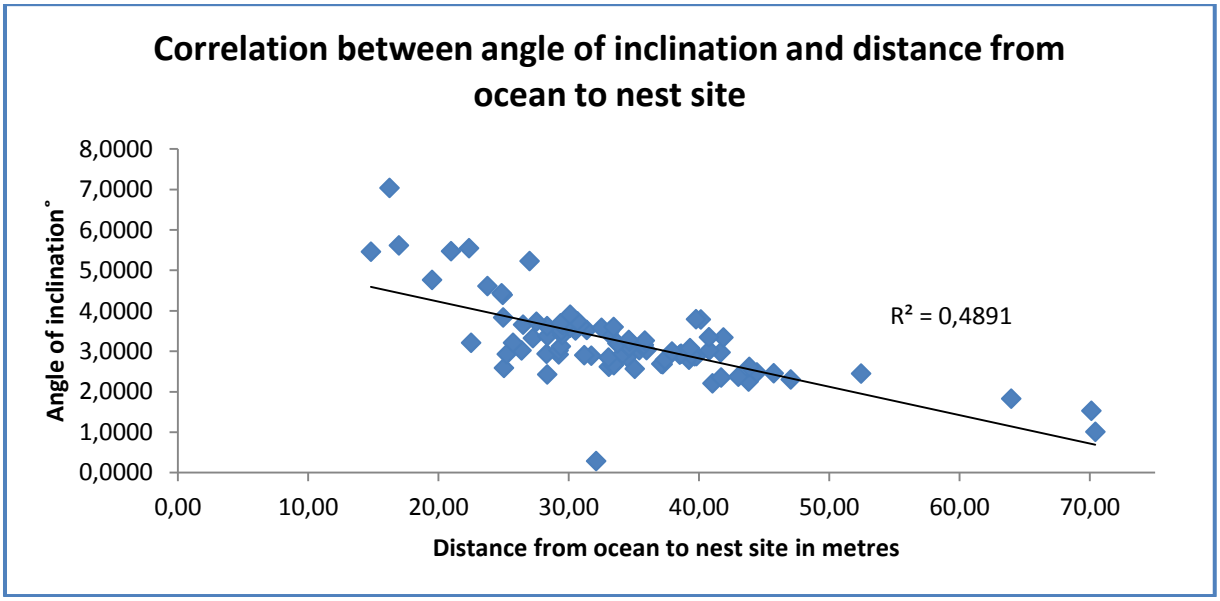

Figure 3.4 Correlation between the angle of inclination in degrees and the crawled distance from ocean to nest site in metres

3.2 Distance from high tide line to nest site

Distance from high tide line to nest site is been measured during this research from 13th of September until 13th of October and 20th of October (figure 3.5). The furthest a turtles crawled during this research is 58.26 metres and shortest is 2.29 metres. During this research there was an average of 22.15 metres. 11% occurred 30 – 60 metres of the high tide line.

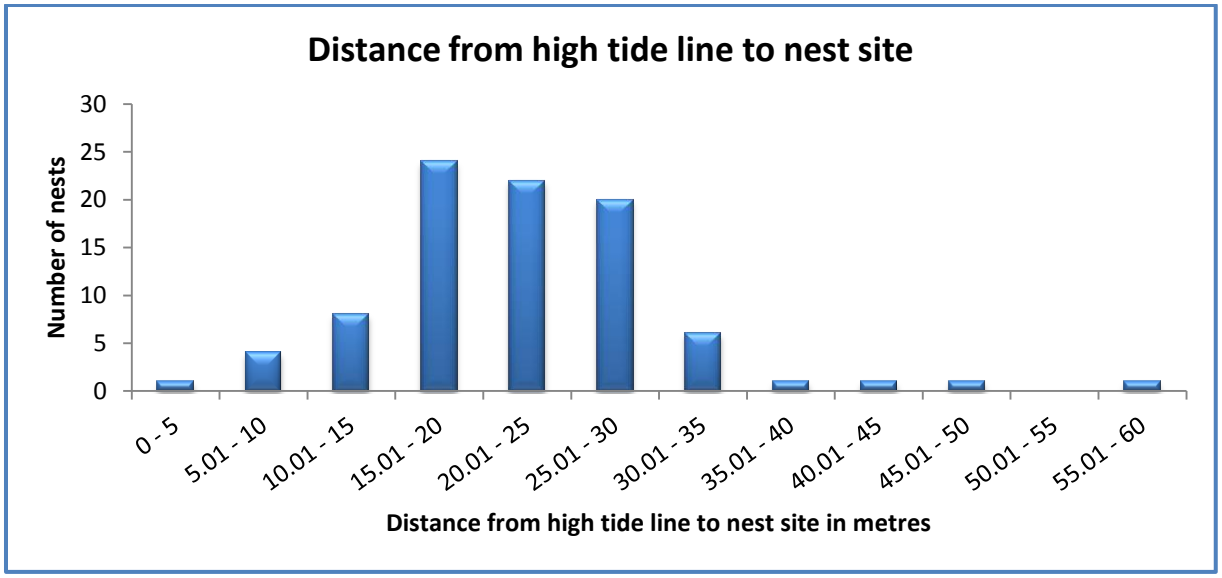

Figure 3.5 Number of nests per 5 metres distance from high tide line to nest site

3.3 Distance from vegetation line to nest site

Distance from vegetation line to nest site is been measured from 13th of September until 13th of October and 20th of October (figure 3.6). The furthest a nest was away from the vegetation line was 16.99 metres and the closest a nest was to the vegetation was 2.35 metres. There was an average of 8.14 metres. 100% of nests occurred within 20 metres of the vegetation line.

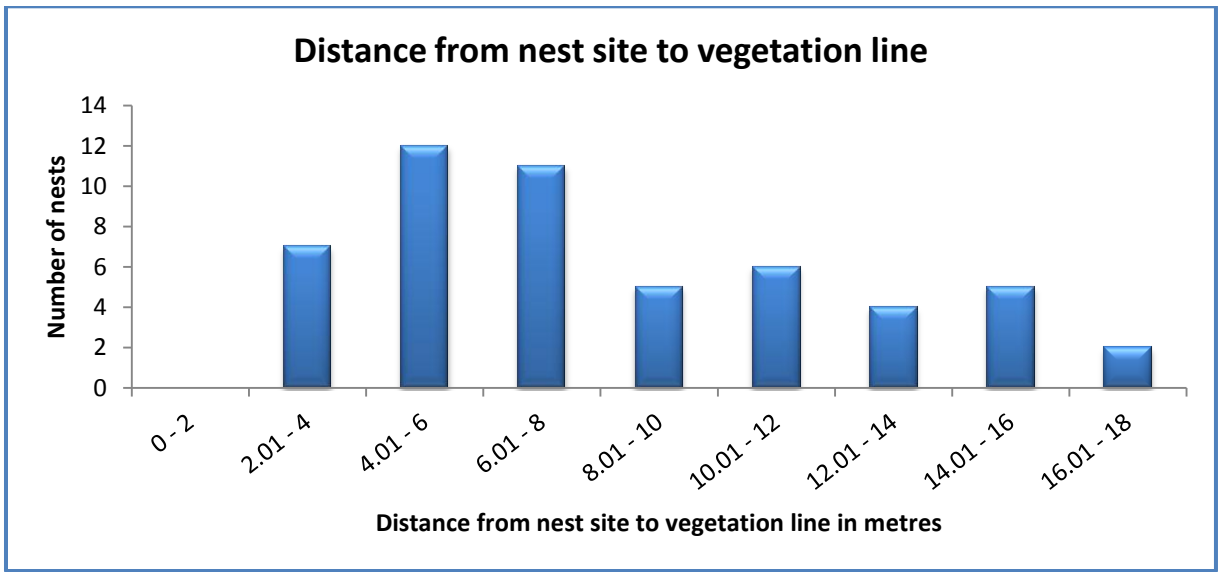

Figure 3.6 Number of nests per 2 metres distance from nest site to vegetation line

3.4 Open, border en vegetation

Percentage of nests per zone, open, border, vegetation, is been reported from 13th of September until 13th of October and 20th of October (figure 3.7). During this research one nest was laid in the open zone, 51 nests were laid in the border, and 37 nests were laid in the vegetation.

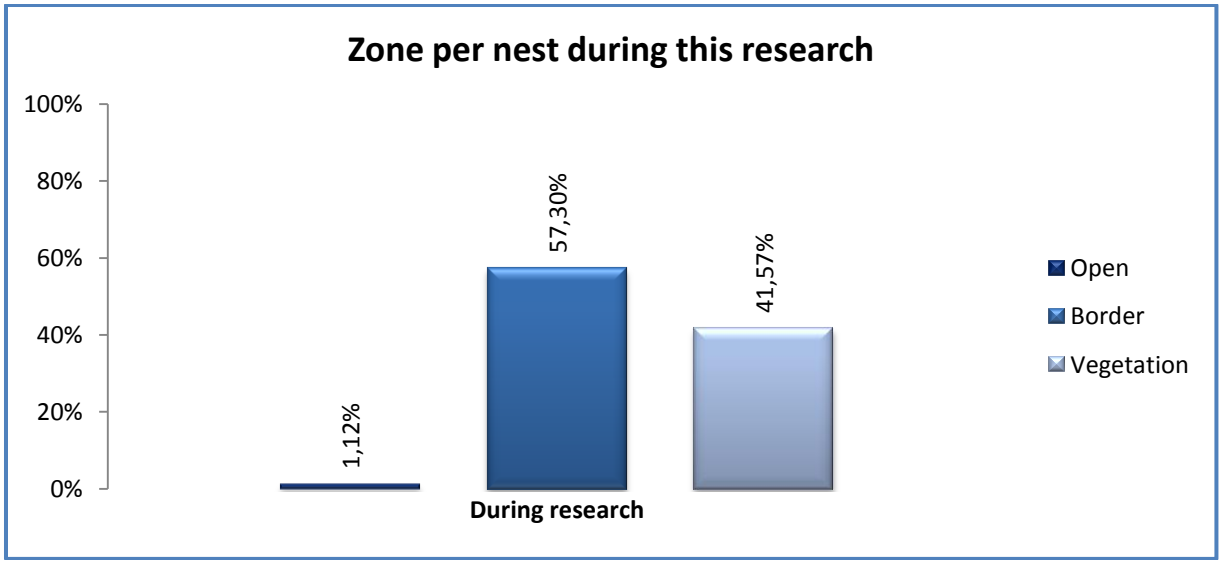

Figure 3.7 Percentage of nests per open, border and vegetation zone during this research

Percentage of nests per zone, open, border, vegetation is been reported in 2010, 2011 and 2012 for every nest (figure 3.8). Every year the highest amount of nests were laid in the border. Remarkable is that more nests were laid in the open zone than in the vegetation in 2010 and 2011. But In 2012 were more nests laid in the vegetation than in the open zone.

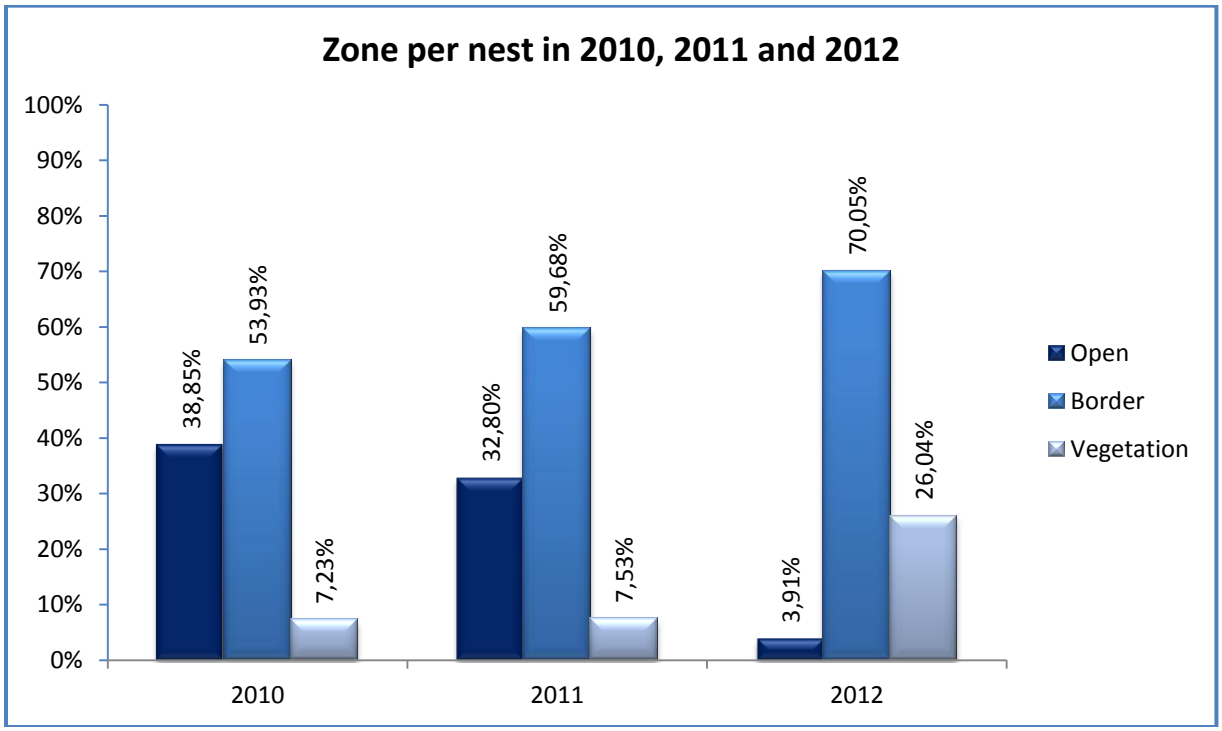

Figure 3.8 Percentage of nests per open, border and vegetation zone for 2010, 2011 and 2012

To test if there is a significant difference between the open, border and vegetation zone in 2010, 2011 and 2012 (including this research) the One-Way ANOVA test is been used. The P-value is 0.240 and the F statistic is 1.678 (appendix 3). That means there is no significant difference between the number of nests laid in the open border and vegetation zone.

4. Discussion and conclusion

The movement and currents of the ocean will make the beach steeper near the water line (Wood & Bjorndal, 2000), those big slopes will make it harder for the turtle to crawl further up to the beach, because it cost them more energy to drag their body up to the beach (Coudert, 2009). This will affect their nest site selection and they will nest closer to the ocean (Wang & Cheng, 1999). The distance from ocean to nest site and the angle of inclination is been measured for 89 nests. There is a correlation of -0.7 between the distance and the angle. How closer to -1 how more perfect the negative correlation is (SPSS handboek, 19-12-12). That means how steeper the beach is, how less far the turtles crawl and there is a negative correlation between the distance from ocean to nest site and the angle of inclination. Just like the expectation, according to Wang & Cheng (1999), the Green turtles crawl less far if the beach is steeper.

According to Brown & Macdonald (1994) 67% occurred 30 – 60 metres from the high tide line and 80% occurred within 20 metres of the vegetation line. So the expectation is that Green turtles nests are further away from the high tide line then from the vegetation line. The distance from high tide line to nest site is been measured and there was an average of 15.25 metres. The distance from vegetation to nest site is been measured and there was an average of 8.14 metres. So the results are the same as the expectation, the Green turtle nests are further away from the high tide line then from the vegetation line. But there is a shorter distance from high tide line to nest site, this is probably because the total distance from the ocean to the vegetation line is shorter on Playa Norte then at the Akyatan Beach in Turkey during the research of Brown & Macodonald (1994).

As you can read in the introduction there is no specific zone where the turtles nest. According to Wang & Cheng (1999), Wood & Bjorndal (2000) and Phillips (2001) the Green turtles nest in the border and vegetation zone. In contrast of this the Green turtles nest in open areas according to Diez & Ottenwalder (1999). Because there are different results where the Green turtles nest, there was no clear hypothesis. During this research the turtles nested more in the border then in the open zone and vegetation. And they nested more in the vegetation then in the open zone. The highest number of nests was every year in the border zone. Although, after comparing the data of 2010, 2011 and 2012 there can be concluded that there is no statistic difference between the open, border and vegetation zones. There was not a clear expectation about the zone where the Green turtles are nesting, because there are different results from different researches. So it is logical that there is no statistic difference between the open, border and vegetation zones.

End conclusion

According to this research can be concluded that if the beach is steeper the Green turtles crawl less far. The Green turtles nest further away from the high tide line then from the vegetation line. There is no statistic difference between the open, border and vegetation zone where the Green turtles nest.

Recommendations

Hatchery on Playa Norte should be at least 15 metres away from the high tide line and less than 8 metres away from the vegetation line. So the eggs will not be eroded and the hatchlings do not have to walk too far to the ocean.

This research should be repeat for at least 10 years so five high seasons and five low seasons will be measured. During these 10 years the whole Green season should be measured so there will be enough information to make a conclusion.

References

Bonham, K. (2012) *'2012 COTERC Marine Turtle Monitoring Project Final Report'* COTERC (unpublished)

Brown, L. & Macdonald, D. W. (1994) *'Predation on Green turtle Chelonia mydas nests by wild canids at Akyatan beach, Turkey'* Wildlife Conservation Research Unit, Department of Zoology, University of Oxford

COTERC (w.y.) *'Caño Palma Biological station, research'* Retrieved September 5, 2012, from www.coterc.org

Coudert, J. (2009) *'An assessment of sea turtles nesting sites in Las Perlas Archipelago, Panama'* Centre for Marine Biodiversity and Biotechnology, School of Lieve Sciences, Heriot-Watt University, Edinburgh

Diez, C.E. & Ottenwalder, J.A. (1999) *'Habitat surveys'* Negociado de Pesca y Vida Silvestra, USA & Coastal & Marine Biodiversity Project, Dominican Republic

Fish, M.R. (2011) *'Guidelines for monitoring beach profiles'* WWF, San Jose

IUCN (2004) 'The IUCN Red List of Threatened Species' Retrieved September 9, 2012, from www.iucnredlist.org http://www.iucnredlist.org/details/4615/0

Miller, J.D. et al. (2003) *'Nest Site Selection, Oviposition, Eggs, Development, Hatching, and Emergence of Loggerhead Turtles'* Bolton

Lagueux, C.J. (2001) *'Statius and distribution of the Green turtle, Chelonia mydas, in the wider Caribbean region'* Wildlife Conservation Society, USA

Phillips, B. (2001) *'Sea Turtle Monitoring Protocols'* Florida Caribbean Science Centre, USA

Sea Turtle Conservancy (2011) *'Information About Sea Turtles, Their Habitats and Threats to Their Survival'* Retrieved September 26, 2012, from http://www.conserveturtles.org/sea-turtle-information.php

Spotila, J.R. (2004) *'Sea turtles - A complete guide to their biology, behaviour, and conservation'* The Johns Hopkins University Press

SPSS (w.y.) *'Correlatie SPSS'* Retrieved December 19, 2012, from http://www.spsshandboek.nl/correlatie.html

Wang, H-C. & Cheng I-J. (1999) *'Breeding biology of the green turtle, Chelonia mydas (Reptilia: Cheloniidae), on Wan-An Island, PengHu archipelago'* National Taiwan Ocean University, Taiwan, China

WisWijzer (2012) *'De stelling van Pythagoras'* Retrieved November 16, 2012, from http://www.wiswijzer.nl/pagina.asp?nummer=136

Wood, D.W. & Bjorndal K.A. (2000) *'Relation of Temperature, Moisture, Salinity, and Slope to Nest Site Selection in Loggerhead Sea Turtles'* American Society of Ichthyologists and Herpetologists, USA

Appendix 1 How to recognize a nest?

A nest can be recognized on tracks going up to the beach (figure 1), the female turtle will select a nest site. If she found a place to nest, she will start digging her body pit (figure 2) and an egg chamber. After this she will start laying her eggs and cover up her nest. This will lead to soft sand at one side of the nest. The last part of nesting is the disguising the nest, a lot of sand spray will be on and next to the nest (figure 3). She will return straight back to the sea (figure 4). If she didn't nest it is a half moon (figure 5). There could still be a body pit and an open egg chamber, but there will not be a lot of sand spray.

Figure 1 Green turtle up track

Figure 2 Body pit from a Green turtle

Figure 3 Sand spray nest to a nest

Figure 4 Green turtle down track

Figure 5 Half moon of a Green turtle

Appendix 2 Correlation in SPSS

Pearson correlation between angle of inclination in degrees and the crawled distance in metres from ocean to nest site.

Correlations

		Angle	Distance
Angle	Pearson Correlation	1	-,699**
	Sig. (2-tailed)		,000
	N	89	89
Distance	Pearson Correlation	-,699**	1
	Sig. (2-tailed)	,000	
	N	89	89

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 3 Statistic test for the zone

The statistic test for the zone where the nest was laid.

ANOVA

Number

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	115581,500	2	57790,750	1,678	,240
Within Groups	309931,500	9	34436,833		
Total	425513,000	11			