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Hawksbill Turtle Eretmochelys Imbricata Nesting Environment and Population Study in Cuero Y Salado Wildlife Refuge on the Coast of Northern Honduras

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Honors Thesis

Hawksbill Turtle *Eretmochelys imbricata* Nesting Environment and Population Study in Cuero y Salado Wildlife Refuge on the coast of Northern Honduras

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Date submitted ______________

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ABSTRACT

This report outlines my contributions to ProTECTOR's Hawksbill turtle conservation project along the beachfront at Cuero y Salado Wildlife Refuge of Honduras. Observation-focused nightly beach patrols were conducted so as to census numbers of turtles nesting in this location presently and beach characteristic surveys were undertaken to create a map of environmental factors relevant to Hawksbill nesting along this beach.

Resulting environmental maps were correlated with known factors contributing to Hawksbill nest site choice in order to assess the suitability of this beach for hawksbill nesting, and thus determine its value for preservation efforts and ongoing funding.

Of the 10 km beachfront under observation, 267 m were selected for more intensive nesting environment data analysis. This analysis included mapping the elevation, multiple vegetation, and pollution factors as multiple overlying map layers so as to identify most viable sites for turtle nesting via ArcGIS technology.

It was found that the while the beach was under populated (our nightly observations yielded a count of 0 nesting turtles), significant portions of the beachfront displayed both overlap of environmental conditions favorable to function as a Hawksbill nesting site and an absence of environmental conditions which are known to inhibit Hawksbill nesting.

I found that certain portions of the beach displayed the most beneficial combination of environmental factors and are of highest value for preservation whereas other portions of the beach lacked positive environmental factors and thus are of a much lower conservation value.

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INTRODUCTION

The Hawksbill Turtle (*Eretmochelys imbricata*) is one of six species of sea turtles distributed in the waters of the Caribbean and tropical western Atlantic, including the Caribbean coast of Honduras (Kame and Delcroix, 2009). If able to survive the extraordinary odds—a mere 1 in 1,000 hatchlings live to maturity—sea turtles are among the oldest creatures in the sea (able to live more than fifty years) and are late maturing, first reproducing at ages ranging from 20 to 40 years (Stapleton and Eckert, 2008 and Chacon, 2004). The sexually mature female Hawksbill only returns to the beach where it was hatched to nest every 2-3 years by using an innate global positioning system (Chacon, 2004). For the seasons in which the female does nest, it may do so several times (1-8 nestings), laying as many as 200 eggs per nest (Chacon, 2004).

The Hawksbill species fills a unique ecological role in the Caribbean's sea grass and coral reef ecosystems due, in part, to their atypical dietary preference for marine sponges (McClenachan, 2006). Their feeding habits help to maintain species diversity in the coral reefs they inhabit, which in turn stabilizes the coast (Stapleton and Eckert, 2008).

Due to the fact that Hawksbills only leave the water during the breeding season when females dig nests in the sand, not much is known of the Hawksbill turtle's life cycle between its birth and reproductive periods. Substantial work has been done however to catalogue the specifics of the hawksbills' nesting process and preferences in terms of sea access, slope of beach, elevation of nesting site above underlying water table, sand composition, moisture, and temperature (Eckert, 2004; Stapleton and Eckert, 2008; Delcroix, 2009). The entire process of nesting (choosing location, digging pit, laying eggs, and refilling the pit) takes 1-3 hours and the hatchlings emerge about two months later at night, guided to the sea by light reflected off the water from the sky (Chacon, 2004).

Evidenced in longstanding records, Honduras' coastline and bay islands once served as important foraging and nesting grounds for Hawksbills in the Caribbean region, a population estimated to have reached 11 million (McClenachan, 2006).

CURRENT STATE OF HUNDURAN HAWKSBILL

In sharp contrast to the once flourishing historic population reported from as early as 1666, 1774, and 1968, a 2001 study reported a maximum of 5,000 Hawksbills nesting annually in the Caribbean region at the time (Meylen, 2001). This number has continued to decrease dramatically over the course of the 20^{th} century due to ongoing illegal exploitation of the population for tortoiseshell products (Kamel and Delcroix, 2009; Bräutigam and Eckert, 2006), harvesting of nesting females and clutches as nonessential food sources (Dunbar, 2009), degradation of reefs from extraction of coral, waste water and solid waste on reefs, destruction of mangroves, occupation of nesting beaches, and fishing fleet traffic (Bräutigam and Eckert, 2006). This population decline prompted the Hawksbill to be listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 1975, thus prohibiting international trade, and then in 1996 to be declared as Critically Endangered on the

World Conservation Union's (IUCN) Red List of Threatened Animals, which recognizes that Hawksbills have suffered adult population declines of at least 80% over their last three generations (Stapleton and Eckert, 2008). In the entire Caribbean 20% of historic nesting sites have been lost entirely and 50% of the remaining nesting sites have been reduced to dangerously low populations; 44% of these beaches host fewer than 10 nesting female hawksbills (Kamel and Delcroix, 2009; McClenachan, 2006).

While some Caribbean countries have allocated significant resources to manage and conserve marine turtles, Honduras has lacked a coherent turtle conservation strategy involving legislation, consistent enforcement, and a national or sub-national marine turtle management plan (Bräutigam and Eckert, 2006). However, Honduras' 671 km of Caribbean coast and bay islands sport 12 marine protected areas, including Cuero y Salado Wildlife Refuge, which was established in 1987 by the Foundation for Cuero y Salado (FUCSA) (Burke and Maidens, 2004). As the mandated establishment of a research protocol for the park never occurred, FUCSA recently requested the aid of the Protective Turtle Ecology Center for Training, Outreach, and Research (ProTECTOR) in doing so. It is at this particular refuge, located at the confluence of the Rio Cuero and the Rio Salado (Fig. 1), that I conducted my field research project under the guidance of Dr. Stephen Dunbar of ProTECTOR in the Department of Earth and Biological Sciences (EBS) at Loma Linda University (LLU).

Figure 1 A map indicating the locations of ProTECTOR bases. 1. Cuero y Salado. 2. El Venado. 3. Punta Raton. 4. Utila.

PROJECT GOALS

ProTECTOR, founded in 2007 by Stephen Dunbar for the purpose of establishing national sea turtle conservation efforts in Honduras, is working to provide information lacking in Honduras' near nonexistent marine turtle database—there are no maps of known nesting beaches, no estimates of Honduran Hawksbill population based on nesting females, no studies of hatching success, and no conservation programs along the majority of the Caribbean coast of Honduras (Dunbar brief, 2009). The data gathered from ProTECTOR's research and observation will be used to report current Hawksbill status and trends in order to assist communities in the monitoring and recovery of this species toward historical numbers in the Honduran waters of the Hawksbills' range (Dunbar brief, 2009).

On the north coast of the mainland of Honduras, the 24km beachfront of the marine protected area of Cuero y Salado Wildlife Refuge is considered a historic nesting beach for Hawksbill turtles and has reports of Hawksbills nesting as recently as July of 2010. It has become (along with the island of Utila) one of the two most recent focal sites of ProTECTOR's Hawksbill Conservation and Population Recovery in the Caribbean Honduras project through FUCSA (Dunbar brief, 2009). This project is directed towards addressing the local community's need for technical assistance in the development of conservation measures to protect and promote nesting beaches and populations of nesting Hawksbills. Within Cuero y Salado Refuge (and along the majority of the Caribbean coast of Honduras), there exists no previous conservation programs for hawksbill nesting, foraging, or migratory habits nor have any estimates been made of nesting hawksbills, nests, hatching success or assessments of critical habitats (Dunbar brief,2009). In light of this deficiency, establishing a long-term index site for population monitoring for nesting Hawksbills is of high importance.

PROJECT SPECIFICS

Within the outlines of accomplishing the establishment of a population monitoring site, the specifics aspects of my role in ProTECTOR's project at Cuero y Salado Wildlife Refuge included careful monitoring of the beachfront and thoroughly characterizing the environment of the beachfront relative to attributes known to be favorable to turtle nesting.

Beach profiling involves collecting data on factors that will encourage or discourage turtles to nest: width of beach, slope, altitude above sea level, density of vegetation, vegetation type, shadows cast, and pollution of both refuse and light. This information can be used to estimate the likelihood of a turtle to nest and a hatchling to successfully reach the water, from varying locations along a single beach, and the corresponding likelihood of this occurring along the beach at large. Matching these maps of slope, vegetation percentage, and beach characteristics with the recorded location of turtle nests, correlations may be drawn to determine the most favorable combination of beach profile features. The resulting conclusions may be used, in light of limited resources, for determining which sites are of the highest conservative priority.

Regular foot patrolling is a well-established research technique providing information on the number and species of sea turtles using the beach in question, and which additionally, by the presence of beach patrollers, results in reduced poaching activity (Stapleton and Eckert, 2008). Marking individual sea turtles for long-term identification, referred to as tagging, and measuring the carapace (shell), allows for more detailed information to be gathered in regards to the turtle's size, growth, number of nesting episodes per season, and migratory pathways. As none of this has been done previously at the beachfront of Cuero y Salado Wildlife Refuge, these efforts, at present, will result in a baseline for the population, and in following summers provide data for further analysis.

MATERIALS AND METHODS

STUDY SITE

Our study was conducted along the 26 km beachfront of Cuero y Salado Wildlife Refuge on the northern Caribbean coast of Honduras. We actively monitored approximately 10 km of beachfront, a stretch of beach divided from the entrance into eastward (6 km) and westward (4 km) portions and bordered by the outlets of Rio Zacate and Rio Salado, respectively. Beach width varied between 3m and 30 m. Both stretches of beach were backed by a coastal woodland forest and progressively thickening vegetation, which included Hicaco (*Chrysobalanus icaco*), various grasses, sea grape (*Coccoloba uvifera*), and a number of unidentified vegetation types. The only exception was a portion of beach open in the west that lacked adjacent forest, where the river bar convenes with the beachfront. The area between east and west beach sectors is the site of a palapa (wooden structure comprised of sticks and overhung with palm fronds) used by local fisherman under which they store canoes. Light pollution was not a factor along the beachfront, eliminating one deterrent for female turtles exiting the water in this location, as the closest homes of Salado Barro village are set back from the beach entrance by approximately 90m. By our observations tidal variations along the beach could not be avoided and thus all measurements of transect profiling were taken assuming the 0 m to be the visible high water mark.

Surveys were taken during July and August 2012, and I participated from July 2nd to August 16th. Hawksbill nesting in the Caribbean Sea stretches from April to November, and is thought to occur from June to September in Honduras (Chacon, 2004).

BEACH SECTOR PATROLS

Initially the beachfront, limited for the sake of patrolling to a 10 km stretch, was divided into sectors by natural landmarks from the entrance and named West 1, West 2, East 1, and East 2. This delineation facilitated scheduling of patrols and reporting of location between patrol groups.

A monitoring program via patrols, for the purpose of tracking the use of nesting sites on the beach has been established (Dunbar, 2010). Patrols were conducted 5 nights out of the week, within an hour of sunset (19:00) until sunrise (5:00), with varied longevity of 3, 4, 6 and 7 hours depending on weather conditions. During the nightly patrol period, each segment of the beach was patrolled each hour. This maximized our chances of observing nesting turtles the marine turtle nesting process typically endures 40 to 90 minutes (Stapleton and Eckert, 2008). When weather did not permit an evening patrol, a morning patrol was done to count tracks and identify any nests laid the night before.

The two standard patrolling groups that covered the westward and eastward respectively were typically composed of at least one researcher, one guard, a volunteer from Tegus University if possible, and one community member. When the presence of a guard became impossible, the group composition increased in community members. When no personnel were available, save the two researchers, a single patrol group covered the entirety of the beach with reduced rest time than designated in standard protocol. Direction of patrols are in the eastward or westward direction, alternating. The patrol groups walk their respective beachfronts continuously for the duration of each patrolling session with 10-20min breaks at each end.

Factors known to discourage female turtles from nesting are light, noise, and movement. While walking the beachfront the patrol groups held flashlights (dimmed if possible) at a low level and parallel to the ground, and scanned the sand as infrequently as possible (regularity being dependent upon visibility). They also took efforts to minimize noise and motion (Stapleton and Eckert, field procedures manual, 2008).

If crawls were encountered they were identified first by species type (the Hawksbill crawl pattern is asymmetrical and of a maximum width of 70-85 cm) and then as either a false crawl or a nesting situation, in accordance to the graphics provided in Stapleton and Eckert's "Field Procedures Manual", 2008 and Gulko and Eckert's *Sea Turtles: An Ecological Guide*, 2004, respectively. If a nesting incident was encountered, a standardized protocol for "Patrol Information Collection" and "Tagging" were followed so as to ensure data collected can be used by the wider Caribbean regional database.

BIPOLAR LINE TRANSECT BEACH PROFILING

We used the bipolar line level to document topographic profiles along the beach, with GPS locations at each transect's beginning and end. The beach (Fig. 2A) was principally divided in the same manner as outlined previously (BEACH SECTOR PATROLS), with each sector further divided into 5 m increments (Figs. 2B-C). The beach entrance was set as the central reference point (aka the 0 m mark in terms of east-west direction). For data recording purposes we assigned the graphical planes X,Y,Z as indicative of the east-west tangent (X), north-south tangent (Y), and up-down (Z) directionalities respectively. The 0 m and central point for X,Y,Z planes was set at the high water mark in line with the beach entrance (Fig. 2D). In demarcating the transect lines in respect of Y (from high water mark to vegetation line), a constant compass bearing of 21 degrees south was maintained to ensure that from the beginning point the transects lines remain parallel and thus the 5 m distances between X0, X1, X2…etc. hold true for each Y point along the given tangents (Fig. E). At a given X point the width of the beach, from high water mark to vegetation line is measured and divided into 5 m segments along the Y axis, with 0 m being the high water mark (Fig. 7F).

In order to topographically survey the beachfront using the bipolar line level method, the following materials are needed: 3 pieces of PVC piping at least 150 cm in length each with a leveler attached (to be considered as pipe F, G, H for referral purposes), a string of at least 10 m length (markings made at 5 m intervals), one soft measuring tape of 1 m length to be affixed to PVC pipe H, a larger measuring tape of at least 20 m length, a detachable leveler able to be hung on a string, a GPS device with compass feature, notebook, pen, and reflective or bright tape for marking sectors.

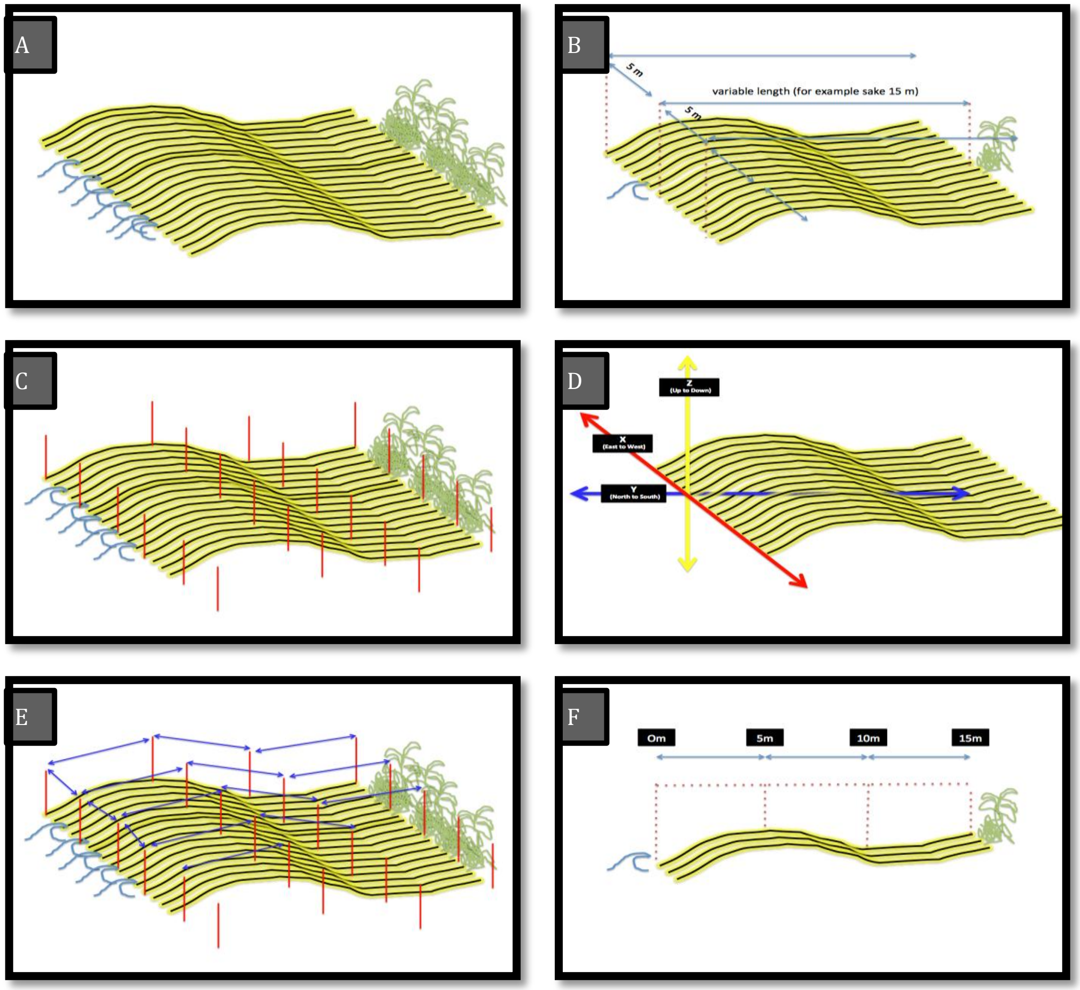


Figure 2 (A) Visual representation of a 15m x 20m beachfront segment for demonstrative purposes. (B) Length of beach in both the Eastward and Westward direction is divided in 5m increments. (C) The orange poles rising vertically from the ground are placed at 5m distances from point 0m in the X (X0, X1, X2….) and Y (Y0, Y1, Y2…) direction. (D) Axes used in measurement are X, Y, and Z; their intersection being the 0 m mark in the X (east to west, parallel to the water and vegetation line), Y (north to south, vertical to the water and vegetation line), and Z (up to down, aka altitude) respect being considered the central point. (E) The maintenance of the constant 21S compass bearing ensures that the lines between X0, X1, X2…etc. and Y0, Y1, Y2…etc. are respectively parallel. (F) Width of beach (Y axis) from water line to vegetation line, divided by 5m increments, considers the Y measurement at the waterline to be Y0.

At the beginning of each transect, the starting point of Y = 0 at the high water mark, was marked both visually (for the placement of PVC pipes held by researchers) and on the GPS device (labeled as Wbeach0, Wbeach1, Wbeach2…etc., or Ebeach0, Ebeach1, Ebeach3…etc.).

Beginning at the high water mark (considered 0 m along the Y axis) of a given tangent, a researcher held the PVC pipe F. The 12 m string was then, at one end, tied to pipe F and at the other, tied to pipe G. Another researcher held pipe G and walked in the southward direction (away from water) until the string was taut. When this was achieved, holding the PVC pipes F and G upright (checked with the affixed levelers), the two researchers adjusted so that the string's mark for 0 m was directly over the transect mark at the high tide line. A third researcher took a compass reading while walking along the string length, from high water to vegetation, to ensure it was lying in the 21 degree south direction, adjusting the position of the second researcher (holding pipe F) if necessary. This was repeated until proper orientation is achieved. The detachable leveler is then used at the string's 5 m mark, to ensure that the string was level, adjusting at which height the string was tied to pipes F and G if necessary. This was repeated until string was level.

The pipe H, with soft measuring tape affixed along its length, was used to measure the height of the string at the 0, 5, and 10 m mark. The affixed leveler on pipe H was used to ensure that it's orientation was directly vertical as measurements were taken. The measured heights (Z) of the string were recorded in a field notebook as heights (Z) at points A, B, C, D…etc. in accordance to the various Y points of 0, 5, 10, 15 m and entered into the computer database at a later time (Fig. 3).

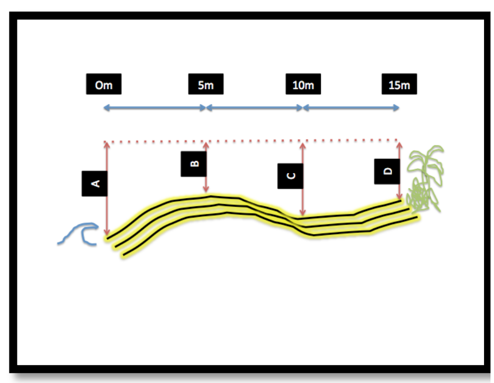


Figure 3 The height of the string between the two poles, having been leveled, is measured at Y0m, Y5m, Y10m…etc. distances (for each X value). The measured heights (Z) of the string are demarcated as the Z value at points A, B, C, D…etc. in accordance to Y0m, Y5m, Y10m, Y15m…etc.

As the width of the beach Y (north/south–from high tide to vegetation) was variable along the X (east/west) axis, it was sometimes necessary to shift the contraption up beach (south) so as to take measurements at Y = 15, 20, 25…etc. (As the length of the string is

10 m, this must be done in 10 m increments). To do so, the first researcher must move pipe F to pipe G's previous position and the second researcher walked with pipe G 10 m 21 degree south until the string was taut. The procedures outlined previously for ensuring that the sting is both lying in the southern 21 degree orientation and level, were followed, with one important difference. Before leveling the string, the height of the string on pipe F was adjusted to the previous height measured at the point Y = 10 m, previously on pipe G (this was done to calibrate the measured height at pipe G). Then, when leveling the string, adjustments were made only to the height of the string tied to pipe G (now located at Y = 20 m). By doing this the string will theoretically remain at a constant level over any Y distance over 10 m.

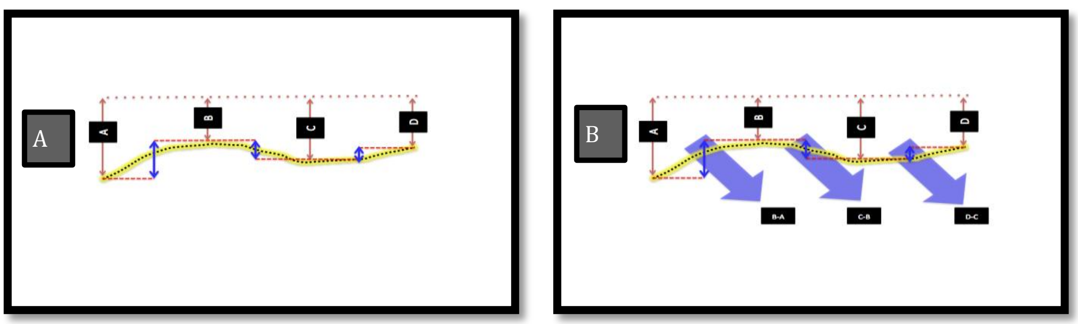
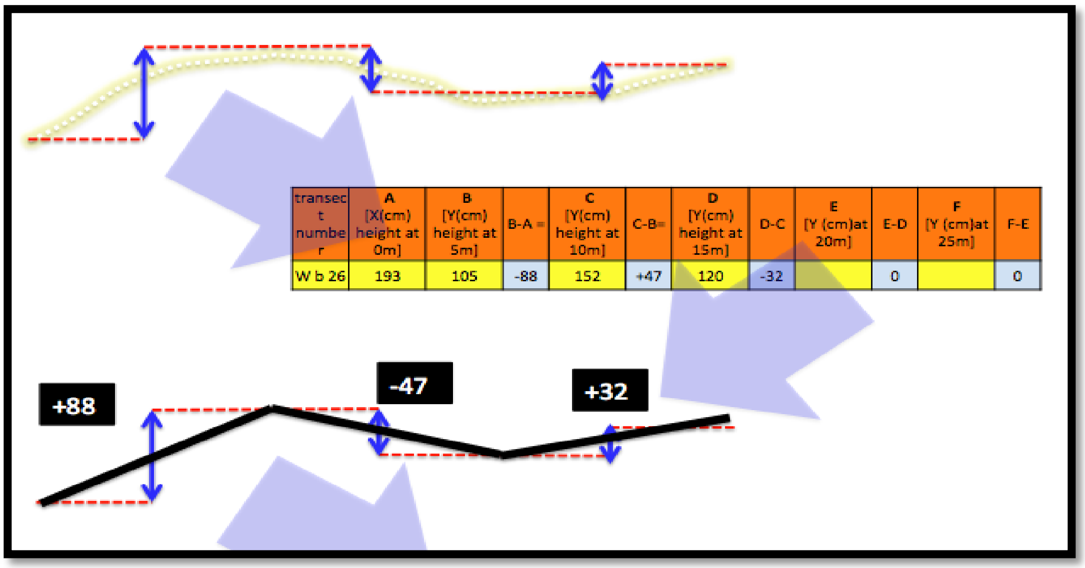


Figure 4 (A) The difference between values of Z for a given tangent (Y) at points A, B, C, D…etc along the beachfront (X) are noted in calculations after data collection. (B) The mathematical difference of the adjacent heights is calculated.

The relative heights of the strings (Z) for a given tangent (Y) along the beachfront (X) were entered into the computer database, in which the mathematical difference of the adjacent heights (Figs. 4A-B) were found and, by reversing the sign of the difference, used to determine the relative slope of each segment (Fig. 5).

From the calculations of relative height differences, by setting the first height measurement at the waterline at an elevation of 0, the subsequent elevations 5m up from the waterline may be determined mathematically.



transect number	A [X(cm) height at 0m]	B [Y(cm) height at 5m]	B-A =	C [Y(cm) height at 10m]	C-B=	D [Y(cm) height at 15m]	D-C	E [Y (cm)at 20m]	E-D	F [Y (cm)at 25m]	F-E
W b 26	193	105	-88	152	+47	120	-32		0		0

Figure 5 The mathematical difference of the adjacent heights, once calculated, can determine the relative slope (by reversing the sign) between X,Y coordinates.

VEGETATION PERCENTAGE BEACH PROFILING

Both my research partner and I received training from Dr. Stephen Dunbar on proper vegetative percentage profiling procedure. We determined the type and distribution of various vegetation categories along the beachfront. Equipment needed included a soft measuring tape of at least 20 m length, a field notebook, GPS device, and three researchers. Pairing vegetation transect section data collection with GPS readings, at the transect section's beginning and end enables for the data to be later put into an all inclusive beach map constructed by the use of ArcGIS technology.

Beginning at the X=0 and Y=15 point (this line was chosen for the following reasons; studies note a 10 m above water line minimum for nesting site and as a procedural note, characterizing the entire beach area by vegetation percentage would be unpractical), a GPS location was taken and the measuring tape stretched (with 0 m of the measuring tape corresponding to the X=0) to the X=20 and Y=15 point, where a second GPS location is marked. With one researcher holding each end of the measuring tape taut, a third noted the distance covered (in m) by each vegetation type in the field notebook. Vegetation classifications were: sand, grass, sea grape, Hicaco, or unknown. In the latter case, the vegetation was sampled and photographed to allow subsequent identification.

This procedure was sequentially repeated along the beachfront in both the eastward and westward directions. For example the next vegetative transect would be from X=20, Y=15 to X=40, Y=15, once again noting the GPS coordinates at the beginning and ending of each transect.

POLLUTION DETERMINATION

Beachfront changed significantly in degree of refuse pollution. Thus we created a protocol for Rapid Beach Description in which we used descriptive methods to divide the beach into sections of more-or-less homogeneity.

Starting at the coordinate X=0, Y=0 (as used in the Bipolar Line Level methodology), a GPS coordinate was marked, serving as the beginning of the profiling segment #1 (P01). The researchers then walked along the high tide line, recording observations regarding the aforementioned pollution features in descriptive terms and qualitatively dividing the beach into homogenous segments.

At the end point of a determined homogeneous segment a GPS coordinate was marked, serving as the end of profiling segment #1 and as the beginning of the profiling segment #2, denoted as P02.

Pollution severity was determined and observations recorded in a qualitative manner because attempts to display differences quantitatively by weighing sand samples proved unreliable.

MAPPING

ArcGIS 10.0 (http://www.esri.com/software/arcgis/arcgis10) was used to generate a multilayered display of environmental features relevant to turtle nesting.

The following attributes known to favor nesting were mapped: beach elevations ranging from .75-1.25 m (Gulko, 2004; Harrocks, 1991; Zare, 2012), sand coverage ranging from 22.5-67% (Zare, 2012), and grass coverage ranging from 35-82% (Harrocks, 1991; Zare, 2012). Also mapped were two features expected to interfere with turtle nesting—combined sea grape and Hicaco vegetative coverage above 60% (Harrocks, 1991; Zare, 2012), and areas of severe pollution (Bräutigam, 2006; Chacon, 2004).

The physiognomies of sand, grass, sea grape/Hicaco, and pollution were mapped for the entire 10 km stretch of beach, whereas beach elevation data were mapped only for the central 267 m of beach front due to time constraints.

The focus of plotting these favorable and unfavorable features was to, by overlaying the resultant maps, identify areas of the beach constituting viable nesting sites—indicated by overlapping of the favorable attributes and an absence of unfavorable characteristics.

RESULTS

BIPOLAR LINE TRANSECT BEACH PROFILING, VEGETATION PERCENTAGE BEACH PROFILING & DESCRIPTIVE BEACH PROFILING

The 10 km study area of beachfront, located north and east of a bend in the Cuero river (Fig. 6A), was mapped for vegetative categories and pollution (Fig. 6B), but only the central 267 m was intensely investigated and mapped with elevation data as well (Fig. 6C).

Beach elevations matching known preferences of nesting Hawksbills were observed (listed as coordinates in degrees minutes seconds in APPENDIX A) at intervals throughout the study area (Fig. 7), with favorable elevation occurring more commonly in the West beach sections.

Favorable percentages of sand-coverage (APPENDIX B; Fig. 8A) and grass coverage (APPENDIX C; Fig. 8B) were found at intervals throughout the study area along the line 15m above high watermark.

Unfavorable percentages of sea grape and Hicaco coverage (APPENDIX D; Fig. 9A) along the 15m line and an area of pollution (APPENDIX E; Fig. 9B) were only observed in the west beach portion.

By layering maps displaying these aforementioned favorable and unfavorable environmental features, the most viable locations on the beach for turtle nesting, which displayed an overlap of three positive nesting environment characteristics and a lack of negative nesting environmental characteristics, were found in a large region in the west beach portion and a small region in the east beach sectors (APPENDIX F; Fig. 10). Also, If we considered feasible nesting ranges as areas displaying an overlap of two positive nesting environment characteristics and a lack of negative nesting environmental characteristics these secondary sites (APPENDIX G) were found in both the east and west beach segments (Figs. 10A-B).

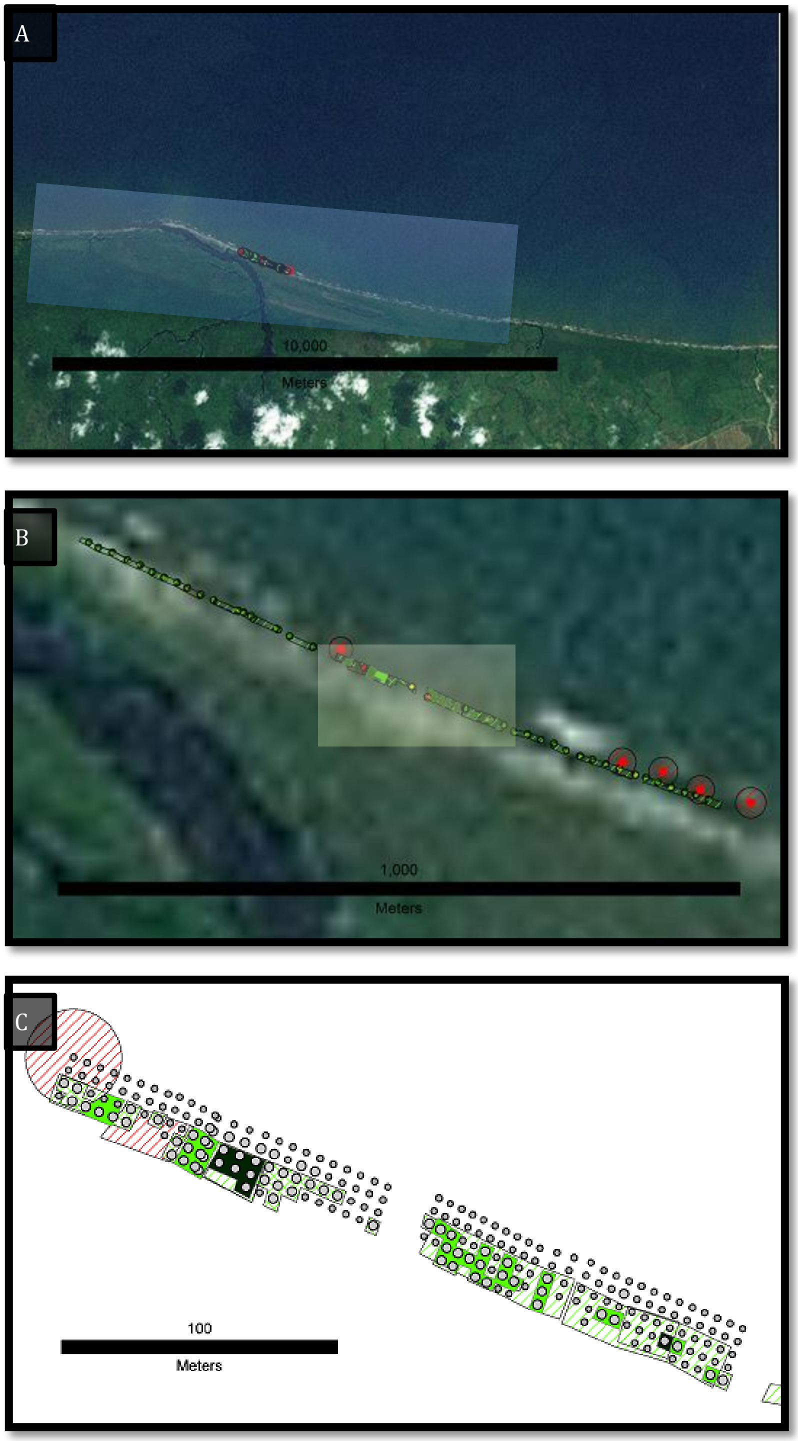


Fig. 6 (A) Map displaying the Cuero y Salado beachfront, highlighted by the blue rectangular box is the 10km of beach front under study. (B) Map of the 10km of beach front under study, highlighted by the green rectangular box is the 267 m considered by intensive data analysis. (C) Displaying the 267 m multilayered data map, including elevation.

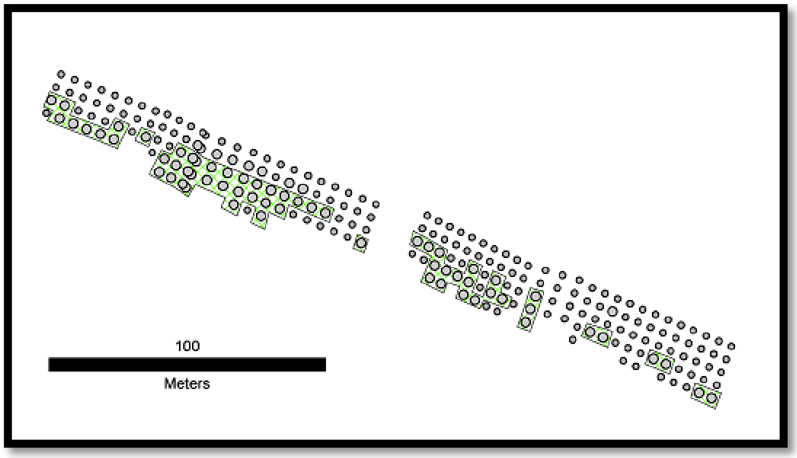


Fig. 7 Areas of favorable elevation between .75 and 1.25m located 10m above sea level indicated by green dots and those points >10m from waterline incorporated in polygons.

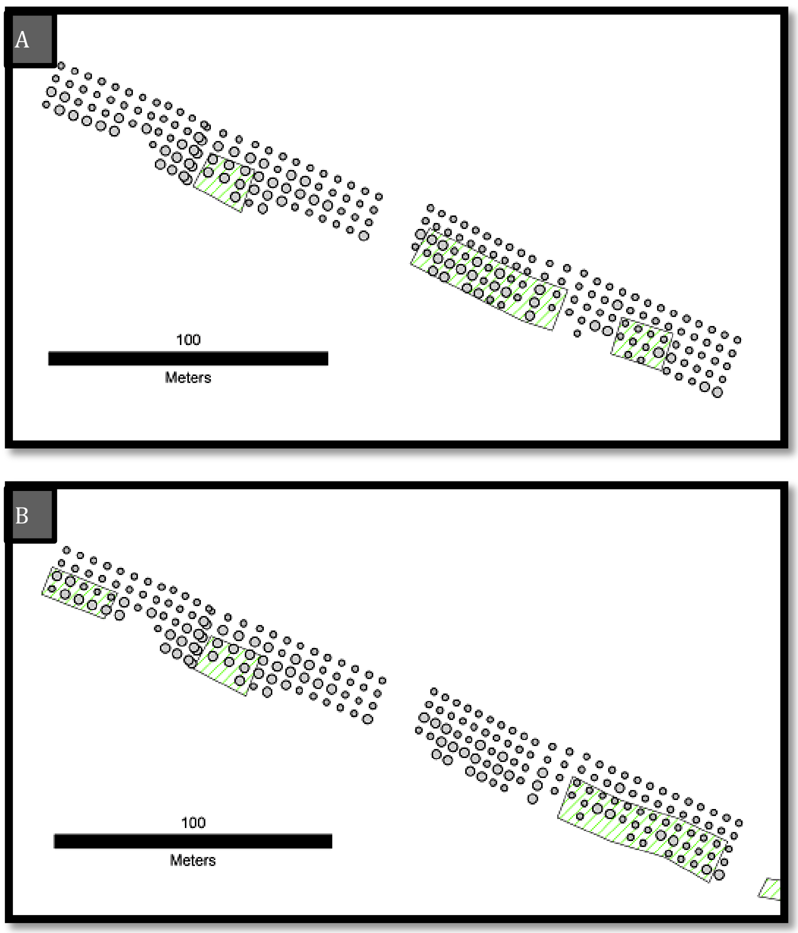


Fig. 8 (A) Displaying areas of favorable sand-coverage percentages between 22.5% and 67% in the green crosshatched boxes. (B) Displaying areas of favorable grass percentage cover between 35% and 82% in the green crosshatched boxes.

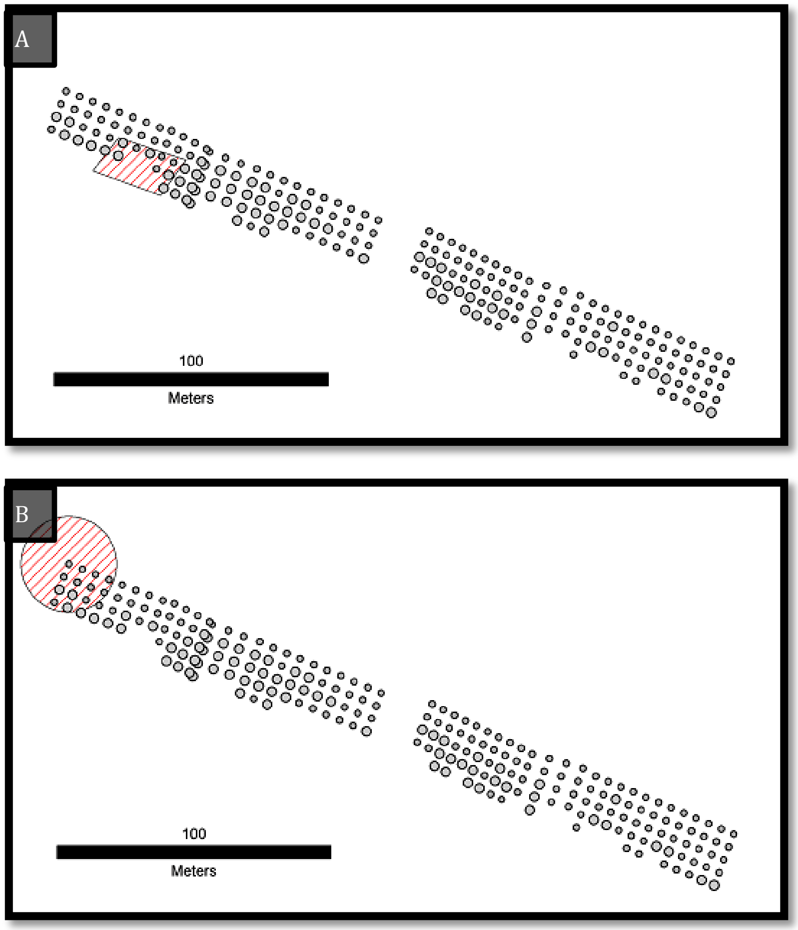
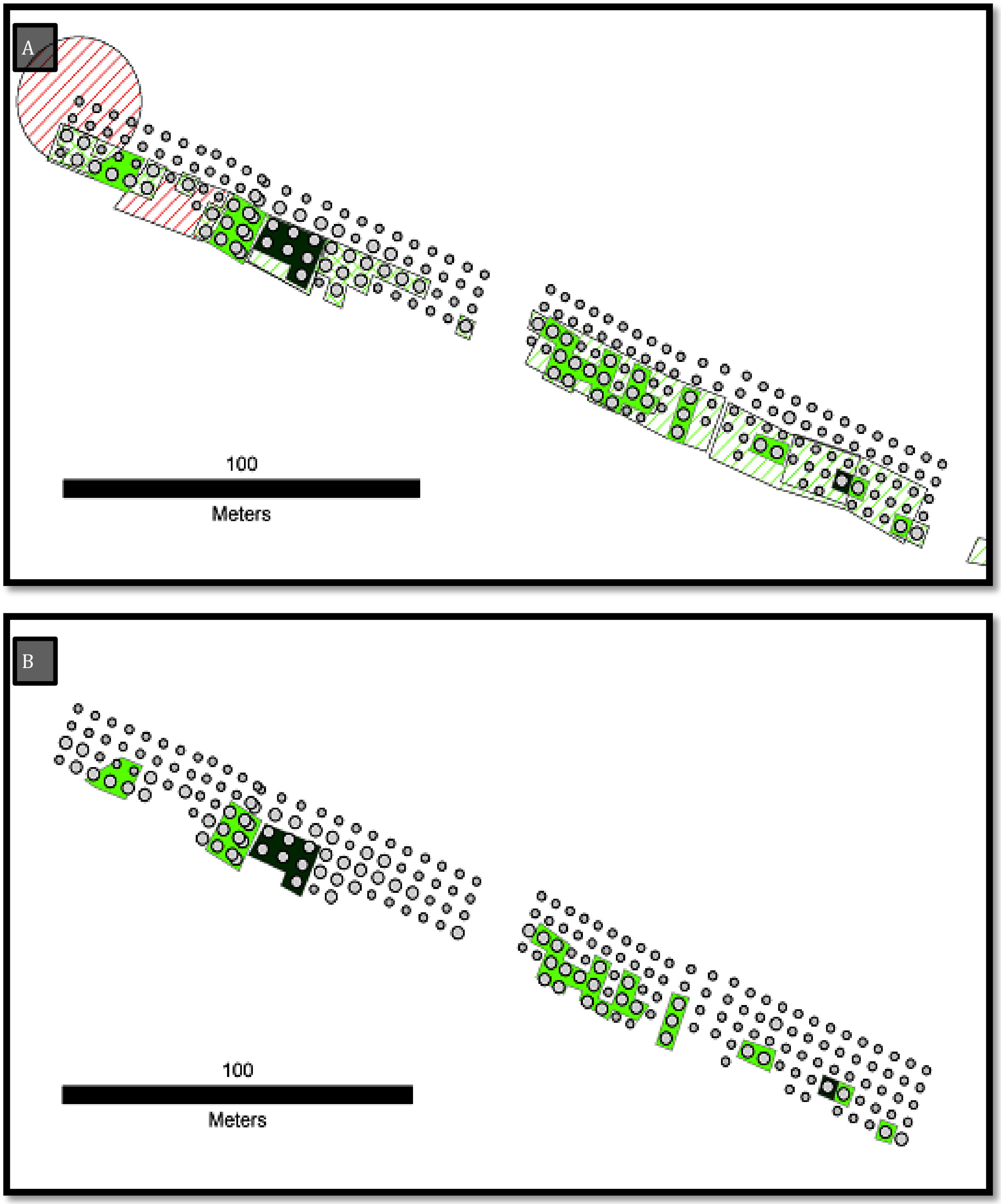


Fig. 9 (A) Displaying areas of unfavorable Hicaco and Sea Grape vegetation cover above 60% in the red crosshatched boxes. (B) Displaying areas of pollution severity classified above level 2 in the red cross-hatched circles.



Figs. 10 (A) Displaying highlighted in dark green are areas most suitable for nesting, with overlap of three positive environmental attributes and devoid of negative environmental attributes, other areas suitable for nesting with overlap of preferred elevation and at least one other positive environmental element and devoid of negative environmental attributes are highlighted in bright green. (B) Displaying viable nesting sites with all other layers removed for visual clarity.

DISCUSSION

No turtles or nesting incidences were observed, demonstrating a current population of 0 along the 10 km beachfront of Cuero y Salado Wildlife Refuge for the months of July and August. Fellow researcher Angella Randazzo has recorded numerous testimonies from local fisherman reporting both Hawksbill turtles and nesting sites from previous nesting seasons, however none were reported to us for the 2012 nesting season. We have further confidence in our conclusion as nightly patrolling procedures were executed in such a way to note all turtle nesting incidences (BEACH SECTOR PATROLS)—and the nights when patrols were shortened or cancelled due to extreme weather conditions represent time periods of very low nesting likelihood, and are thus not suspected to have influenced results.

Our study's observations are disturbing but not unexpected. The resultant established 0 baseline population for Cuero y Salado's historic nesting beach confirms the wider worldwide and regional trend as it applies to Honduras (Bräutigam, 2006; Chacón, 2004; McClenachan, 2006).

Caribbean Hawksbills were abundant in the past, as confirmed by historical records, with an estimated population of 11 million Hawksbills (McClenachan, 2006) and high-density nesting areas. At present, however, the Hawksbill population is very diminished over the entire western Atlantic Caribbean region (Chacón, 2004), now listed as critically endangered on the IUCN's Red List for having suffered adult population declines of at least 80% over their last three generations (Stapleton and Eckert, 2008). The present vacancy of Cuero y Salado's beachfront aligns with the estimated 20% loss of historic nesting sites and, of the remaining nesting sites, a 50% reduction to dangerously low levels (McClenachan, 2006).

There have been no previously detailed marine turtle population counts, nesting habitat studies, or maps of nesting beaches done in Honduras. Thus our results contribute much-needed information to Caribbean Hawksbill conservation efforts (Dunbar, 2009; Bräutigam, 2006).

The other significant portion of our study are the maps of environmental factors relevant for turtle nesting success. These maps are vital in making the case for habitat preservation of Cuero y Salado's beachfront, because we have demonstrated that it is a suitable nesting area.

Results from previous Hawksbill studies in other countries note that turtles tend to cluster their nests at specific elevations, near 1 m, and that elevation is the most important cue for nest-site selection (Harrocks, 1991; Zare, 2012). Another factor noted to be of significance in previous studies is beach width, for a necessary minimal distance of nest site from high tide line (average distance of 10 m) of which this beach generally displays beach width over 15 m (Harrocks, 1991; Zare, 2012).

Distribution of vegetation cover has been documented in other studies as yet another vital characteristic in determining a beach's suitability (Eckert,2008; Gulko, 2004; Harrocks, 1991; Kamel, 2009; Zare, 2012). Hawksbills particularly, in contrast to leatherback and green turtle, are known to prefer beaches with mature vegetation (Stapleton and Eckart, 2008), such as that which borders nearly the entire 10km of Cuero y Salado Wildlife Refuge beachfront.

Of the 10 km beachfront under observation, 267 m were considered for more intensive nesting environment data analysis. This analysis correlated elevation, beach width, multiple vegetation percentages, and pollution severity—displayed as multiple map layers able to be overlain so as to identify most viable sites for turtle nesting via ArcGIS mapping. We have demonstrated that the beachfront at Cuero y Salado preserves viable nesting habitat; we documented substantial regions displaying low pollution, and interspersed vegetation with fair sand coverage within the central 1 km area along with significant areas of correct elevation and beach width within the 267 m central area. It is important to note that while these results are suggestive of the entire beach's state, the limited beach area of data analysis (only 1/10 of the entire 10 km beach front was characterized by vegetation and pollution, and of that only the central 670 m was analyzed in terms of elevation) has the potential to be misrepresentative.

CONCLUSION

In summary we have demonstrated that the historically noted Hawksbill nesting beach of Cuero Y Salado (currently under study and observation by the ProTECTOR program) has a very low population density. Various beach characterizations of principal environmental factors (elevation, vegetation, beach width, and pollution) suggest, however, that the beach is still suitable for—though, due to substantial population decrease, not currently being used as—a nesting beach of significant preservative value.

I believe a precedence and framework was set on which to build a long-term national nesting beach conservation program and establish a long-term index site for population monitoring should ProTECTOR decide to continue investing in this area.

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APPENDIX

APPENDIX A

Favorable elevations (from .75 m to 1.25 m) are found in the following ranges, expressed as coordinates in degrees minutes seconds: 86°59'59.586"W 15°46'14.613"N and 86°59'59.415"W 15°46'14.551"N, 86°59'59.493"W 15°46'14.406"N and 86°59'58.824"W 15°46'14.151"N and 86°59'58.767"W 15°46'14.303"N, at 86°59'58.433"W 15°46'14.179"N, 86°59'58.006"W 15°46'14.014"N and 86°59'56.242"W 15°46'13.283"N, 86°59'58.205"W 15°46'13.91"N and 86°59'56.818"W 15°46'13.345"N, 86°59'58.27"W 15°46'13.779"N and 86°59'57.928"W 15°46'13.586"N, at 86°59'57.352"W 15°46'13.394"N, at 86°59'57.017"W 15°46'13.27"N, at 86°59'55.808"W 15°46'12.918"N, 86°59'55.125"W 15°46'12.96"N and 86°59'54.841"W 15°46'12.822"N, 86°59'54.905"W 15°46'12.663"N and 86°59'54.513"W 15°46'12.491"N, 86°59'54.976"W 15°46'12.519"N and 86°59'54.421"W 15°46'12.264"N, at 86°59'54.158"W 15°46'12.498"N, 86°59'54.215"W 15°46'12.353"N and 86°59'54.079"W 15°46'12.284"N, 86°59'53.034"W 15°46'11.885"N and 86°59'52.856"W 15°46'11.816"N, 86°59'52.237"W 15°46'11.561"N and 86°59'52.849"W 15°46'11.816"N, 86°59'52.244"W 15°46'11.568"N and 86°59'52.095"W 15°46'11.527"N, 86°59'51.696"W 15°46'11.175"N and 86°59'51.54"W 15°46'11.106"N.

APPENDIX B

Favorable percentages of sand coverage: 86°59'57.756"W 15°46'13.712"N and 86°59'57.178"W 15°46'13.506"N, 86°59'55.12"W 15°46'12.821"N and 86°59'53.435"W 15°46'12.072"N, 86°59'52.746"W 15°46'11.788"N and 86°59'52.145"W 15°46'11.559"N.

APPENDIX C

Favorable percentages of grass coverage: 86°59'59.72"W 15°46'14.504"N and 86°59'58.937"W 15°46'14.219"N, 86°59'57.808"W 15°46'13.724"N and 86°59'57.181"W 15°46'13.487"N, 86°59'53.388"W 15°46'12.055"N and 86°59'51.545"W 15°46'11.259"N.

APPENDIX D

Sea grape and Hicaco coverage(above 35% and below 82 %: 86°59'58.952"W 15°46'14.197"N and 86°59'58.147"W 15°46'13.896"N.

APPENDIX E

Pollution incidence was noted at the following point: 86°59'59.459''W 15°46'14.895''N

APPENDIX F

86°59'57.654"W 15°46'13.898"N, 86°59'57.124"W 15°46'13.701"N, 86°59'57.319"W 15°46'13.257"N, 86°59'57.504"W 15°46'13.353"N, 86°59'57.462"W 15°46'13.464"N, and 86°59'57.817"W 15°46'13.625"N; 86°59'52.284"W 15°46'11.676"N, 86°59'52.128"W 15°46'11.618"N, 86°59'52.18"W 15°46'11.443"N, and 86°59'52.336"W 15°46'11.508"N.

APPENDIX G

86°59'59.044"W 15°46'14.492"N, 86°59'59.396"W 15°46'14.285"N, 86°59'59.009"W 15°46'14.121"N, and 86°59'58.844"W 15°46'14.41"N; 86°59'57.986"W 15°46'14.096"N, 86°59'57.697"W 15°46'13.928"N, 86°59'57.911"W 15°46'13.484"N, and 86°59'58.235"W 15°46'13.674"N; 86°59'55.007"W 15°46'13.019"N, 86°59'54.727"W 15°46'12.834"N, 86°59'54.78"W 15°46'12.701"N, 86°59'54.54"W 15°46'12.589"N, 86°59'54.487"W 15°46'12.739"N, 86°59'54.331"W 15°46'12.662"N, 86°59'54.447"W 15°46'12.347"N, 86°59'54.318"W 15°46'12.304"N, 86°59'54.22"W 15°46'12.61"N, 86°59'54.042"W 15°46'12.537"N, 86°59'54.105"W 15°46'12.352"N, 86°59'53.971"W 15°46'12.296"N, 86°59'54.078"W 15°46'12.158"N, 86°59'54.358"W 15°46'12.167"N, 86°59'54.354"W 15°46'12.175"N, 86°59'55.047"W 15°46'12.537"N, 86°59'54.949"W 15°46'12.778"N, and86°59'55.101"W 15°46'12.864"N; 86°59'53.736"W 15°46'12.399"N, 86°59'53.58"W 15°46'12.347"N, 86°59'53.744"W 15°46'11.891"N, and 86°59'53.896"W 15°46'11.947"N; 86°59'53.051"W 15°46'11.986"N, 86°59'52.744"W 15°46'11.891"N, 86°59'52.811"W 15°46'11.719"N, and 86°59'53.109"W 15°46'11.848"N; 86°59'52.126"W 15°46'11.615"N, 86°59'51.984"W 15°46'11.568"N, 86°59'52.046"W 15°46'11.392"N, 86°59'52.17"W 15°46'11.448"N; 86°59'51.73"W 15°46'11.284"N, 86°59'51.57"W 15°46'11.215"N, 86°59'51.637"W 15°46'11.077"N, and 86°59'51.779"W 15°46'11.116"N.