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Effects of Plastic Pollution Density on the Crawling Rates of Hawksbill Hatchlings in Utila, Honduras

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ABSTRACT

The hawksbill turtle (*Eretmochelys imbricata*) is a critically endangered species. Hence, various conservation efforts by groups such as ProTECTOR are taking place to stabilize its population. To support such efforts, my study focused on the turtle population in and around the island of Utila, Honduras. Specifically, I sought to determine if various densities of plastic pollution had an effect on crawling times during the migration of hawksbill turtle hatchlings from nest to water. A reduction in crawling time could increase predation time and cause the hatchling to expend additional energy before they reach the ocean. We constructed four experimental corridors (approximately 8 m in length) with varying densities of pollution and recorded hatchling crawling time from start to finish (10 hatchlings/corridor). Crawling rates differed significantly across corridors (Kruskal-Wallis H test). In addition, a potential baseline pattern of turtle abundance at dive locations around the island was observed through a survey of turtle sightings and mapped using ArcGIS to determine any patterns of distribution.

INTRODUCTION

The hawksbill turtle (*Eretmochelys imbricata*) is found in the tropical waters of the Atlantic, Pacific, and Indian Ocean, inhabiting the coastal waters of almost 108 countries (Baillie and Groombridge, 1996). These turtles play an important role in the food webs of marine ecosystems, transporting nutrients across the oceans as well as in helping to maintain the diversity and complexity of coral reef communities throughout the Caribbean by consuming sponges that compete with coral reefs (Bouchard and Bjorndal 2000; Meylan 1988). Depending on its habitat, the hawksbill diet may range from algae (Whiting 2000) to soft corals (Limpus 2004).

Unfortunately, the hawksbill turtle is a critically endangered species (Baillie and Groombridge, 1996). Many factors contribute to this status, such as the destruction of nesting grounds, low survival rates, and exploitation (Baillie and Groombridge, 1996). Only 1 in 1000 hawksbill hatchlings survive to adulthood, and due to the long maturation period of 20- 40 years (Chaloupka and Musick 1997), sufficient time is needed for these turtles to be ready to reproduce. However, the hawksbill turtle has been hunted for its exquisite shell, meat, and its eggs, devastating the population of hawksbills by almost 80% from what was believed to be over 10 million; in Honduras, the status of these turtles is simply "depleted" (McClenachen 2006; IUCN 2001b). Exploitation has limited the time needed to allow the hawksbill to reproduce. In addition, human activity has resulted in the destruction of nesting grounds; vegetation near the shore line has been eradicated for both private and commercial property development (Mortimer 2004). Therefore, much of this great decrease in the population of hawksbills could be attributed to the actions of humans.

To counter the negative effects humans have had on the population of hawksbills, many studies and conservation efforts are taking place to potentially increase and stabilize their populations. Essentially, one common goal exists among studies involving hawksbill turtles—to promote conservation. In this spirit of conservationism, the non-profit organization, Protective Turtle Ecology Center for Training, Outreach and Research, Inc. (ProTECTOR) was founded by Dr. Stephen G. Dunbar in 2007 to support research on sea turtles in Honduras to raise awareness for conservation efforts and to facilitate better decision-making regarding marine area management by monitoring nesting beaches, tagging turtles, and undertaking sea turtle research in and around Honduras (Dunbar and Salinas 2013). One study supported by ProTECTOR documented favorable areas for nesting hawksbill turtles, suggesting that some environments have higher conservation value than others (Cunningham 2013). Another study conducted by members of ProTECTOR suggested concentrating conservation efforts in areas that contained items constituting the diets of hawksbills, such as sponges (specifically *Melophlus ruber* and *Chondrilla caribensis*) to stabilize the population of hawksbills (Berube *et al.* 2012).

Similar to the studies mentioned above, my study concerned the conservation biology of hawksbill turtles, specifically the hawksbill population in and around the island of Utila, Honduras. Essentially, two studies were accomplished. The first study observed a critical period in the life of hawksbill hatchlings; the period when hatchlings emerge from their nest to crawl to the ocean. The second study attempted to establish a baseline pattern of turtle abundance at dive locations around the island.

Prior studies have documented the impacts of pollution, such as plastic debris, on juvenile and adult stages (Carr 1987), yet little is known about its impacts on hatchlings. One recent study, however, focused on the impact of plastic pollution on loggerhead hatchlings as they attempted to crawl to the ocean. Triessnig *et al.* (2012) observed a reduction of crawling speeds in loggerheads hatchlings with an increase in pollution debris. Hence, we sought to observe if this same trend would be seen in hawksbill hatchlings, and specifically determine the effect of plastic debris on the rate of hawksbill hatchling movement. Therefore, we tested the hypothesis that debris may deter the movement of hawksbill hatchlings in Utila, Honduras. We undertook the study by briefly capturing newly born Hawksbill hatchlings, and timing their movement along experimental corridors with varying densities of plastic pollution. The deterring of movement, then, could potentially increase predation time, causing the hatchlings to expend additional energy, thereby resulting in a lower survival rate.

The second part of my study involved a survey of turtle sightings around the waters of Utila. To gather data on sea turtle sightings around the island, we involved the various dive shops that were located along the southeast coast of Utila. Dive shops are prominent in Utila due to the colorful coral and other marine organisms that make their home in its waters. Since dive masters and divers have direct contact with sea turtles in their natural habitat, this could aid us in gathering turtle sightings data around the island. Ultimately, we aimed to establish a baseline pattern of turtle abundance at dive locations around the island to observe any location preferences of hawksbills around Utila. ArcGIS was used to construct a map of Utila with turtle sightings around the island.

MATERIALS AND METHODS

Effect of Plastic Debris on the Movements of Hawksbill Hatchlings

To observe the specific effects of plastic debris on the movements of hawksbill hatchlings, four corridors with varying densities of trash were prepared alongside an established hawksbill nesting beach. Our study site (Figure 1.) was located on the northeast side of the island of Utila, specifically on Pumpkin Hill Beach (N 16.38, W0-86.91).

Figure 1. Map of Utila, Honduras. Our study site (Pumpkin Hill Beach) is marked with a red pin.

We chose to establish our four corridors in a relatively flat area to factor out slope differences from potentially influencing differences in the movements of hawksbill hatchlings. A strip of flat beach close in proximity to a hawksbill nest was divided into 4, 1-m wide corridors that extended from the top of the beach near the vegetation to the water's edge below the wrack line. The distance of these corridors was 8.5 $\pm$ 0.7 m. Corridors were then labeled as "High Density" (HD), Moderate Density" (MD), "Low Density" (LD), and "Control". The control corridor had no plastic pollution while the other corridors contained plastic pollution gathered from the surrounding beach. Each corridor contained plastic pollution according to a pre-determined relative density of debris arranged in each one (Figure 2.).

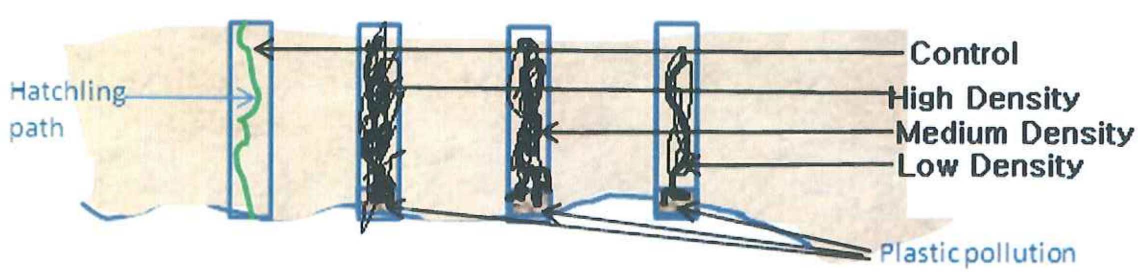

Figure 2. Example of treatment sites on the beach consisting of four corridors with varying densities of trash.

Furthermore, to ensure the separation of each corridor, we constructed physical barriers with driftwood logs found along the beach (Figure 3.). These logs marked the boundaries of each corridor. The purpose of establishing physical boundaries was to prevent hatchlings from crossing into other corridors.

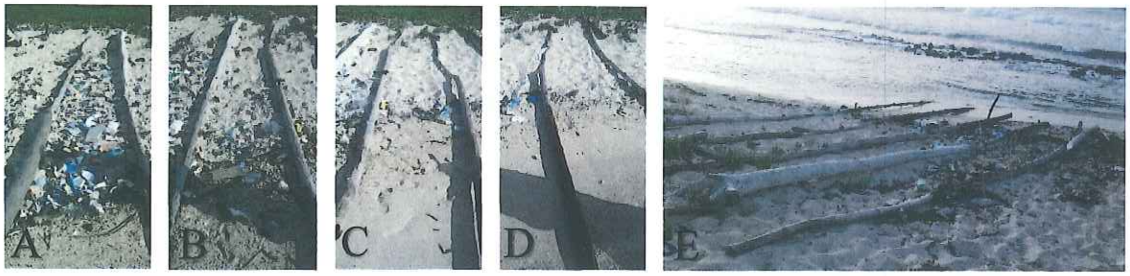

Figure 3. Pictures of treatment sites. From right to left, HD (A), MD (B), LD (C), and Control (D). The furthest picture (E) on the right depicts all of the four corridors.

We prepared the corridors prior to nest hatching. One day prior to the due date of the hatchlings, a mesh nest was placed around the nest. In addition, the nest was monitored 24 hours per day as the due date approached to stop turtles from escaping the nest into the ocean before testing and to protect against poaching. Hence, we watched the nest carefully until turtles hatched on the evening of July 17th, 2013. A batch of 40 hatchlings was quickly chosen to participate in the treatments (10 for each corridor). Then, the hatchlings were taken to their respective corridors and released one by one (Figure 4.). We ran two hatchlings through separate corridors at the same time. We started with the HD and MD corridors and worked our way down to the LD and control corridors. At the commencement of each trial, one researcher kept track of time (in seconds) with a stopwatch when the hatchling was released; the stopwatch was stopped when the hatchlings reached the end of the corridor near the water's edge. When the hatchlings reached the end of the corridors, we measured each hatchling for flipper length, straight carapace length (SCL), and straight carapace width (SCW) in mm with a tape measure. After measurements were obtained, hatchlings were released along the water's edge. No hatchling was reused in any of the corridors.

Figure 4. Pictures of hawksbill hatchlings (A, B). The two pictures on the right (C, D) depicts hatchlings running through the various pollution corridors.

During the treatments, we stood behind the hatchlings and prevented the casting of any shadows or lights from our flashlights onto the hatchlings. These shadows and lights could potentially alter the direction and run time of hatchlings, influencing our results as a whole. Furthermore, we never interfered with the movements of hatchlings, unless hatchlings were trapped within the plastic debris. If trapped, we utilized the run-time extension period. After 5 minutes of entrapment, the hatchling was physically removed, measured, and released into the water. In our trials, none of the hatchlings were entrapped in any of the plastic debris, use of the run-time extension was unnecessary. We completed the timing of all 39 hatchlings on the night of July 17th, 2013 between the hours of 8:31 P.M. and 1:00 A.M. We only timed 9 hatchlings in the control corridor due to the lethargic nature of the last hawksbill hatchling.

The next day, we quantified the density of plastic pollution in each corridor by counting trash in 3 adjacent quadrats (1 m × 1 m) starting from the end of the corridor where the plastic debris was concentrated. All the trash in each quadrat was counted and categorized on a data sheet for entry into the beach pollution database. This quantification of the plastic debris was necessary to confirm the different densities of trash in each corridor.

Due to the varying corridor lengths, we calculated the movement rates (m/s) for each hatchling run and used these rates (versus raw movement times) in subsequent analyses. Since the preliminary analysis failed to indicate homogeneity of variance, we used the non-parametric Kruskal-Wallis H Test to determine if significant differences existed among the corridors. The α was set to 0.05.

Establishing a Baseline Pattern of Sea Turtle Abundance Around the Island of Utila

During the days between July 21st and 28th, I visited all 12 dive shops around Utila at the end of the day to survey the divers to gather data on sea turtle sightings around the island. We utilized surveys that asked divers the depth of any sea turtle sightings, the species of the sea turtle, the dive site at which the sea turtle was found, and the date the sea turtle was seen.

After gathering the data through surveys, the GPS locations of each of the 90 dive sites around Utila was obtained. Using ArcGIS, I plotted the specific dive sites at which sea turtles were found. Specifically, I plotted the occurrence and density of observations of sea turtles in general, as well as of individual species. The data were then analyzed graphically for spatial patterns; statistical analyses were not done due to our data not being independent (e.g., the same sea turtles may be observed multiple times on different days). Through ArcGIS, a baseline pattern map of various sea turtle sightings was created.

RESULTS

Effect of Plastic Debris on Crawling Rates of Hawksbill Hatchlings

The results of the average crawling rates of hawksbill hatchlings in the various corridors were expected (Figure 5.). The average crawling rate was the fastest in the control corridor, equaling to 0.0233 m/s. The average crawling rate decreased slightly in the LD corridor to

0.0230 m/s. In the MD corridor, the average crawling rate decreased even more to 0.0180 m/s. The slowest average crawling rate was observed in the HD corridor, equaling to 0.0130 m/s. Differences in crawling rates across all corridors were statistically significant (Kruskal-Wallis H test, n=39, df=3, p=0.002).

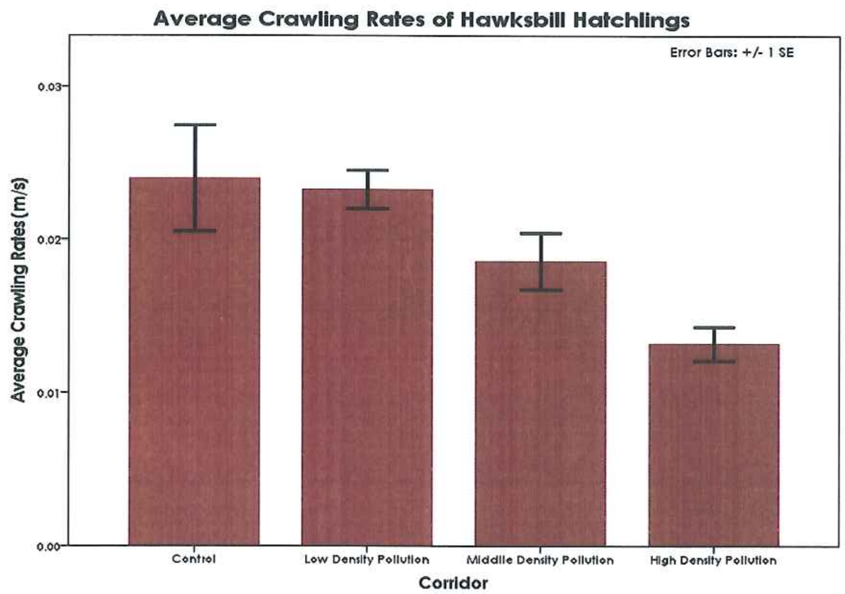

Figure 5. Histogram of average crawling rates of hawksbill hatchlings in treatment corridors. Error bars are ± 1 SE. All corridors were significantly different.

To ensure that the pollution densities differed between the corridors, the plastic debris was quantified (Table 1.). The average of plastic debris in the HD corridor was the greatest, equaling to 229 pieces. In the MD corridor, the average of plastic debris equaled 123 pieces; LD corridor had the lowest average of plastic debris (35 pieces). These plastic debris ranged from soda bottles to straws to toothbrushes. Differences between the

	HD	MD	LD
Quadrat 1	329	79	49
Quadrat 2	230	171	36
Quadrat 3	128	118	19
Average	229	123	35

Table 1. Quantity of plastic debris in corridors

groups was significant (One- way ANOVA test n=9, df=8, p=0.0284)

Baseline Pattern Map of Sea Turtle Sightings in Utila

Through ArcGIS, a potential baseline pattern map of sea turtle sightings around the waters of Utila was constructed (Figure 6). Divers reported 44 sea turtles sightings during the sample period. Table 2 summarizes the number and species of the various sea turtle sightings.

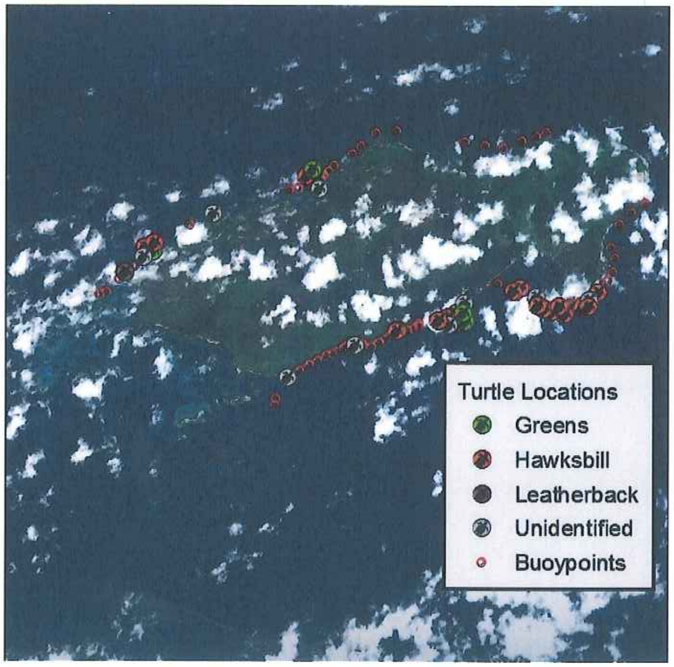

Figure 6. Baseline pattern of sea turtle sightings in Utila, Honduras. Each turtle icon represents one turtle sighting.

Sea Turtle Type:	# of Turtles Seen
Hawksbill	23 (15 adults, 8 juveniles)
Green	6 (4 adults, 2 juveniles)
Leatherback	1 (1 adult)
Unidentified	14
	TOTAL: 44

Table 2. Table of various sea turtle sightings around Utila

DISCUSSION

Analysis of the Effect of Plastic Debris on the Movements of Hawksbill Hatchlings

Overlap of error bars in adjacent corridors was apparent. The error bar was the largest in the control, indicating the high variability that exists within that corridor. The control group of turtles was the last group of hatchlings to run through the corridor; hence, the hatchlings may have reduced metabolic rate between capture and the experiment to conserve energy. During the trial runs, the hatchlings in the control corridor remained still for some time and seemed disoriented. Based on the graph, the control corridor did not differ from the LD corridor, and it is difficult to determine the difference between the LD and MD corridors based on the graph (Figure 5). However, the most significant difference between these plastic debris corridors existed between the HD corridor and the LD corridor.

Based on the results of the Kruskal-Wallis H test, the differences in the crawling rates between all corridors was statistically significant. Hence, we conclude that the plastic pollution did indeed influence the crawling rates of the hawksbill hatchlings; with an increase in plastic debris, the crawling rates of hawksbill hatchlings decreased. The decrease in crawling rate is statistically significant; the hatchling then would be forced to spend more time on the beach, navigating through the plastic pollution. Though this dash to the ocean is the shortest segment of the life cycle of hawksbills, losses frequently occur during this episode when the hatchling is vulnerable to predators (Davenport 1997). Therefore, the shorter the period of time spent on the beach, the better the survival chances of the hatchling (Triessnig, *et al.* 2012). If the time spent on the beach was elongated due to slower crawling speeds, this could negatively influence the survival rates of hawksbill hatchlings. Furthermore, plastic debris could make it more difficult for the hatchling to find the ocean, which could increase the risk of predation (Santidria′n Tomillo, *et al.* 2010).

Another negative impact of plastic debris on hawksbill hatchlings is forcing them to expend additional energy before they reach the ocean. Dial (1987) reported that loggerhead hatchlings display hyperactive motile behavior as they crawl to the ocean to escape predation. The hatchlings may be forced to continue this hyperactive motile behavior as they navigate through plastic debris, expending energy that could be conserved to use on reaching the waters instead. Therefore, the results of this study shows the importance of clean beaches free of plastic debris for increasing survival rates of hawksbill hatchlings as they run from their nest to the ocean. Based on our results, conservation efforts should focus on cleaning the beaches free of trash during nesting season to encourage the most optimal speed of crawling hawksbill hatchlings. A clean beach could potentially result in higher survival rates of hatchlings.

Analysis of the Baseline Pattern Map of Sea Turtle sightings

Although there were numerous sea turtle sightings on the southern part of the island, no pattern of sea turtle sighting was observed. Unfortunately, lack of a standard of monitoring procedures in our data collection made it impossible to effectively interpret our data. For example, the abundance of sea turtle sightings in the southern part of the island may simply reflect greater use of these sites by divers during our sample period. To establish a pattern of sea turtle sightings, changes must be made to our methodology to prepare a standard of monitoring procedures, such as collecting data on all dive locations visited by each dive shop, including those with no sightings. Data gathering would also have to occur over a longer period of time to depict an accurate picture of the abundance of turtles around the island of Utila. Even so, reports of > 40 sea turtle sightings in our 7 day period suggests that sea turtles were at least moderately abundant in the waters around Utila at this time of year.

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