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The Effects of Human Activities on the Conservation of Endangered Sea Turtles in Mexico:
A GIS and Ethnographic Analysis

A Capstone Project
By
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The Effects of Human Activities on the Conservation of Endangered Sea Turtles in Mexico: A GIS and Ethnographic Analysis

Abstract

This is a study about the effects of human activities and tourist development on the Olive Ridley, an endangered sea turtle species that nests on the beaches of the Northern shores of the Bay of Banderas, Nayarit, Mexico. I traveled to the site and I used a mixed methods approach to do my research. First, I mapped the nesting sea turtle sites using GIS/GPS technology. I used a GPS devise to collect control points on the ground and georeferenced them in Google images in GIS. I recorded the location of the nests on the beach using the GPS device for a period of three weeks. The data were imported into GIS and analyzed. Second, for the Ethnographic qualitative methods, I gathered information in the field by interviewing the conservationists in the Sea Turtle Preserve and other subjects. Additionally, I collected historical data from the Preserve, including the number of sea turtle nests, incubated eggs and released hatchlings that the Preserve has protected each year since 1995. The GIS analysis of the mapped areas shows “hotspots” in both light polluted and dark areas along the 14 km long beach. Through my data analysis, I observed that the Sea Turtle Conservation program is showing an increased number of protected nests and returning sea turtles. The analysis also reveals the extent of poaching, successfully gathered and protected nests and false nests. This study will help identify the nesting “hotspots” in the beach in order for the Sea Turtle Preserve personnel to increase their presence in those areas. The study also shows the positive effects the Nuevo Vallarta Sea Turtle Preserve has had on the survival of the species.

Key Terms: Olive Ridley, Geographic Information Systems (GIS), Ethnography, Sea Turtles, and Tourism.
INTRODUCTION

This study analyzes the effects of human activities and tourist development on Olive Ridley and its nesting habitat. Olive Ridley is an endangered sea turtle species that nests on the Northern shores of the Bay of Banderas, Nayarit, Mexico. The study focuses on selected human/cultural factors and processes that affect the reproduction and conservation efforts to save the Olive Ridley sea turtle species. The selected factors include: human activities such as the construction of sea walls and hotels on the beaches, construction of palapas (sunshade structures that are built out of palm fronds) on the beaches, debris contamination, and egg theft or poaching. This research also examines how human activities, particularly the recreational use of the beaches, adjacent waters, and the expansion of the tourist industry, are negatively impacting the nesting patterns of the Olive Ridley turtles. The study takes into consideration the ways in which human efforts to protect the Olive Ridley are making a significant positive impact in the survival of the species. The study systematically examines measurable variables that impede or contribute to the conservation of the species.

Sea turtles, which as species date back millions of years, are currently endangered and threatened by human, cultural, and economic activities throughout the oceans of the world, including the Bay of Banderas in Nayarit, Mexico where this study was conducted. Mexico is important for the conservation of sea turtles because its coasts are nesting sites for six out of the seven known sea turtle species in the world. Turtles return in varying numbers during different times of the year to the Bay of Banderas and Mexico’s shores for the foraging, nesting, migration, reproduction and conservation (Plantaz 2008:5). Due to Mexico’s importance for the survival of sea turtles, the government has been taking steps to protect the species through the

\[1\text{ Acknowledgments}\]
enactment of laws and the establishment of conservation programs since 1981 (Razo A., personal communication, July 12, 2009). In 1986, the international community pressured the Mexican government to declare twelve of its beaches as sea turtle reserves (Razo, A., personal communication, July 12, 2009). From 1990 to 1991, Mexican President Salinas de Gortari established a total ban and he criminalized the "taking, killing and commercializing sea turtles and their products" (Cartron et al., 2005:417). Commercialization is a major cause in the decrease of sea turtles in Mexico. For some, sea turtles are an exotic species that can be freely exploited as a commodity. One nest with an average of 100 eggs can bring as much as US 100.00 in an area where the daily wage is approximately US $10.00 (Carlos, M., personal communication, June 5, 2009).

The commercial demand for sea turtle eggs is based on the idea that turtle eggs are an aphrodisiac for men, a type of natural Viagra (Wilson and Tisdell 2005:149). It is important to note that the belief that sea turtle eggs are an aphrodisiac is more popular in big cities miles away than in the coastal towns, thus poaching satisfies a market demand that is urban in nature. Poaching activities have caused "the loss and deterioration of nesting habitat to commercial touristic development" (Alvarado-Diaz J. et al., 200:5). Additionally, sea turtle eggs are susceptible to predators including “feral dogs [and cats], nocturnal mammals, beach crabs and man” (Convis 2001:156). Today the greatest threats to sea turtle survival are: the hunting of turtles, incidental capture in fishing nets and long lines, the stealing and selling of eggs as an aphrodisiac, coastal development, and the contamination of seawater through untreated sewage water flowing down streams and rivers and sand contamination (Wilson 2001; Grupo Tortuguero 2009).
Marine turtles are notable for their ability to live in the ocean all their lives, except for the females who come out to the coasts only to dig nests and lay their eggs and reproduce. To observe the behavior and patterns of the female sea turtles and the threats to their survival, I decided with the advice of my capstone advisors and AMA Mexico representatives to do a field grounded study in the Bay of Banderas in the Nuevo Vallarta, Flamingos and Bucerias beaches, Nayarit, Mexico (which incorporates the northern part of the Bay of Banderas that is 14 km long) (see Figure 1).

Figure 1: Map of Nayarit, Mexico.

This study references the history of sea turtle conservation, practices dating back to fifteen years, along with actions taken by CONANP, its predecessors, and AMA Mexico an NGO (AMA Mexico-Association for Environmental Harmony with Mexico). Additionally, the study examines the impact of conservation and public education activities by the AMA Mexico-Association. The data were collected using a GPS Trimble GeoXM handheld GPS devise and
then it was evaluated using GIS technology. All the methods are described and studied using mapping data and corresponding on-the-ground data obtained through ethnographic interviewing techniques.

Turning now to the research questions that guided this study. Researchers of sea turtle behavior have suggested that there will be variation in nesting patterns according to the degree of artificial lighting or natural darkness on the beach. More specifically this research focuses on the following two questions. (1) Are all the concentrated hotpots (clusters of nests) on dark beaches without artificial light? (2) To what extent has the Nuevo Vallarta Sea Turtle Preserve been effective in protecting the sea turtle population?

LITERATURE REVIEW

The literature related to the decline and survival of sea turtles populations seems to agree on many of the reasons and factors that cause the decline of the species. In Convis’ book on conservation practices and GIS technology, in addition to analyzing the decreasing number of turtles, he writes about how a group of people set up a satellite telemetry project, SAT TAG 2000 in order to “promote international conservation and support efforts in Mexico… [this] was established and conducted in response to the urgent need to develop international measures of conservation for all species of sea turtles and their habitats” (Convis 2001:156). By using GIS technology, researchers were able to obtain data that would otherwise be unavailable. In developed countries like the United States, this data is used to make recommendations in areas where fishing industries exist and where sea turtles nest. To carry out this study, the group relied on the help of biologists, researchers, and volunteers. This is the same model that the Sea Turtle Preserve in Nuevo Vallarta employs. In Nuevo Vallarta, although the group is small, they also
rely on the main contact, Antonio Razo (veterinarian), the non-profit organization AMA-Mexico, Government programs, and volunteers.

In Third World countries like Mexico, the local communities who are seeking the promise of economic growth and employment support tourist development. However, tourism does have negative effects. As Davenport states, “[T]he greatest ecological threats that mass tourism poses undoubtedly lie in the infrastructure and transport arrangements required to support it, particularly where the numbers of tourists are subject to little control” (Davenport, Davenport 2006). In underdeveloped countries, government, often holds tourist businesses to low safety and ecological standards. In the long run this can have devastating effects in the environment. Researchers generally agreed that there are both positive and negative aspects of eco-tourism. Some even argue that in order for sea turtles to survive, an eco-tourist program has to exist and that the presence of sea turtles is an added value for many tourists that visit an area (Witham 1982). Others argue that eco-tourism, if managed properly, can have positive effects on the survival of sea turtles, but if managed poorly, it will severely and negatively impact sea turtles (Tisdell, Wilson 2002).

In the past few decades, the hotel industry in the Mexican coasts has grown tremendously, “[m]ass tourism is a modern phenomenon, stemming primarily from the introduction of personal vehicles and motorized mass transport… Coastal resorts became increasingly popular as tourist destinations; the benefits of the water, seafood, beaches, scenic views [are] the initial attraction” (Davenport, Davenport 2006). Mexico has also “attracted the largest number of foreign tourists and hard currency over the past 25 years” (Clancy 1998:9). During my field study, I observed that hotels not only attract many people, but they use
construction machinery to flatten the sand at night after the tourists have gone to sleep so that in the morning the sand looks intact. This practice can destroy the nests and crush eggs.

According to an anonymous source in Nuevo Vallarta, due to the economic power that hotels have in Mexico, they can evade the laws to buy and build in zones that are supposed to be Federal Reserves” (Personal Communication, 2009). These entities only have to pay a fee and because of the corruption and the lack of law enforcement when it comes to affluent businesses, the tourist industry has the freedom to profit at the expense of the declining biodiversity and probable extinction of animal species. Here, the problem is not the absence of laws, but the lack of enforcement and side-steping the law. In Mexico, hotels are not allowed to build 20 meters from high tide because that territory is considered federal zone (see Figure 2). However, nearly all coastal businesses in the Nuevo Vallarta area violate this law, which is an indication the hotels must be finding means so that the government grants them "exceptions," or at least the laws are not enforced because these businesses violate laws without being prosecuted.
Researchers Clem Tisdell and Clevo Wilson (2005) conducted a research study on the importance of conserving sea turtles. According to them, the benefits of preserving turtles are economical and non-economical. They talk about the human activities that are threatening the sea turtle species including the human consumption eggs and meat is threatening the species. In many countries sea turtle eggs besides Mexico these eggs are considered an aphrodisiac and are consumed usually by local tourists and/or national tourists, and the demand of sea turtle products increases especially during holidays. Tisdell focused their research in a Sri Lanka community. He states that in the absence of tourists "turtle eggs and meat are consumed locally" (Does Tourism Contribute to Sea Turtle Conservation: 149) In other countries such as Mexico turtle
meat is erroneously considered seafood because turtles live in the ocean. During Easter, Catholics consume turtles because they are considered fish and the religion prohibits the consumption of red meat. The Catholic Church allows some seafood to be consumed and sea turtles are in the menu according to Nichols J. Wallace and Jennifer L. Palmer (2006). Such traditions have devastating effects in sea turtles especially in urban beaches where there is tourist development.

Currently, no other study to my knowledge has been conducted using Average Nearest Neighbor Distance and Kernel Density Estimation analysis to demonstrate whether sea turtles are nesting more in developed beaches, namely those with light polluted beaches. The GIS literature used in this research comes from studies where the Average Nearest Neighbor Distance and Kernel Density Estimation analyses were used, but the studies were not related to sea turtle preservation. Therefore, I used research studies, which used GIS to find "hotspots" or clusters in crime studies, the same methods that were used in my case study. Tony H. Grubesic conducted a study to detect crime hotspots using cluster analysis. In his reports Detecting Hot Spots Using Cluster Analysis and GIS, Grubesic found the technique very useful in detecting areas with activity hotspots. The Average Nearest Neighbor Distance analysis in GIS tells us if there are hotspots but it does not show where those hotspots are. In order to visualize the location of the hotspots, I used Kernel Density Estimation analysis.

Because I was not finding literature, in which the Kernel Density Estimation analysis was used in a project related to mine, I turned to research papers in other fields. Tessa K. Anderson (2009) wrote a research paper Kernel Density Estimation and K-means Clustering to Profile Road Accident Hotspots. Anderson used the Kernel Density analysis to identify accident hotspots. In her research, she integrated the accidents locations into GIS, and the software
identified the hotspots. The results are useful in making those streets safer. Although the study is not related to my topic, it uses the same methods and it shows the effectiveness of using Kernel Density.

**Sea Turtle Nesting Behaviors: Theoretical Premises and Hypotheses**

The first hypothesis formulated for this study analyzes whether sea turtles are more attracted to naturally dark beaches where there is no artificial lighting and human development. The theoretical premise of the hypothesis rises from the fact sea turtles including the Olive Ridley are nocturnal nesters (Witherington 1992). These turtles are attracted to darker natural habitats as opposed to areas with human structures and lighting (Jacobson et al. 1994). The book *Behavioral Approaches to Conservation in the Wild* supports of the theory that marine turtles prefer the dark areas to nest and the book explains the following:

> Sea turtles are affected profoundly by artificial lighting, making photo-pollution at sea turtle nesting beaches an important conservation issue for the six sea turtle species (of seven extant species) listed as threatened or endangered. Lighting deters sea turtles from emerging from the sea to nest on otherwise preferred beaches (Witherington 1992a). Where nesting on lighted beaches does occur, hatchlings emerging nocturnally from nests are unable to locate the sea and wander inland toward light sources. This sea-finding disruption (often termed disorientation) results in high hatchling mortality. (Clemonds and Bucholz 1997, pg. 304)

Moreover, according to Blair Witherington and Erik Martin, “The most clearly demonstrated effect of artificial lighting in nesting is to deter turtles from emerging from the water. Additional authors have noted a relationship between lighted beach development and reduced sea turtle nesting” (1996). Witherington and Martin point to the presumed effect of lighting and the deterrence of turtle nesting in those areas. Furthermore, their study highlights the negative effects that light pollution in beaches has on sea turtles. According to the authors of this study, light pollution is very detrimental to the not only because it discourages the hatchlings
from emerging but also because it disrupts their nocturnal behavior. Sea turtles also tend to nest at night because they feel more protected and "artificial lighting in the beach is perceived by the turtles as daylight, which may suppress behavior that is usually nocturnal" (Witherington 1996:4). In this report, Witherington and Martin concluded by recommending that the best way to stop the problem is to completely turn off the lights at night, reduce their "wattage," move the light polls behind trees or other structures to minimize the amount of light that reaches the beach. Witherington (1992) also conducted a study in Florida and Costa Rica, and he found that the number of sea turtle nests have decreased in beaches where there is artificial lighting.

Ross Witham conducted a separate study (1982) on the disruption of sea turtle habitat by human influences such as light pollution, structures, and human activities. He found that artificial lighting disoriented hatchlings because they would crawl towards the artificial lighting instead of the sea. Because they crawl more than the usual when there is light, they are more exposed to land predators, and when they made it to the sea, they were tired and this made them easy targets to fish and other sea predators. Other obstacles like sea walls in the beach are also affecting the hatchlings that get stranded. According to Witham, "Nesting sites have been degraded or lost because erosion control structures" (Witham 1982:520).

If in fact, and as the authors claim, sea turtles tend to nest in darker areas; the results from the compilation of data using GPS technology in this study should show support for this claim. My data was collected using a handheld GPS, and this data was integrated into GIS and analyzed it using two methods. The first method is the Kernel Density Estimation analysis, which is also called hotspots. The hotspots indicate whether the sea turtles are nesting in dark or lighted beaches at night. Figure 3 indicates which parts of the beach are dark and which ones are light polluted.
Figure 3. Dark and light polluted beaches in Nuevo Vallarta, Flamingos, and Bucerias. Source: Authors data from GIS mapping of the beaches July, 2009.
The newer and more radical proposition is that human development when accompanied by a conservation program, helps to reduce the negative effects and conserve sea turtle species that nest there (Plantaz 2008:23, Carlos M, personal communication, June 5, 2009). Eco-tourism is a very controversial issue in the conservation community; some scholars argue that in order for sea turtles to survive, an eco-tourism program needs to be set up (Wilson and Tisdell 2001). Although the Sea Turtle Preserve camp in Nuevo Vallarta is not an eco-tourist program, some of its activities could be considered eco-tourist related. For example, tourists are invited to do turtle releases when the camp has hatchlings and the camp also offers educational workshops on sea turtle conservation. In order to test this proposition, data from the Sea Turtle Preserve camp was collected to see whether the number of protected turtles has been increasing or decreasing during the time that the Sea Turtle Preserve has been in operation.

In related literature I found that sea turtle conservation programs are vital in the survival of the sea turtle species. In the research paper, *Saving Sea Turtles from the Ground Up* by Stephen Delgado and Wallace J. Nichols (2004), the authors analyzed the importance of conservation practices in Northern Mexico. The authors found that conservation programs "helped to promote a network of marine protected areas" (p. 97). In their research, they also found that the program has successfully helped increase the number of sea turtles that nest in the beach. Conservation programs have gained popularity in the community because they educate the people on the importance of conserving the sea turtles (Delgado and Wallace: 95). The methods used in their study were similar in my research since I collected data from the Nuevo Vallarta Sea Turtle Preserve to find out whether this is significant factor in increasing the number nests.
Nueva Vallarta Sea Turtle Preserve

The history of the Nuevo Vallarta Sea Turtle Preserve Camp was obtained through personal communication with Antonio Razo, the biologist in charge of the Sea Turtle Preserve in Nuevo Vallarta. In 1986, Mexican President Miguel de la Madrid declared 12 beaches as sanctuaries for sea turtle nesting, but the Nuevo Vallarta beaches were not included. It was not until April 30, 1990 that Mexican President Carlos Salinas de Gortari created a decree banning the commercialization of every product and sub-product of sea turtle in Mexico. In 1993, the Nuevo Vallarta Sea Turtle Preserve was established and operated by the National Institution of Fishing. Then in 2001, the Sea Turtle Preserve became part of SEMARNAT (Secretary of Environment and Natural Resources), and later in 2005 it changed to CONANP (National Commission of Protected Areas). In 2002, the NGO AMA Mexico was created after Hurricane Kenna destroyed the Nuevo Vallarta Sea Turtle Preserve and the biologists working in the camp abandoned the Sea Turtle Preserve. The sea turtle hatchings that nested after the hurricane came out during the first three months in 2003 and this gave the opportunity for tourists to volunteer to protect the turtles working alongside the biologists from ITMAR (Technological Sea Institute). AMA Mexico was born out of this event. AMA Mexico helped the Nuevo Vallarta Sea Turtle Preserve financially and with volunteers. According to Dr. Carlos, the Sea Turtle Preserve would not be able to accomplish as much without volunteers and the economic assistance given stipends by AMA Mexico to university student interns.

METHODOLOGY

The mixed methods used in this study are (ethnography) qualitative and (GIS) quantitative. The goal of using mixed methods is to get a “sense of both the general and the particular” (Cope and Elwood 2009:5). The results will be more complete by using both
methods as opposed to only using one method. For the qualitative part, I conducted ethnographic research. Ethnography focuses on participatory observation also known as fieldwork which encompasses “being there” (Sluka and Robben 2007:24); this occurred while I was living and engaging in the daily activities of the conservationists living in the Sea Turtle Preserve camp in Nuevo Vallarta. The purpose of ethnography is gain firsthand experience of what is happening in the field. At the Preserve I was able to interview the person in charge of the Sea Turtle Preserve camp, Antonio Razo. I worked side by side with him in conservation activities and was able to see the effort it takes to protect sea turtle egg clutches and nests. I also interviewed the founders of the NGO AMA Mexico Dr. Manuel Carlos and Ann Carlos before I left for the field and after I got there, as they too were at the site and involved with turtle conservation while I carried out this study. The interviews were recorded in MP3 format and then transcribed into Word. I was able to participate in the daily activities of the Sea Turtle Preserve camp for a period of three weeks. I went on the nightly patrols in ATVs (All Terrain Vehicles) every night from approximately 12:00am to 8am. After finding a nest, we would dig and collect the eggs. Each turtle lays from 80 to 120 eggs, and each one is the size of a golf ball. We patrolled 14 kilometers along the coast every night. Aside from collecting the sea turtle eggs, I used a GeoXM handheld GPS to record the location of every nest. After collecting the eggs we would take them back to the camp, we would dig a hole similar to the one the Olive Ridleys dig to lay their eggs and we would replant the eggs. During the day, I helped the Sea Turtle Preserve personnel with educational talks to tourists (national and international); these were about the importance of the conservation of the Olive Ridley.

For the quantitative methods, I used GPS and GIS technology to map the location of the nest sites along the beach. I then analyzed the data using the Kernel density estimation to see if
all the hotspots of nesting sea turtles were in the dark areas and not in the light polluted areas along the beach. I also gathered data from the Sea Turtle Preserve, which had been collected from 1995 to 2008 and it consists on the number of nests the Sea Turtle Preserve has been able to protect, the number of eggs that were incubated and the number of hatchlings that been released every year. That data was then used to analyze the second hypothesis, which is that a conservation program is balancing the negative effects of development on the beach.

**Ethnographic Method**

To gather my data, I traveled to Nuevo Vallarta, Mexico during the month of July 2009. There, I lived and fully engaged in the daily activities of the Nuevo Vallarta Sea Turtle Preserve. A normal day in the preserve began at about 2 pm. At this time tourists began arriving at the Sea Turtle Preserve to see the hatchlings. At the Preserve we would give educational talks to the tourists about the importance of conserving sea turtles. I would give the English educational talks to foreign tourists who did not speak Spanish. These tourists were mainly from Canada and the United States. We would also clean the nests where the turtles had already hatched; we would remove the egg shells and the rotten eggs that did not hatch. Later at night, at about 8 pm, we would get all the equipment ready for the nightly patrol. Equipment consisted of ATV’s, GPS, paperwork, flashlights and bags. During the nightly patrols we would talk to the local fisherman in the beach about the sea turtles. The fishermen gave us key information about the dead turtles that were washed out to the shore. They told us about the boat that dropped an illegal long fishing net at night, which was responsible for drowning the turtles. The night patrol concluded at about eight in the morning. Thereafter, we would head back to the Preserve to re-plant all the eggs collected during the night patrol. The information gathered from talking to the people was then recorded in a daily journal. Later, the data was then analyzed to explain the GIS results.
During my time in the field, I used ethnographic interviewing techniques to interview key people like the Biologist Antonio Razo. Additionally, I interviewed people like fishermen and the hotel security guards that we would see during our night patrols. I used open-ended questions to gather information about the history of the Sea Turtle Preserve, the effects of the tourist industry, and the cultural factors affecting the habitat of sea turtles. Some of the interviews were recorded in a laptop with the permission of the subjects. By conducting ethnographic research in the field, I was able to decipher the results and the information that is not explained by using technology. For instance, the information from the security guards explained the reason why there was egg poaching in certain parts of the beach.

**GIS Database Creation**

The methods are as follows: Using GPS Pathfinder Office software, I created a data dictionary in order to go to the field and gather the locations of the nesting sites using a Trimble GeoXM handheld GPS device. The purpose of the creation of the data dictionary is to program the GPS so that when I turn on the GPS in the field is going to have a menu where I will enter the number of eggs the turtle laid and it will automatically record the time, date, and feature name of each nest. I collected the points by going in nightly patrols with the conservationists and biologists of the Sea Turtle Preserve. Every time we found a nest I would get its location with the GPS, which uses satellites to record the location of the nest on the planet. This was done every day and night for a period of three weeks. After collecting all the points and areas with the GPS each night, I entered the data in Pathfinder Office and differentially corrected the data. I exported my correction points, areas, and lines to ArcGIS 9.2. Thereafter, I georeferenced Google images using control points in the ground. The coordinate system that I used for all files is WGS 1984 UTM Zone 13S. All the points and areas were converted to a geodatabase format in ArcCatalog,
then the data was analyzed using the Kernel Density Estimation and Nearest Neighbor methods. Kernel density estimation (KDE) is used to identify high-density areas or "hotspots" (Anderson 2009). In this case, the results should show whether the hotspots of nests are in dark beaches or in beaches that have development. I used GIS to create “hotspots” of both light polluted and dark areas along the 14 km long beach. A light polluted beach is where there are tourist resorts or any type of development with artificial lighting. A Dark beach is an empty undeveloped area. In my study I labeled sections of the beach based on direct observation of the Coast. The analysis also reveals the extent of poaching, successfully gathered protected nests and false nests; it demonstrates the lamentable instances and locations of the drowned adult sea turtles.

RESULTS/DISCUSSION

The following results were obtained from the Nuevo Vallarta Sea Turtle Preserve, which have been collecting data since 1995 (see Table 1). From 1995 to 1999 the number of protected nests and hatchlings remains relatively the same. In the year 2000, the number of nests begins to increase to 3,566, but it significantly decreases again in 2002 to 1,839. The reason is that in October 25, 2002, Hurricane Kenna devastated the Bay of Banderas where the Nuevo Vallarta beach is located and the Sea Turtle Preserve was destroyed. At the time, the Biologist abandoned the Sea Turtle Preserve Camp believing that the hurricane destroyed all nests (Dr. Carlos. Personal Interview, 2009). From October 2002 to January 2003, during high nesting season the camp was not operating and no data was collected, this explains the decreased number of protected nests during that year. The camp reopened in 2003, this year the number of protected nests began to gradually increase and the number peaked reaching 9,973 nests. As the number of protected nests increased, so did the number of liberated hatchlings and incubated eggs (see Figure 4 & 5).
### Table 1: Protected Nests, Incubated Eggs and Liberated Hatchlings from 1995 to 2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Protected Nests</th>
<th>Incubated Eggs</th>
<th>Liberated Hatchlings</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>1,858</td>
<td>184,253</td>
<td>119,253</td>
<td>1,858</td>
</tr>
<tr>
<td>1996</td>
<td>1,816</td>
<td>174,566</td>
<td>125,508</td>
<td>1,816</td>
</tr>
<tr>
<td>1997</td>
<td>1,555</td>
<td>139,125</td>
<td>75,934</td>
<td>1,555</td>
</tr>
<tr>
<td>1998</td>
<td>1,178</td>
<td>108,051</td>
<td>79,569</td>
<td>1,178</td>
</tr>
<tr>
<td>1999</td>
<td>1,748</td>
<td>144,421</td>
<td>108,740</td>
<td>1,748</td>
</tr>
<tr>
<td>2000</td>
<td>3,566</td>
<td>342,290</td>
<td>274,437</td>
<td>3,566</td>
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<tr>
<td>2001</td>
<td>4,368</td>
<td>429,470</td>
<td>363,974</td>
<td>4,368</td>
</tr>
<tr>
<td>2002</td>
<td>1,839</td>
<td>176,008</td>
<td>83,562</td>
<td>1,839</td>
</tr>
<tr>
<td>2003</td>
<td>4,340</td>
<td>412,259</td>
<td>349,566</td>
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<tr>
<td>2004</td>
<td>5,015</td>
<td>468,839</td>
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<td>2006</td>
<td>8,444</td>
<td>812,343</td>
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<tr>
<td>2007</td>
<td>9,973</td>
<td>898,721</td>
<td>737,085</td>
<td>9,973</td>
</tr>
<tr>
<td>2008</td>
<td>5,053</td>
<td>430,598</td>
<td>205,885</td>
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<td></td>
<td></td>
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<td></td>
<td>55,731</td>
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</tbody>
</table>

Source: Historic data from the official documents of the Sea Turtle Preserve of Nuevo Vallarta.

![Figure 4](chart.png)

**Figure 4.** Shows the number of protected nests from 1995 to 2008. Source: historic data from the official documents of the Sea Turtle Preserve of Nuevo Vallarta.
Figure 5. Shows the number of eggs and liberated hatchlings from 1995 to 2008. Source: historic data from the official documents of the Sea Turtle Preserve of Nuevo Vallarta.

There is a dramatic decrease in 2008 in the number of liberated hatchlings, incubated eggs, and protected nests. According to Razo and Carlos, in 2008 there was a lack of volunteers and the Biologist in charge of the Sea Turtle Preserve collected no data for two months during high season. In September 2008, the biologist resigns and Antonio Razo is hired. The camp only has two paid staff and consequently, it relies on volunteers to operate. The hypothesis that the turtle conservation program is balancing the negative effects of the tourism industry in the beach is supported by the data collected from the Nuevo Vallarta Sea Turtle Preserve. The success of the conservation program depends on volunteers, if there are no volunteers during high season like in 2008, many turtle nests will be left in the urban beach to either destroyed or stolen.

**GIS ANALYSIS**

Before conducting the Kernel Density analysis, I conducted an Average Nearest Neighbor Distance Analysis, which lets us know if there are cluster patterns of nests in the beach.
by "calculating the nearest neighbor index based on the average distance from each feature to its nearest neighboring feature" (ESRI, 2009). The results showed that there is less than 1% likelihood that this clustered pattern could be the result of random chance with an "Observed Mean Distance of 0.17 and a Z Score of -31.53 (see Figure 6). "The nearest neighbor measure is a comparison of the distance between two points with the average distance between all points" (Grubesic, 2002). Next, the GIS Kernel Density analysis was performed, which "calculates the magnitude per unit area from point or polyline features using a kernel function to fill a smoothly tampered surface to each point or polyline" (ESRI, 2009). The Kernel Density shows hotspots in dark areas along the beach (see Figure 7). There is only one hotspot that is not in a dark area. The total of nests recorded using GPS from July 5, 2009 to July 25, 2009 were 397 (see Figure 8). During that period, 30 nests were stolen (see Figure 9). Most of the nests that were stolen were in dark beaches where there were no watchful eyes of citizens or security personnel and a smaller number where in light polluted beaches were there are no security guards at night to stop poachers.
Figure 6. Average Nearest Neighbor Distance Analysis demonstrates that there are clusters of nests on the beach. Source authors data from GIS mapping of the beaches from July 5th-July 25th, 2009.

During that period, there were a total of 14 dead turtles: twelve females and two males washed out to the shore (see Figure 10). All dead turtles washed out to the shore were in the southern part of Nuevo Vallarta beach. During our night patrol in July 11th four local fishermen close to the Ameca River informed us that during the night of July 9th they saw a boat dropping a long fishing net, which is illegal in that area. The fishermen stopped fishing because their short fishing nets, which are legal were not catching any fish because the long fishing net that the boat dropped was catching everything. Sea turtles are reptiles and they have to come out to the surface to breath. Biologist Antonio Razo (personal communication, July 12, 2009) came to the conclusion that the turtles got caught on the fishing net and drowned.
Figure 7. Kernel Density Estimation of “hotspots” using GIS software. Source: Authors data from GIS mapping of the beaches July, 2009.
Figure 8. Olive Ridley nests in Nuevo Vallarta, Flamingos, and Bucerias. Source: Authors data from GIS mapping of the beaches July, 2009.
Figure 9: Olive Ridley nests in Nuevo Vallarta, Flamingos, and Bucerias. Source: Authors data from GIS mapping of the beaches July, 2009.
Figure 10: Dead turtles in Nuevo Vallarta, Flamingos, and Bucerias. Source: Authors data from GIS mapping of the beaches July, 2009.
The historical data from the Preserve shows an increase in protected nests and an increase in the number of returning sea turtles. The highest concentration of nests is around the Sea Turtle Preserve where half of the beach has development and half is empty. This hotspot analysis does not support the theory that sea turtles tend to nest in dark beaches rather than in beaches with artificial light and development.

A total of 87 false nests were located in the Nuevo Vallarta beach (see Figure 11). Of those false nests 59 were in light polluted areas and 27 were in dark areas. A Kernel Density Estimation was conducted in GIS to identify the hotspots. The results show no hotspots, which means that they are dispersed randomly and are not caused necessarily by lighting or obstacles in the beach. Biologists still cannot find the reason for false nests.
Figure 11: False nests in Nuevo Vallarta, Flamingos, and Bucerias. Source: Authors data from GIS mapping of the beaches July, 2009.
By examining the data that was collected during the three weeks in July 2009, it is inconclusive whether sea turtles are more likely to nest in dark areas as opposed to light polluted areas. The Kernel Density analysis however points to a possible, unexpected phenomenon, “the chemical imprinting theory” which argues that adult sea turtles are able to locate their natal beaches (Lutz, Musick, et all: 127). These researchers took a number of sea turtle eggs and exposed them to different types of chemicals to see if after hatchling, they would be able to recognize or have a preference for the chemicals that they were exposed to before hatchling. The results, proved to be inconclusive due to the limitations of the studies. However, both authors do express the need to do further studies on this topic. Another hypothesis on the topic and in the same book is the “magnetic map hypothesis.” This theory suggests that species, such as sea turtles have a map sense, and “although the nature of the sea turtle map remains unknown, a new hypothesis proposes that turtles determine position using geomagnetic parameters.” (Lutz, Musick et all: 128-129).

Another valid interpretation is that the beach resorts despite artificial lights, beach lounges, etc. provide more protection for nesting turtles because of their security guards stop human predators and this reduces the number of stolen nests. It thus appears that nesting obstructions make it more difficult, but they do not stop turtles from successfully nesting. It seems like Sea turtles are adapting to their changing habitat, but the limitations on this study make it difficult to assert any theories. A longer period of data collection will be required to assert those theories.

CONCLUSION

Through my research I was able to develop and test my initial hypotheses and guiding theoretical premises. In the theoretical assertion regarding the effects of artificial lighting and sea
turtle nesting, the compilation of my data resulted inconclusive due to the fact that the Kernel Density Estimation showed a main hotspot in a developed light polluted area. However, although the results proved to be inconclusive, in order to develop and prove that artificial lighting does affect sea turtle nesting as the literature indicates, more studies have to be performed. My study was limited to three weeks of data gathering in field, and in order to collect more accurate results, the study should be performed for an extended period of time. Also, the field studies on the topic of artificial lighting are scarce and they are focused on different turtle species. The dearth of research using technology to access the preservation of sea turtles and the effects of touristic development and artificial lightning make it difficult to establish any proven theory.

The second hypothesis and underlying theoretical premise tested by my research was that human development when accompanied by a conservation program could offset the negative effects of development. Through my own observations and the data collected in the field, I was able to see that since the establishment of the Nuevo Vallarta Turtle Preserved, the number of nests and hatchlings has gradually increased year by year. The decrease during certain periods can be explained by events that occurred like Hurricane Kenna. Since its establishment, the Preserve has been able to protect and increase the number of hatchlings. In addition, the camp has deterred the stealing of eggs by patrolling the beaches, by incorporating the cooperation of the near by security guards of the tourist resorts to its preservation efforts, and educating the public about the importance of sea turtle conservation. Without the Preserve, it is doubtful that the Olive Ridley would be able to survive in this environment of development and commercialization of eggs and sea turtle products. Additionally, the Preserve is working to change the mindset of a culture that believes that sea turtle eggs can be used as an aphrodisiac,
by doing presentations in the community and the local schools on the significance of protecting an endangered species, the Olive Ridley.

From my research, I learned that Mexico is a very bio-diverse country and unfortunately most of its Native and migratory species are disappearing. In the Coasts, endangered sea turtles are striving to survive in the midst of development and cultural factors. Sea turtle conservation is no longer a local issue; it is now a global concern. As the world turns more towards a global interconnected market where the boundaries of human communication and travel are blurred and more people are able to visit places that used to be ancient sea turtle habitats, it becomes everyone’s responsibility to ensure the survival of the species. It is important to contribute to the survival of the Olive Ridley because if this species becomes extinct other species will follow since species depend on each other to survive. Moreover, ecotourism will also be affected given the fact that nowadays, a portion of people traveling to Nuevo Vallarta go there to be part of the conservation effort of the Sea Turtle Preserve, which in turn helps the local economy.

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