Determining the Correlation Between Sea Surface Temperature, Chlorophyll Concentration, QuikSCAT Wind Data and the Presence of *Caretta Caretta* and *Chelonia Mydas* in the Mid-Atlantic

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***Abstract*—** The long distance movement of marine turtles is one of the wonders of the natural world, with recapture techniques showing how some species move thousands of kilometers across the ocean (Meylan, 1995). The Mid-Atlantic serves as a host environment for a number of sea turtle species that encompasses their seasonal migration routes. Currently, out of the six turtle species all are labeled as either threatened or endangered under the Endangered Species Act. Previous research suggests that migration routes are strongly influenced by two factors: sea surface temperature and chlorophyll concentrations. Studies in the past that investigate sea turtles and their correlation with Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature (SST) and chlorophyll concentration have only focused on one turtle species, the *Caretta caretta* (loggerhead turtle). This study included two species of sea turtles, the Caretta caretta and *Chelonia mydas* (green turtle). These turtles were tracked along the Mid-Atlantic to determine if a correlation exists between migration routes, sea surface temperature, chlorophyll concentrations, and wind data. Archived AVHRR sea surface temperature and OrbView-2 SeaWiFS chlorophyll data were derived, processed, and analyzed at the Center of Excellence in Remote Sensing Education and Research (CERSER) located on the campus of Elizabeth City State University. CERSER has a TeraScan 1.5m System that is configured to ingest data from polar orbiting satellites. The system contains a suite of software which was utilized for the processing and analysis of the data. In addition, AVHRR sea surface temperature and QuikSCAT wind data were utilized from the Jet Proportions Laboratory.

Before processing the data, TeraScan Capture Control, a software package used for scheduling and viewing images that are ingested into the TeraScan System, was used to locate data. Once data was located it was retrieved from archival tape using the TeraScan pass disk. After retrieval AVHRR data was processed using the command 'hrptin'. The command 'outliers' was then used to correct for noisy data. Once the noisy data was corrected it was calculated for the sea surface temperature using the command 'nitpix'. 'Nitpix' converts brightness temperature to sea surface temperature in areas that are determined to be cloud free. 'Nitpix' is an implementation of the Multichannel sea surface temperature (MCSST) algorithm. The AVHRR data was then ready for analysis.

Before the SeaWiFS data could be processed it first had to be decrypted. CERSER has a two week delayed license. With this license SeaWiFS data must remain on the system for two weeks before it can be processed. After decryption of the data it was processed using the command 'seawifsin' and calculated for chlorophyll concentrations using the command 'swcolor'. 'Swcolor' implements the official SeaWiFS ocean color algorithms to derive chlorophyll, pigment concentrations, and aerosol optimal depth. The SeaWiFS data was then ready for processing.

This project was a continuation of the paper "A Determination of Temporal and Spatial Distribution, Migratory Patterns, and Habitats for Sea Turtles using AVHRR".

I. Introduction

A. Background

Sea Turtles are large, air-breathing reptiles that live in tropical and subtropical seas around the world. Research on marine turtles has uncovered many facts about these ancient creatures. Most of this research has been focused on nesting females and hatchlings emerging from the nest, largely because they are the easiest to find and study. Thousands of sea turtles around the world have been tagged to help collect information about their growth rates, reproductive cycles and migration routes. After decades of studying sea turtles, much has been learned. However, many mysteries still remain.

The purpose of our project is to conduct a study that will help us understand marine turtle life style, in and out of the water. Our goal is to help protect these species. All six species of sea turtles that are found and nest on the United

States beaches are designated as either threatened or endangered under the Endangered Species Act. These turtles were listed because their populations had declined largely as a result of human activities. This study is a continuation of a study conducted entitled "AVHRR sea surface temperature and SeaWiFS chlorophyll concentration serving as indicators for the movement of loggerhead sea turtles in the Mid-Atlantic" and "A determination of temporal and spatial distribution migratory pattern, and habitats for sea turtles using AVHRR."

B. Loggerhead and Green Sea Turtle

Our research was focused on two types of turtles: The Loggerhead Turtle (*Caretta caretta*), and the Green Sea Turtle (*Chelonia mydas).*

The loggerhead turtle species gets his name from their really heavy and large head. The carapace of sub-adult and adult loggerheads is reddish-brown. Average carapace length is about 92 cm and average body mass about 113 kg. The loggerhead was listed in 1978 as a threatened species and it is considered vulnerable by the International Union for the Conservation of Nature. Recent population studies have concluded that the number of females that nest in the Southeast U.S. is continuing to decline. The greatest threat for the loggerhead turtles is the loss of nesting habitat due to coastal development, predation of nests, and human disturbances. Other major threats include incidental capture in shrimp trawling and pollution.

The green sea turtle gets his name from the green-colored fat tissues in its body. His carapace often is covered in green algal growth, and is about 2 inches long. The average body mass of the green sea turtle is about 200 to 350 pounds. Green sea turtles are found throughout the world's oceans, with major population in the United States, found off Florida's east and west coasts, in the Caribbean, and off the pacific coast of Mexico. The green sea turtles were listed endangered under the United States Federal Endangered Species Act. They were also listed endangered facing a very high risk of extinction on the wild on the near future by the International Union for Conservation of Nature and Natural Resources on July 28, 1978. The greatest threat is from the commercial harvest for eggs and food. Other green turtle parts are used for leather and small turtles are sometimes stuffed for curios. Incidental catch in commercial shrimp trawling is an increasing source of mortality.

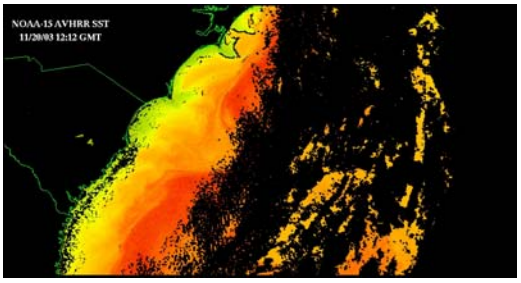

Figure 2.1

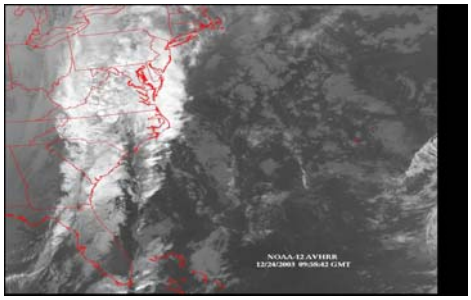

Figure 2.2

II. METHODS

A. Background

The goal of this study was to determine if there is a correlation between sea surface temperatures, chlorophyll concentrations, QuikSCAT wind data, and the presence of Caretta caretta and Chelonia mydas in the Mid-Atlantic. The data used in this study was Advanced Very High Resolution Radiometer (AVHRR) from the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellite and Sea-viewing Wide Field of View Sensor (SeaWiFS) from the OrbView-2 satellite. The images that were used covered a period from October 14, 2003 to January 26, 2004.

B. AVHRR SST Datasets

The Sea Surface temperature was derived from the processed AVHRR data. This data was located by using the Tera Capture Control, a software component of TeraScan 1.5 system, and then retrieved from the respective archived tapes. Each image was placed on a pass disk, for temporary storage, to be processed. Over 120 AVHRR images were processed. All images were corrected for noisy data, and then the function 'nitpix' was used to calculate the sea surface temperature. Upon viewing the 120 images in TeraVision approximately 40 were usable images. Figure 2.1 is an example of a usable image. The images that were not used had tremendous cloud coverage, as shown in figures 2.2. Because of the lack of usable images, The Physical Oceanography Distributed Active Archive Center (PO.DAAC) Jet Propulsion Lab website, http://poet.jpl.nasa.gov was used to collect the SST at the latitude and longitude of the sea turtles. Figure 2.3 is an example of an image from the Jet Propulsion Lab website that was used in this study.

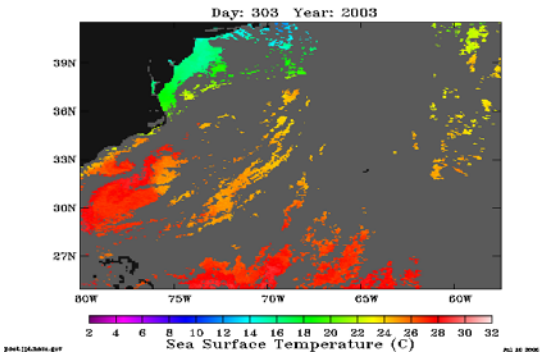

Figure 2.3

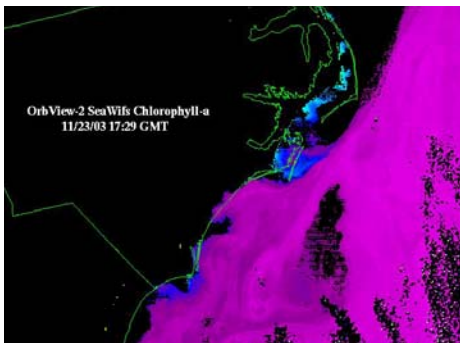

Figure 3.1

C. *SeaWiFS Chlorophyll Datasets*

Raw SeaWiFS data is broadcast as swcrpt and must be decrypted. Elizabeth City State University has an authorized delayed mode license to decrypt this data from the OrbView-2 satellite. These datasets were also located, retrieved and stored to a pass disk to be processed. Processing SeaWiFS data on the TeraScan system requires the use of the functions 'seawifsin'. The function 'swcolor' was used to implement the official SeaWiFS ocean color algorithms to derive chlorophyll amounts, pigment concentration, and aersol optical depth. Once the SeaWiFS data was processed, it was converted into chlorophyll data. Using TeraVision, to view the images, turtle points were plotted using the function point, according to their latitude and longitude to find the chlorophyll-a concentration. Figures 3.1 show an image of chlorophyll data.

D. *QuikSCAT Wind Datasets*

Wind data was found through the PO.DAAC Jet Propulsion Lab website, http://poet.jpl.nasa.gov, using QuikScat as the source. The SeaWinds instrument on the QuikScat satellite uses a specialized microwave radar that measures both the speed and direction of winds near the ocean surface. The instrument collects wind speed and wind direction data in a continuous 1,800-kilometer-wide band, making approximately 400,000 measurements each day.

E. *Visualizing with ArcGIS*

To create a visualization of where the sea turtles were located, we used ArcGIS. Before we were to use ArcGIS, turtle points were import from Field Trip Earth's website, http://www.fieldtripearth.com. A SST Geotiff was also imported from the Jet Propulsion website. Then a layer was created to visualize all turtle points. Figure 3.2 shows the coordinates of the loggerhead and green sea turtles.

F. *Analyzing the Data*

Pearson's Correlation was used to analyze the datasets. Pearson's correlation is used to determine if there is a correlation between two variables and the degree to which the variables are related. It ranges from +1 to -1. The software packages used to conduct the correlation was Minitab. Minitab is a graphical and statistical software package.

III. RESULTS

Previous studies have concluded that sea surface temperature and chlorophyll concentration play a significant role in the migration routes of sea turtles. In 2002, a research project entitled "A Determination of Temporal and Spatial Distribution, Migratory Patterns, and Habitats for Sea Turtles using AVHRR" was conducted. Results showed that loggerhead turtles prefer to remain within a given range of temperature. In 2003, this research was confirmed in the paper, "A Determination of Temporal and Spatial Distribution, Migratory Patterns, and Habitats for Sea Turtles using AVHRR." This study showed that turtles remain within a given range of temperature and concluded that a correlation exists between sea surface temperature and chlorophyll concentration.

In this study the green sea turtle remained in a general range throughout the study period. The average ranges of the temperature and the chlorophyll throughout the study area for the green turtle was respectively 18.7 to 25.32, and .29 to .6338mg/m ^{3}. It tends to stay in areas that are within this given range of temperature. Based on previous studies, the average for the loggerhead turtle is 28.33C, and 4.226mg/m ^{3}.

Our study on the loggerhead turtle indicated that he tends to stay in areas with sea surface temperatures ranging from an average of 19.38 to 25.70 and the chlorophyll concentration from .292 to .764mg/m ^{3}. In a previous study on the loggerheads there is not such a big difference. The averages of temperature and chlorophyll data on loggerhead turtles were respectively 28.33C, and 4.226mg/m ^{3}.

In our study, a correlation was not found between sea surface temperature and the chlorophyll levels according to the Pearson's correlation. There was also no correlation between sea surface temperature and the wind data. Figures 4.1 and 4.2 shows the correlation between sst with chlorophyll and sst and wind data for the loggerhead turtle, respectively. However previous research on the loggerhead indicates a correlation between these two factors. The lack of correlation may exist due to the number of turtles spotted on shore. Both turtles remained on shore for a considerable amount of time during our study period. Turtles spend most of their lives in the water. They only come to shore during nesting. Nesting seasons occur at different times around the world. In the United States, nesting occurs from April to October. In our study, turtles were spotted on shore at the end of the nesting period. They

were also spotted on shore during the months of November and December. In previous studies the turtles did not remain on

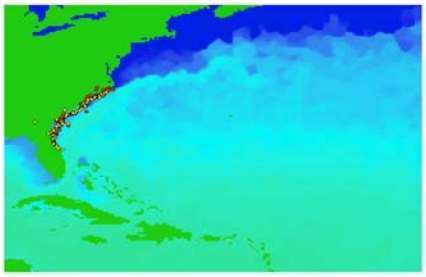

Figure 3.2

shore for long periods of time, but were always spotted in the water.

Green turtles mainly stay near the coastline and around islands and live in bays and protected shores, especially in areas with sea grass beds. Rarely are they observed in the open ocean. They nest at intervals of 2, 3, or more years, with wide year-to-year fluctuations in numbers of nesting females. Females nest between 3 to 5 times per season. She lays an average of 115 eggs in each nest, with the eggs incubating for about 60 days. Figure 4.3 shows the nesting location of this turtle.

Loggerhead turtle prefers to feed in coastal bays and estuaries, as well as shallow water along the continental shelves of the Atlantic, Pacific and Indian Oceans. Females nest at intervals of 2, 3, or more years. They lay 4 to 7 nests per season, approximately 12 to 14 days apart. They lay an average of 100 to 126 eggs in each nest. Eggs incubate for about 60 days. Most females nest at least twice during each mating season; some may nest up to times in a season.

DISCUSSION

Previous studies on the loggerhead turtle show that there is a correlation between sea surface temperature and chlorophyll concentrations. The nesting period of sea turtles may have affected the outcome of our data. The lack of correlation could be to the fact that many turtles were spotted on land. Because so many turtles were spotted on land, further studies should be conducted with a wider range of dates. A Similar study should be conducted to determine if there is a correlation.

ACKNOWLEDGMENT

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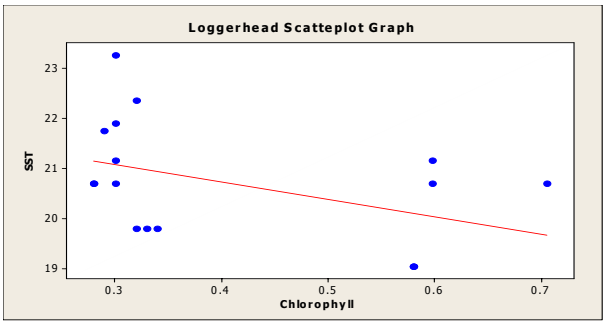

Figure 4.1

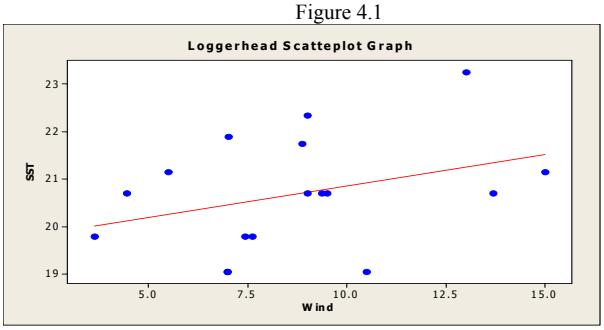

Figure 4.2

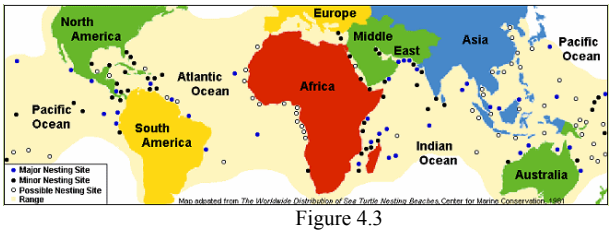

Figure 4.3

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