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Subject: Temperature study
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Attachments: [Utley Research Grant report.Mar 2010.pdf](#)

Larry,

Attached is a copy of the report that was submitted to Eastern National to fulfill the reporting requirements for the research grant. There are plans for completing the data analysis and submitting an article to a peer-reviewed journal later. That information would become available for distribution once the publication process is completed.



Utley Research Grant report.Mar 2010.pdf

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Robert M. Utley Research Grant

Final Report, March 2010

Submitted by: Michelle Bogardus & Eric Frey, Biological Science Technicians

“Estimating Hatchling Sex Ratios of relocated Loggerhead Sea Turtle (*Caretta caretta*) nests at Cape Hatteras National Seashore, NC”

Project Purpose and Objectives:

In 2007 Cape Hatteras National Seashore (CAHA) was the recipient of the above titled grant from Eastern National. This was to be a three year project with a projected completion date of December 2009. The objectives of this project were as follows: (1) To determine the levels of sand temperature variance on sea turtle nesting beaches within CAHA ranging from the northern most beaches at Bodie Island to the southern most beaches on Ocracoke Island, as well as the profile of these beaches ranging from the dunes to the high tide line; (2) To record levels of thermal variance between relocated sea turtle nests vs. nests left in-situ; (3) To determine if these temperature variances, if any is found, is significant enough to alter natural sex ratios of sea turtle hatchlings.

Study Design and Project Status:

From the original grant proposal to the culmination of the three-year study, many advances were made to the original project design, and the data created from this project has already led to a better understanding of turtle biology and management.

Throughout the study, temperature data loggers (HOBOS) were used in a two pronged approach.

Transects

HOBOS were attached to transponder balls (used for underground locating) and buried in line transects. There were three HOBOS per transect, with one at the dune line, one mid-beach, and one at the high tide line. There were five transects in all (Bodie Island, Bodie-Hatteras, North Hatteras, South Hatteras, and Ocracoke). This was designed to provide a baseline for northern, mid, and southern beaches on CAHA. For each year, transects were installed in the same area of beach. In some cases, transects could not be placed in the exact same locations as they were in 2007, due to beach erosion and concerns about the ability for recreational users to access the area. The transects, in these cases, were placed as close to the original site as possible (less than one mile).

Transects were installed on May 1, and were left in place until November 15th during all three years. Any data accumulated prior to May 1 and after November 15 was removed for standardization. These dates are different from the original project proposal, as it was determined that a nest could be laid as early as May 1, and nests could continue to incubate beyond November 1st. HOBOS were sometimes washed out due to storm activities. If the

HOBO was recovered, any data was still collected and uploaded to the date of wash out. Some HOBOS were not recovered (see Table 1.)

Table 1. Useable Transect Data (Y = Usable data, N = HOBOS was not recovered)

| | 2007 | | | 2008 | | | 2009 | | |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | High Tide | Mid Beach | Dune Line | High Tide | Mid Beach | Dune Line | High Tide | Mid Beach | Dune Line |
| Bodie Island | Y | N | Y | Y | N | Y | Y | Y | N |
| Bodie/Hatteras | Y | Y | Y | N | N | N | Y | Y | Y |
| North Hatteras | Y | Y | Y | Y | Y | Y | N | Y | Y |
| South Hatteras | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Ocracoke | Y | Y | Y | N | Y | Y | Y | Y | N |

Some examples of transect data are shown below. In Fig. 1, dune line transect HOBOS from 2007 are shown. In Fig. 2, high tide line transect HOBOS from 2007 are graphed. In both, you can see a correlation between beach latitude and temperature; northern beaches appear to be colder than southern beaches. Analysis will be done to determine any significant differences between each beach as well as temperature trends between high tide, mid-beach, and dune line areas.

Fig.1 – Transect data (dune line, 2007)

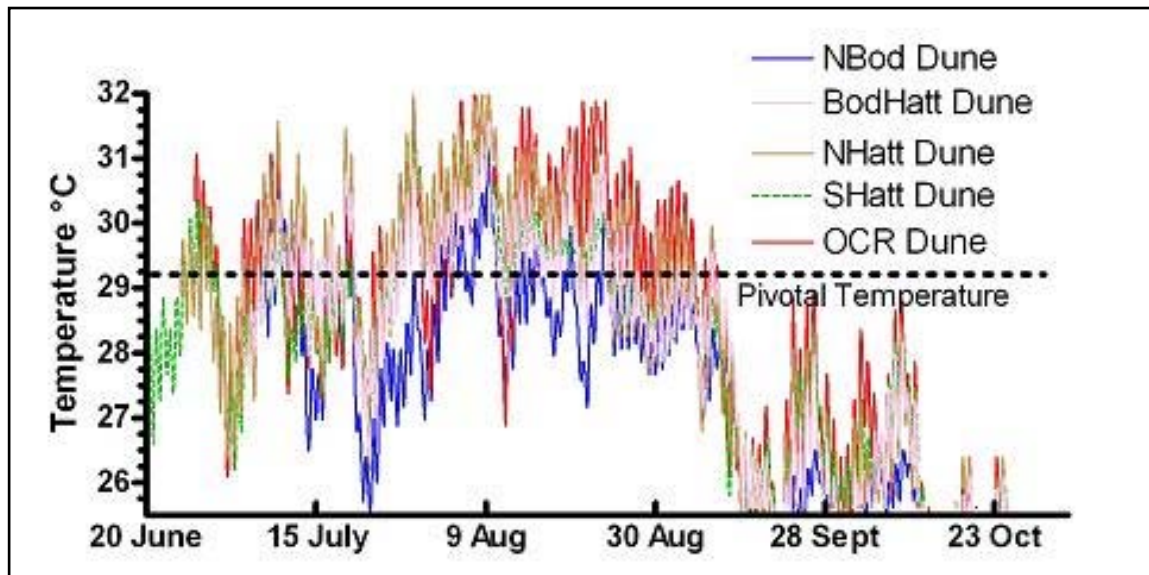
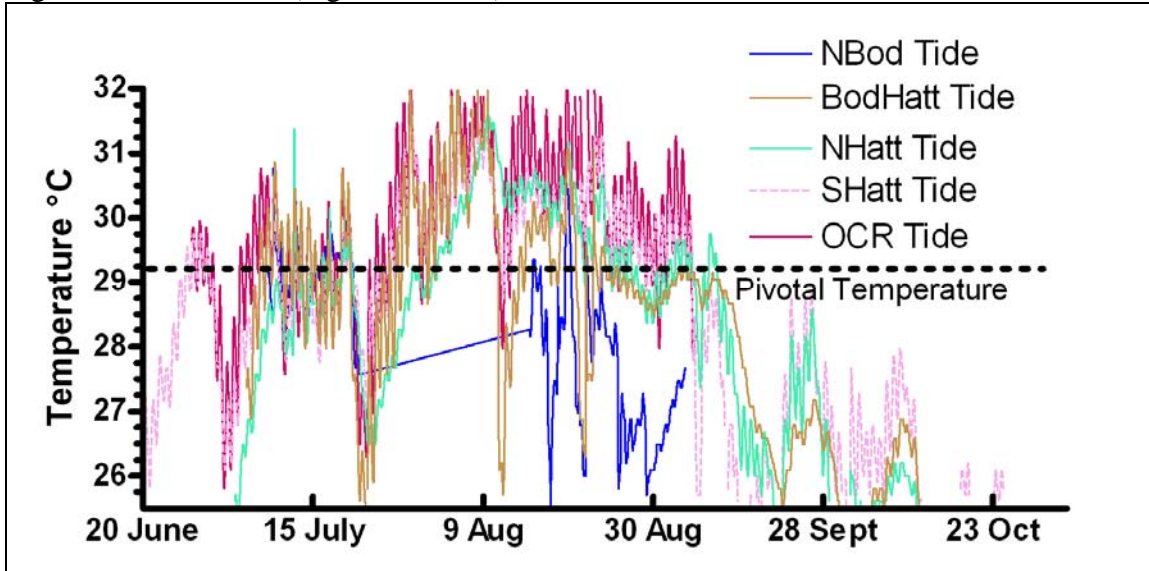


Fig. 2 – Transect data (high tide, 2007)



HOBOS within Nests

HOBOS were also placed within sea turtle nests. On the date the nests were located by turtle patrol, 10-15 eggs were removed from the nest and the HOBOS inserted near the middle of the egg chamber. The eggs were then replaced and recovered with sand. HOBOS were collected when the nest was excavated (2-5 days post-hatching) and uploaded for analysis.

It was not possible to collect temperature data for *all* nests laid on CAHA during the study years. A small percentage of the nests did not receive HOBOS due to HOBOS availability. Occasionally, nests also did not receive HOBOS due to the nest being found too late in the day to manipulate the eggs (State regulations dictate that nests found after 10 a.m. cannot be relocated or the eggs moved in any way). Temperature data was also not collected in a small percentage of nests that received HOBOS for reasons including HOBOS battery failure or the HOBOS being washed out by the ocean. Overall, we placed HOBOS in 250 of the 298 nests over the last three years (83.9%). The percentage of nests in each year and district that temperature data was collected is shown in Table 2.

Table 2. Nests by year and district with inserted HOBOS

| Year | District | Total Nests | Nests w/ HOBOS | % |
|-------|----------|-------------|-------------------|-------|
| 2007 | Bodie | 19 | 15 | 78.9 |
| | Hatteras | 35 | 34 | 97.1 |
| | Ocracoke | 28 | 25 | 89.3 |
| 2008 | Bodie | 13 | 11 | 84.6 |
| | Hatteras | 75 | 66 | 88.0 |
| | Ocracoke | 24 | 20 | 83.3 |
| 2009 | Bodie | 19 | 15 | 78.9 |
| | Hatteras | 53 | 42 | 79.2 |
| | Ocracoke | 32 | 22 | 68.8* |
| TOTAL | | 298 | 250 | 83.9 |

* Multiple battery failures were reported, resulting in a smaller percentage of HOBOS with usable data.

Both relocated nests and in-situ nests received HOBOS. In 2008, Matthew Godfrey, North Carolina Wildlife Resources Commission (NCWRC), Sea Turtle Biologist, suggested that nests that were relocated should also have a HOBOS placed in the original nest location to show the thermal difference between the spot the nest was laid and the spot the nest was moved to. However, it was found that when this was applied, the majority of the HOBOS at the original sites washed away and could not be recovered. Without being able to compare temperatures from original nest site and relocated nest sites, our second and third objectives of the project will be difficult to analyze. Instead, we will use transect data to determine if relocation of nests up the beach toward the dune line would have any significant effect on incubation temperatures and sex-ratios of nests.

After nests were excavated, HOBOS were recovered and uploaded. HOBOS were managed, installed, and uploaded by Eric Frey (CAHA). The data was then sent to Michelle Bogardus (CAHA) and Matthew Godfrey NCWRC for analysis. Data is continuing to be assessed. Between seasons, HOBOS were cleaned and re-calibrated by Matthew Godfrey and returned to CAHA prior to May 1.

Preliminary Findings:

Data from 2008 and 2009 is still in the process of being analyzed. 2007 data analysis has resulted in some interesting preliminary findings.

1. **Seasonal Variation:** Data shows that there is a significant seasonal variation in sand temperatures, with highest temperatures occurring from early August to early September. At this time, sand temperatures were above the “pivotal temperature,” or the temperature at which the sex ratio of hatchlings is 50% male, 50% female. This means that nests laid

in July, which reached their sex determination period in August, were more likely to produce females than males. Nests laid at any other time were more likely to produce males than females.

2. Beach Range: Data showed that the area at the base of the dune was significantly warmer than the mid-beach location. This indicates that nests relocated from a mid-beach location to the toe of the dune would result in approximately 25% more females than if the nest had been left in place, depending on the date at which it was laid.
3. Beach Differences: The data also indicated that there is a significant difference in beaches based on how far north or south they are. Beaches to the north (Bodie Island and Bodie Hatteras) had far cooler temperatures throughout the season, most likely resulting in a higher percentage of males per nest. Beaches to the south (Ocracoke and South Hatteras) were overall warmer than the northern beaches, but also had some differences due to whether the beach faced east-west or north-south. It was found that nests on South Hatteras, a beach that is distinctly east-west and therefore received a longer amount of sunlight per day, had proportionally warmer temperatures, most likely resulting in higher ratio of females.

Overall, the data indicates that moving nests toward the dune-line can result in a significant difference in hatchling sex ratios. This information supports the fact that relocation of nests is a good management tool that should be used when necessary, but also used cautiously so as to not alter the natural ratio of loggerhead hatchlings in the area over time. The data also shows that CAHA can expect a differentiation in the sex ratios between north and south beaches, as well as north-south beaches vs. east west beaches. Additionally, CAHA has learned what an important role seasonal temperature has in sex ratio determination. Together, this information will ultimately help CAHA in managing the nesting population of sea turtles with a better understanding of nesting biology and the effects of relocation as a management tool.

Example Data:

The following graphs (Fig. 1 - Fig. 3) are representative samples of the data collected. These illustrate the differences in nests laid on northern beaches, mid-latitude beaches, and southern beaches.

Fig. 3 - Nest on Bodie-Hatteras District (northern beach) in July, 2007

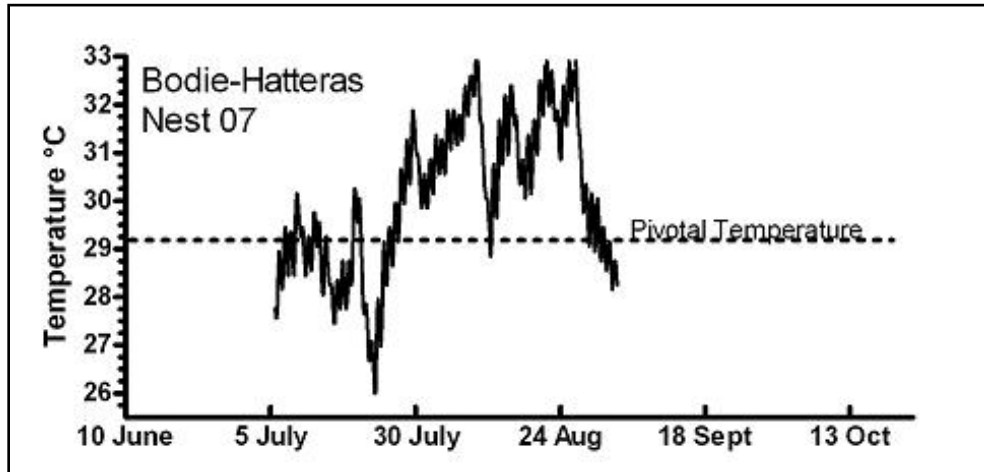


Fig. 4 - Nest on Hatteras District (mid-latitude beach) in July, 2007

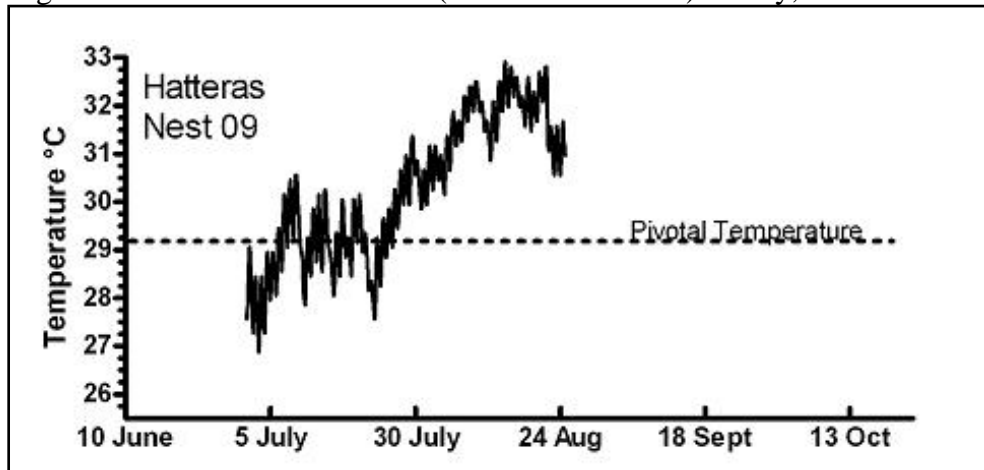
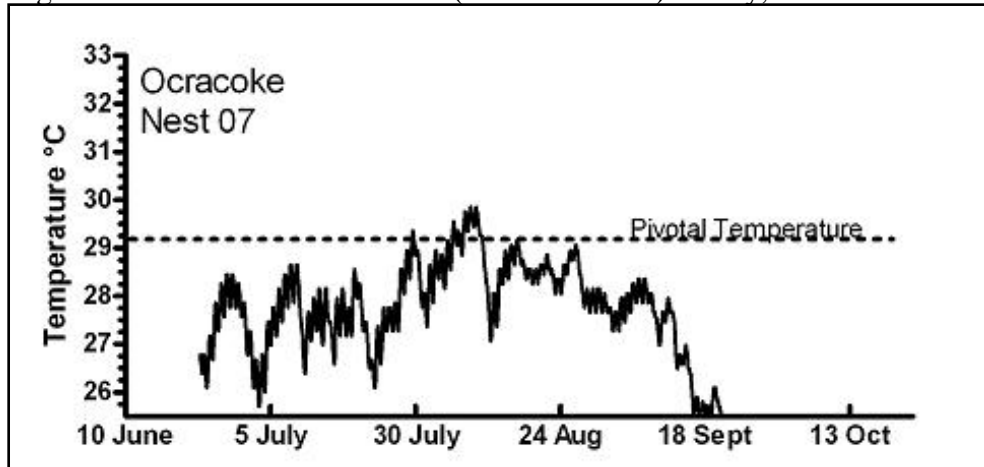


Fig. 5 - Nest on Ocracoke District (southern beach) in July, 2007



It would be expected that the nest in Fig. 3 would incubate at higher temperatures as it is more southern than those in Fig. 1 and Fig. 2, but this nest was laid at the high tide line, resulting in lower sand temperatures. The above trends are preliminary and will continue to be refined as additional data is analyzed.

Further Study

Although our three year commitment to Eastern Nationals grant has been completed, we will continue to follow the established protocol and continue data collection for upcoming years. We are considering installing additional transects along our shoreline to give us a better idea of temperature variances between beaches and shed light on turtle nest site selection. This data will also help in predicting if sex ratios would be different for each beach location.

When looking at the data, we will also be analyzing in detail the middle third period of incubation when sex determination in sea turtles occur. This data will ultimately determine the overall sex ratio of loggerhead hatchlings on CAHA over the study period.

A detailed statistical analysis of all the data from 2007, 2008, and 2009 will be compiled with the assistance of Matthew Godfrey, NCWRC. This analysis will be presented to CAHA as both an oral and written report. A copy will also be sent to Eastern National.