

2005 Sea Turtle Monitoring Project Report Bogue Banks, North Carolina

INTERIM REPORT



Leatherback nesting on Pine Knoll Shores in May 2005

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Introduction

The Sea Turtle Monitoring Project, initiated in 2002, was designed to observe and record sea turtle nesting activity on the island of Bogue Banks in Carteret County, North Carolina. The project area the ocean-facing beaches on Bogue Banks between the Atlantic Beach/Fort Macon State Park boundary and Emerald Isle at Bogue Inlet. Sea turtle nesting activities are recorded daily from May 1 through August 31, including research data relative to the effects of beach nourishment on sea turtle nesting: sand compaction, sand temperature, and nest temperature throughout the sea turtle nesting season.

A 50-year Shore Protection Project designed by the US Army Corps of Engineers (USACE) includes periodic sand renourishment to beaches on Bogue Banks. Phase I of the Bogue Banks Beach Restoration Project took place from November 2001 to April 2002. Dredge material was pumped onto the beaches of Pine Knoll Shores and Indian Beach, covering an area of approximately seven miles. Phase II, from January to April 2003, nourished the eastern half of Emerald Isle. Phase III, from February to April 2005, completed the renourishment of the western end of Emerald Isle. Additionally, dredge material was placed on Indian Beach and Salter Path, together with the extreme western end of Pine Knoll Shores, from February to March 2004. This activity was Phase I of "Project 933," a component of the Morehead City Harbor Federal Navigation Project that includes regular dredging of the harbor channel. Phase II of Project 933 was linked to the scheduled maintenance pump-out of Brandt Island (November 2004 through February 2005) that involves placing material on Fort Macon and Atlantic Beach every 8 years or so. Phase II was intended to spread the material from Ft. Macon through Pine Knoll Shores in December 2004 – April 2005. As reported in the *Survey Report 2005, Bogue Banks, North Carolina* for the Carteret County Shore Protection Office, "out of an estimated 2.9 million cubic yards placed, upward of 1.15 million cubic yards were lost (presumably into deeper water) because of presence of mud and very fine sand." For this reason, Phase II was not successfully completed in 2005, such that Pine Knoll Shores and the western quarter of Atlantic Beach did not receive any material.

The study of the effects of beach renourishment on sea turtle nesting was initiated following concern that the material placed on the beach during nourishment may be different from what originally existed on the nesting beaches. The differences in sediment may have negative impacts on sea turtle reproduction. For instance, characteristics such as sand compaction and sand temperature directly affect sea turtle nests. Sex determination in hatchlings is dependent upon the temperature at which nests incubate: higher temperatures yield greater numbers of females while cooler temperatures result in more male hatchlings (Wibbels 2004). Given that darker colors absorb more solar radiation, sediment used as beach fill could result in warmer nests if turtles lay their eggs in darker nourished sand (Hays et al. 2001). North Carolina is roughly the northern boundary of sea turtle nesting in the SE USA. North Carolina sand temperatures are cooler than those of more southerly states, thereby producing relatively more male hatchlings than more southerly states (Mrosovsky et al. 1984; Mrosovsky and Provancha 1992). Other potential impacts include the possibility that dark sediment could create nest temperatures that are too hot for successful incubation or that the nourished material is too compact for successful nest construction.

The goal of the study in the 2005 nesting season was to continue to collect information on sea turtle reproductive success on Bogue Banks, relative to nourishment activities.

Methods

The 2005 sea turtle monitoring season began May 1, 2005. Unlike the previous 3 nesting seasons, the project ATV was out of service and could not be used for daily patrols. Instead, the Bogue Banks Sea Turtle Biologist as well as local volunteers patrolled on foot, covering all sections of beach within the project area (from the eastern boundary of Atlantic Beach to the Western boundary of Emerald Isle). Patrols were conducted after daybreak in the early morning, to ensure that turtle tracks were discovered before being effaced by human footprints. Daily patrols concluded on August 31, although marked nests were regularly monitored for emergence through October.

Sea turtle nesting activity was recorded by both the Bogue Banks Sea Turtle Monitor and the volunteers. Information collected included date of activity, identification as a nest or a false crawl, location description, GPS coordinates, and species identification when possible. Nests were identified only after careful digging to confirm the presence of eggs in a body pit. The sand was carefully replaced on confirmed nests and marked by four wooden stakes, flagging tape and a Sea Turtle Protection Program sign. During incubation, each nest was monitored during the daily morning patrols for signs of disturbance and ocean washover. The Bogue Banks Monitor collected sand compaction readings at every nest and false crawl using a cone penetrometer (Field Scout SC-900). Three readings at depths of 6, 12, and 18 inches were taken at each south, east, north and west point surrounding a nest or at the turn in a false crawl.

To monitor nest temperatures during incubation, temperature dataloggers (Hobo Pendant-Temp, Onset Computer Corporation, USA) were buried in the center of select nests on the morning that the nests were first observed. For datalogger placement, some eggs were removed to create a pocket in the middle of the nest where the datalogger could sit. All eggs were replaced in the nest, with rotation of the eggs kept to a minimum to avoid early embryonic mortality.

Volunteers prepared for nest emergence on day 55 of incubation. A hatchling runway was constructed, consisting of built up sand edges lining a smooth track toward the ocean and marked with flagging tape to provide protection from curious beach walkers. Volunteers sat with nests after dark. Nest sitting provided protection for the hatchlings, especially in areas of bright ambient lighting. This time also allowed volunteers to interact with beach visitors and educate the public about sea turtles, nesting, and protection efforts.

After a minimum of 72 hours after the first hatchling emergence, each nest was excavated for evaluation of hatching success and to free any trapped live hatchlings within the nest cavity. Dataloggers were recovered at this time. Their data were downloaded to a computer for analyses. During the nest excavation the eggs were inventoried. The clutch total was calculated by adding the number of empty shells (ES) to the number of unhatched eggs (UH) and pipped eggs (PE). The number of dead hatchlings found in the nests was recorded as (DH). Live hatchlings found in the nests were released and allowed to crawl along the runway to the ocean. When hatchlings were injured or not yet fully developed, they were taken to the NC Aquarium at Pine Knoll Shores for rehabilitation and eventual release. The emergence success rate of each nest was calculated using the following formula:

$$(ES - DH) \div (ES + UH + PE) * 100 = \text{emergence success rate (\%)}$$

In addition to nest temperatures, the Sea Turtle Monitoring Project also collected sand temperature data from dataloggers buried at 6 transects along the island in different sections of beach: Atlantic Beach, Pine Knoll Shores, and Emerald Isle. At each transect, the dataloggers recorded sand temperature at high and low locations along the beach, at 45cm depth

(corresponding to mid turtle nest depth), from May to September 2005. Dataloggers were removed from the sand transects in early September in anticipation of Hurricane Ophelia. The majority of sea turtle nests were laid in the zone encompassed by the high and low sites. Also, two dataloggers were placed in the sand at mid-nest depth on Bear Island (Hammocks Beach State Park), which lies west of Emerald Isle, across Bogue Inlet. Because all beaches on Bogue Banks had been nourished since the monitoring project began, the thermal environment of Bear Island could be considered as a “control” as its beaches have never been nourished. There were insufficient dataloggers available to monitor nest temperatures on Bear Island.

2005 Season Results

Nest Activity and nesting success

In the 2005 monitoring season, 36 sea turtle nests were laid on the island of Bogue Banks. Of these nests, 33 were laid by loggerheads (*Caretta caretta*), 2 by leatherbacks (*Dermochelys coriacea*), and 1 by a green turtle (*Chelonia mydas*). In addition to the 36 confirmed nests, 23 false (or non-nesting) crawls were reported on Bogue Banks. Fort Macon State Park on the eastern most end of Bogue Banks reported 3 confirmed loggerhead nests and no false crawls.

Table 1. Loggerhead nests and false crawls on Bogue Banks, NC

Season	Nests	False Crawls	Ratio
2002	19	19	1:1
2003	38	80	1:2
2004	21	20	1:1
2005	33	23	3:2

The ratio of nests to false crawls for loggerhead turtles in 2005 was 3:2, which was relatively different from previous years (Table 1). Although loggerhead turtles are reported to exhibit a roughly 1:1 ratio of nests to false crawls (Dodd, 1988), the ultimate factors driving the behavior of nest site selection (or rejection) remain unknown (Miller et al. 2003). Emerald Isle had the greatest number of false crawls in 2005 (Table 2).

Table 2. Turtle activity on Bogue Banks in 2005

Beach area	False crawls	Nests	Hatchling emergence success
Atlantic Beach	2	3	30.1%
Pine Knoll Shores	4	15	73.1%
Indian Beach / Salter Path	2	4	43.6%
Emerald Isle	15	14	30.3%
Bogue Banks	23	39	49.6%

The majority of nests were laid in Pine Knoll Shores and Emerald Isle (Table 2). Hatchling emergence success was reduced in 2005 relative to 2004, primarily due to egg loss associated with Hurricane Ophelia: 11 nests were either washed away or severely flooded in September 2005. Nests in Atlantic Beach were laid in a nourished area that was high in mud content that contributed to the reduced hatchling emergence success (Figure 1, Appendix I).



Figure 1. Heavy mud content in material placed on Atlantic Beach during 2004/2005 nourishment project.

Sand Temperatures

Sand temperature data were collected from 4 of 6 transects, as the dataloggers in the eastern end of Atlantic Beach and the western end of Emerald Isle were lost to erosion associated with storm surge. Sand temperatures on Bogue Banks were cool ($<25^{\circ}\text{C}$) at the start of the 2005 nesting season, and warmed rapidly in June to reach normal temperatures ($\sim 30^{\circ}\text{C}$, Figure 2). The sand temperature at nest depth displayed variation in July, August and September, associated with heavy rain or storm surge events that rapidly cooled sand temperature. All dataloggers were pulled from the beach on 11 September 2005, just prior to the passing of Hurricane Ophelia.

The intention was to use sand temperature data of Bear Island, located west of Emerald Isle, across Bogue Inlet, for comparison with data from Emerald Isle. Unfortunately, one datalogger from Bear Island was lost and the second failed mid-way during the nesting season, so no sand temperature data were available from a non-nourished area for comparison.

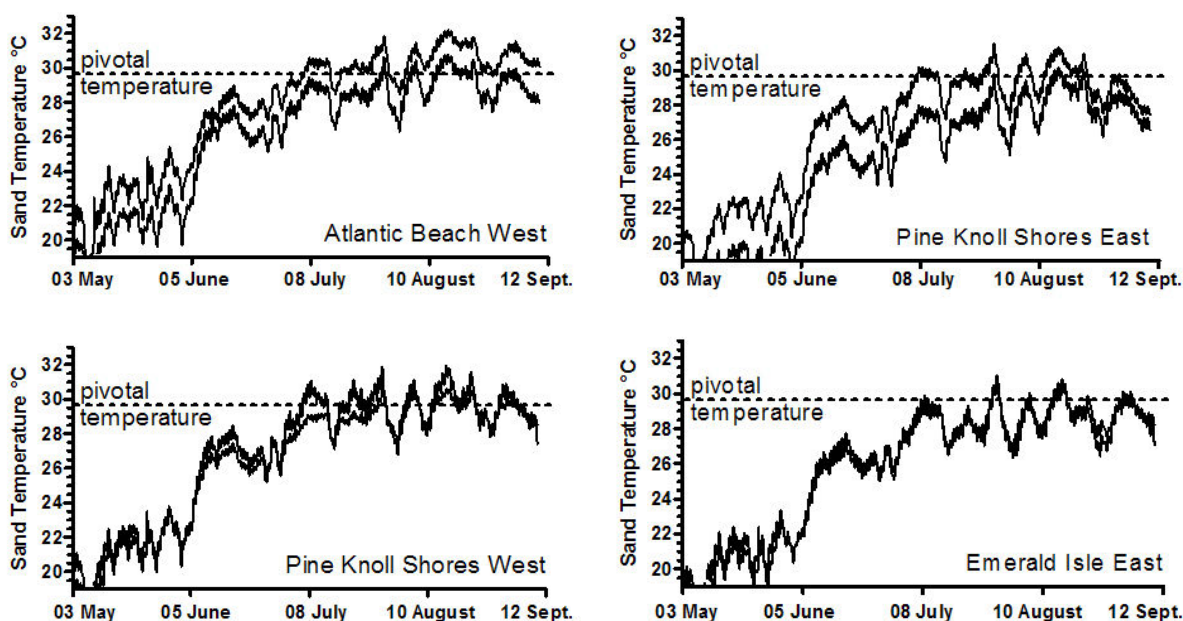


Figure 2. Sand temperatures at sea turtle nest depth on Bogue Banks during the 2005 nesting season. Each graph represents temperatures at middle and upper zones of the beach (lower and upper lines, respectively). Dotted line represents pivotal temperature of loggerheads in North Carolina (Mrosovsky 1988)

Nest Temperatures

Dataloggers were placed in 25 nests to record incubation temperature during the nesting season. Four of the dataloggers were lost when the incubating nests were washed away during Hurricane Ophelia. An additional 5 dataloggers were in nests that did not successfully complete incubation. The remaining 16 dataloggers revealed that the nests experienced variable temperatures throughout incubation, with drops in temperature associated with heavy rainfall or high overwash from ocean storm events (Figure 3). By the 2005 nesting season, all zones of Bogue Banks had undergone renourishment, making direct comparisons of nest temperatures from nourished and nonnourished areas impossible.

In indirect measure of nest temperature is incubation period, as warmer temperatures result in shorter incubation periods and vice versa (Godfrey and Mrosovsky 1997). To control for seasonal variation in sand temperatures (Figure 2), we compared the incubation periods of nests from Bear Island and Emerald Isle that were laid within 6 days of each other. The small sample size made statistical comparison impossible. Nevertheless, a trend was visible with nests on Bear Island (non-nourished) having longer incubation periods than nests on Emerald Isle (nourished), which is consistent with data from previous years that suggest that nourished sand is warmer due to its darker color.

Table 3. Incubation periods of loggerhead nests laid on Bear Island and in Emerald Isle

Beach	Average Incubation Period	Sample size
Bear Island	58 days	2
Emerald Isle	56 days	2

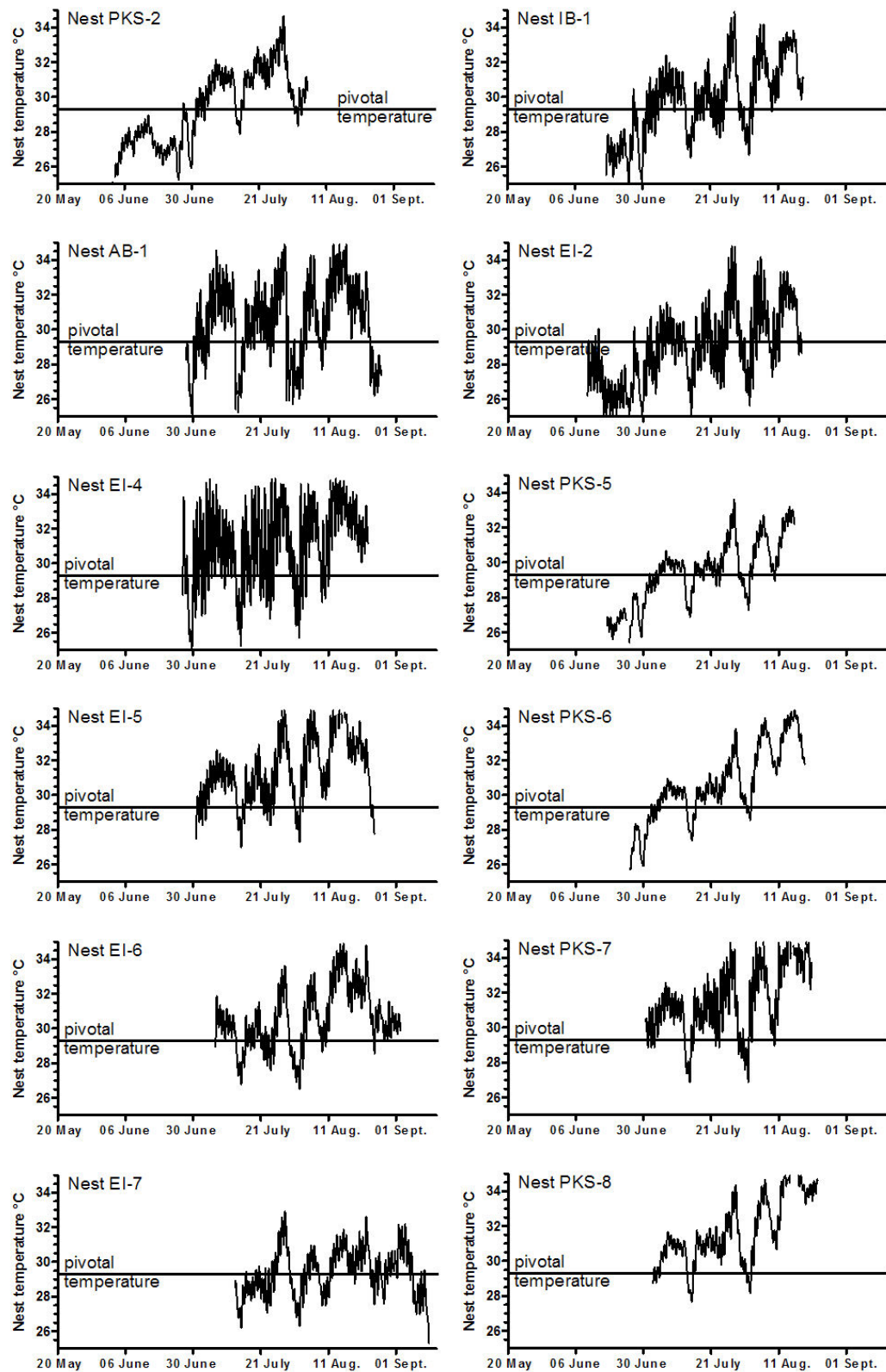


Figure 3. Loggerhead nest temperatures during incubation on Bogue Banks in 2005. Horizontal line represents pivotal temperature for NC loggerheads (Mrosovsky 1988). See Appendix II for full details of each nest.

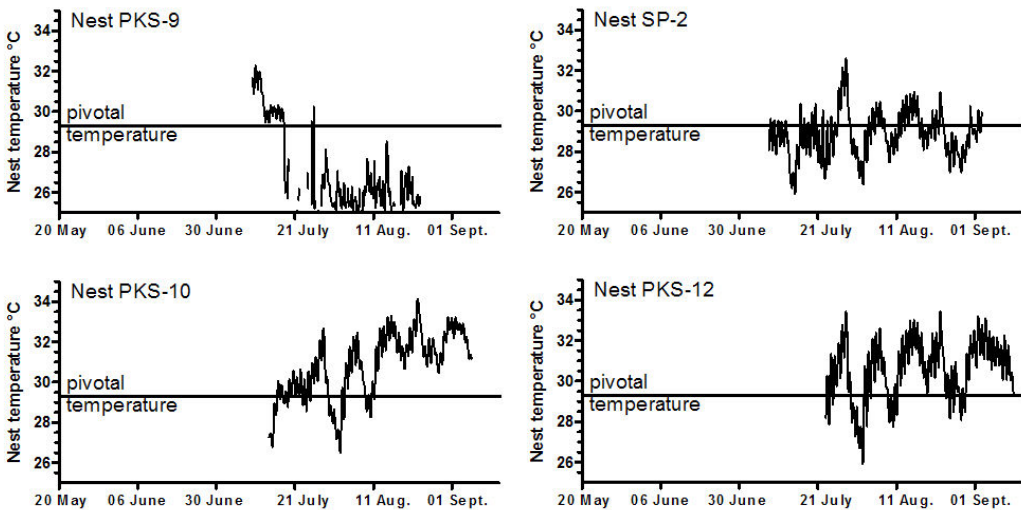


Figure 3 continued.

Sand Compaction

Unlike previous years in this study, there were no nonnourished zones on Bogue Banks in 2005. Therefore, there are no comparisons of compaction data between nourished and non-nourished areas. However, the compaction data from various nests and false crawls show considerable variation across Atlantic Beach, Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle (Figures 4-8), and generalizations can be made about the sand compaction data collected near nests and false crawls in 2005.

It was often impossible to reach the intended maximum depth of 18 inches with the compaction meter. This is shown by the lack of data at 18 inches depths in Figures 4-7, and may reflect the high level of compaction of the substrate or the presence of small shells, stones or other debris that impeded the compaction meter. It is also possible that compaction meter itself is not suitable for measuring at depths >12 inches on the beach. Note that it is thought that compaction measured on a vertical axis with a penetrometer does not adequately mimic sand resistance encountered by turtles that dig at non-vertical angles with their rear flippers when constructing a nest (Davis et al. 1999).

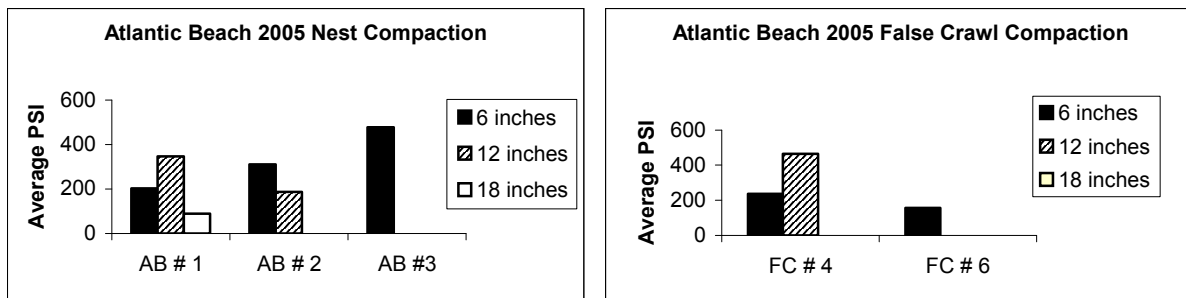


Figure 4: Sand compaction measurements taken at sea turtle nests and false crawls in Atlantic Beach.

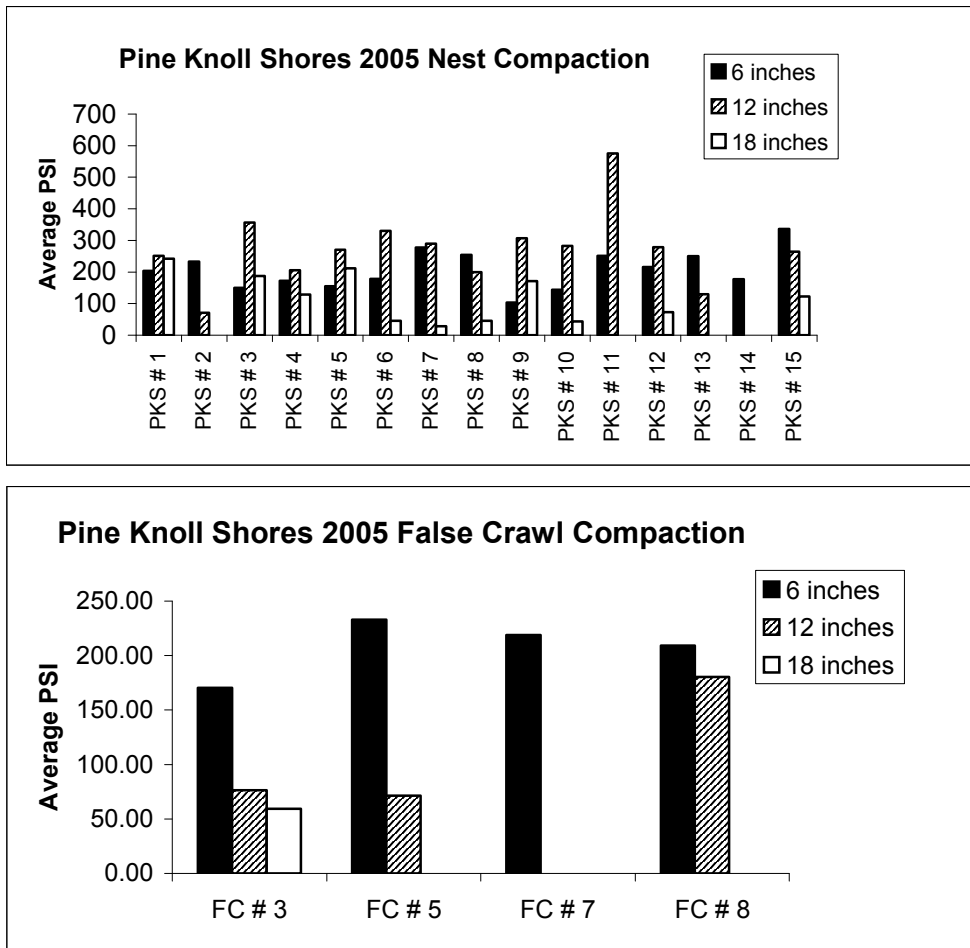


Figure 5: Sand compaction measurements taken at sea turtle nests (top) and false crawls (bottom) in Pine Knoll Shores.

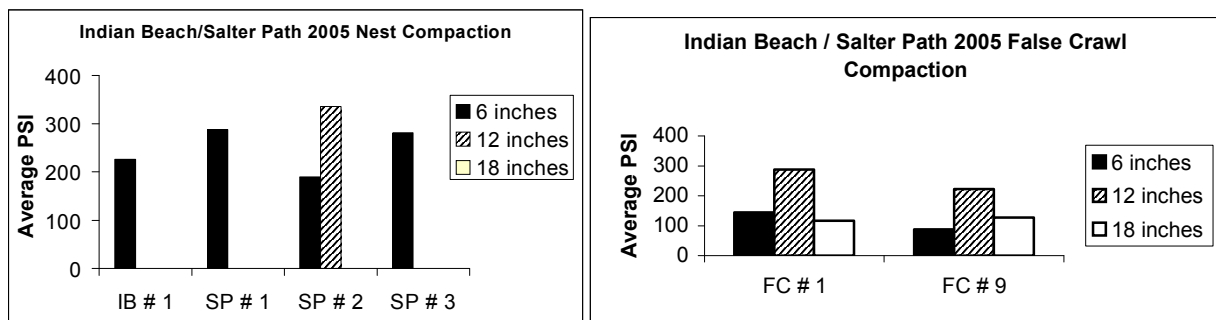


Figure 6: Sand compaction measurements taken at sea turtle nests and false crawls in Indian Beach/Salter Path.

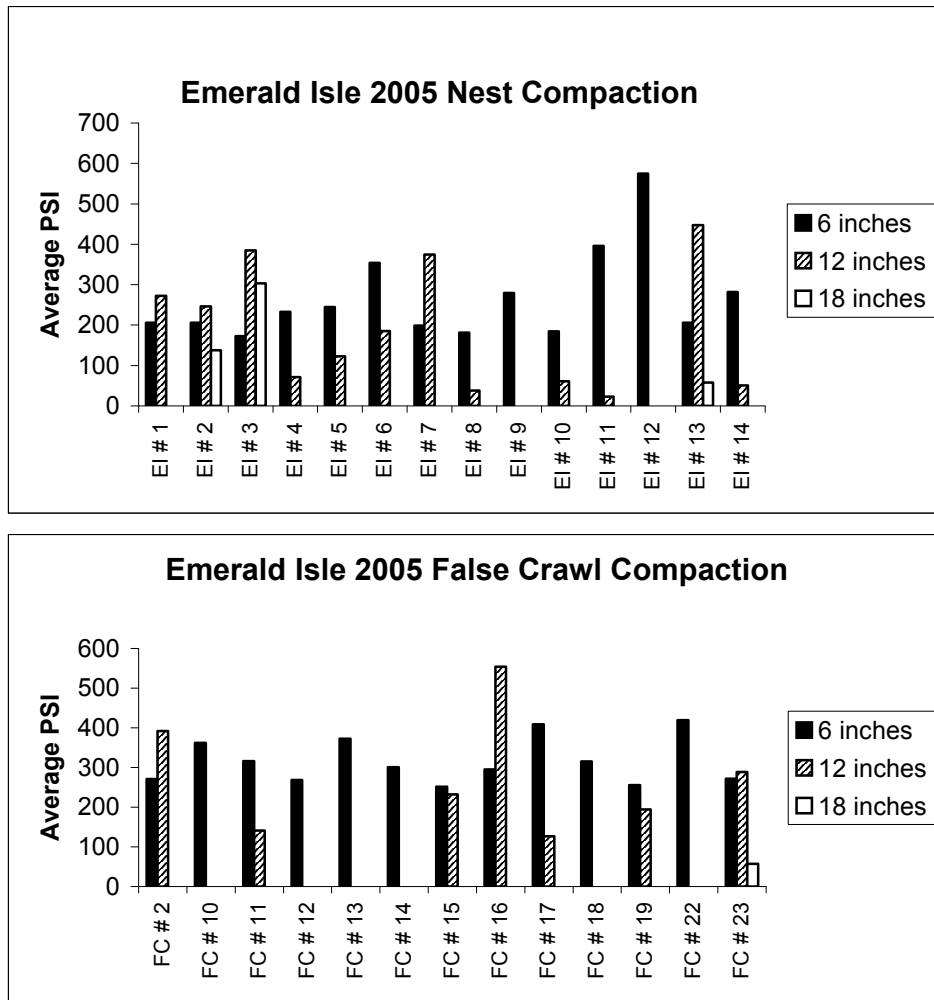


Figure 7: Sand compaction measurements taken at sea turtle nests (top) and false crawls (bottom) in Emerald Isle.

Regardless of the total compaction scores of the different nests, most nests were successful in producing viable hatchlings. The primary cause of nest failure was inundation due to storm surge. However, the three nests laid in Atlantic Beach appeared to have been affected by the heavy muddy sediment in which they were incubating – this sediment was placed on the beach during the nourishment project in early 2005 (Appendix I).

Another effect of the 2005 nourishment project in Atlantic Beach was the post-project formation of severe escarpments (some reaching >2 meters) just above the swash zone several hundred meters to the west of Atlantic Beach Circle (Figure 8). Consultation among NC Wildlife Resources Commission, Atlantic Beach Public Works and the US Army Corps of Engineers resulted in limited bulldozing to level the escarpments to approximately 45° angle in June. This action made it possible for turtles to crawl up the beach in this area and also reduced the possibility of accidental injury to beach visitors.



Figure 8: Steep escarpment on Atlantic Beach in May 2005.

Conclusion

The 2005 nesting season comprised the fourth consecutive monitoring period for this study on the impact of beach nourishment on sea turtles on Bogue Banks. In the 2005 season an increase was observed in the number of nests laid on Bogue Banks compared with those laid in 2004. And the results were consistent with previous years in that sea turtle nests were laid in nourished zones (all of Bogue Banks by the 2005 season) and successfully produced hatchlings.

In December 2005 a bid was submitted to the US Army Corps of Engineers for a Section 933 project that would place sand dredged from the ocean bar of the Morehead City Harbor along the shoreline of Pine Knoll Shores (Rudolph, Beach News, 12/21/05). If completed by the start of the 2006 monitoring season impacts from this nourishment project will be assessed in the 2006 Sea Turtle Monitoring Project Report.

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Appendix I – Fate of Sea Turtle Nests on Atlantic Beach, Bogue Banks

Account of sediment quality at Atlantic Beach nest sites following Brandt Island pump-out and Project 933 Phase II renourishment projects

Three loggerhead sea turtle nests were laid in Atlantic Beach on Bogue Banks in the 2005 nesting season following beach renourishment. All three nests were laid in the nourished material that was placed on the beach in early 2005. The success of all three nests appeared to have been affected by the new sediment on the beach. The following accounts describe the conditions of each nest and nest location.

Nest AB1: Towards the end of incubation, a depression was observed in the center of the AB1 nest, indicating that some movement had occurred in the nest cavity. This is usually an indication of impending emergence of hatchlings from the nest. After three days, there were no signs of emergence, and the nest was opened artificially to check on its status. Upon excavation, there was dark, thick, and heavy sediment overlying the top of the nest cavity. This clay-like material was difficult to dig into and likely too dense for loggerhead hatchlings to penetrate prior to emergence. The Sea Turtle Monitor, Kristin Holloman, assisted by volunteer, Carolyn Giles, removed large clumps of sediment before reaching the first live hatchling. The turtle was carefully removed and placed on the beach. Eight more hatchlings were found trapped in the thick sediment and were removed from the nest in a manner similar to the first. Upon removing nine hatchlings and loosening the nest sediment, the nest began to ‘boil’ with 55 additional live and energetic loggerhead hatchlings emerging from the nest and moving down the beach. Six more turtles were removed from deep within the nest chamber; these were considered too weak and lethargic for immediate release, so they were taken to the NC Aquarium at Pine Knoll Shores for rehabilitation. Out of 109 eggs that were inventoried in AB1 there were 34 unhatched eggs, 10 dead hatchlings, 5 dead pipped eggs, and a total of 70 empty eggshells (55.05% hatch success). It is likely that had the nest not been opened artificially, few if any of the hatchlings would have survived.

AB2: This nest was located just west of the Triple S Pier in Atlantic Beach. The nest crawl was observed on June 28, 2005, and consisted of three abandoned nesting attempts in addition to the final successfully laid nest. The first two abandoned nest attempts were quite shallow and seemed to reflect that the female used little efforts to dig. The third attempt was seemingly more aggressive. The attempted hole, although quite shallow, was noticeably deeper than the first two, and was in the middle of a ‘mud ball’. The final nest was laid at a depth of 20 inches to the top of the sand. Significant erosion occurred immediately in front of (ocean side) this nest, creating a V-shaped cut into the sand directly toward the nest. After 58 days of incubation, 1 hatchling emerged from the nest on its own and 17 more emerged when volunteers were not present. Three days later, during nest excavation, Kristin Holloman and volunteers discovered that the same muddy, clay-like sediment had impeded 16 other live hatchlings from reaching the surface of the nest chamber. Large mud balls were removed from the nest, allowing the live hatchlings to work themselves free from the sediment. Three more hatchlings were found dead and 1 dead pipped egg was discovered. There were 53 unhatched eggs remaining in the nest chamber. Volunteers continued to monitor the nest site following the excavation and no new emergences were noted. While hatchlings from nest AB2 were more successful at emerging on their own

than those of nest AB1, it is likely that the sediment placed on Atlantic Beach was negatively impacting the hatchlings produced in this nest.

Nest AB3 was laid east of Atlantic Beach Circle, and did not produce any live hatchlings. When excavated after 80 days incubation, we found 85 unhatched, decomposing eggs and 13 dead pipped eggs (eggs containing developed turtles that had attempted to emerge from the egg prior to death). The dead pipped eggs indicated that at least some of the eggs were fertile and therefore environmental factors likely contributed to the lack of success of this nest. At the time of excavation, the AB3 nest was found to have four to five inches of standing water in the bottom of the nest cavity, likely due to increased tidal overwash from Hurricane Ophelia on September 13 and 14. It is possible that the sediment associated with the nourishment project created conditions for the standing water to remain in the nest cavity. Sea turtle eggs can survive brief periods of inundation during incubation, but cannot withstand long-term exposure to standing water in the nest cavity.

Appendix II – Sea Turtle Nest Data from Bogue Banks.

Atlantic Beach

nest number	location	date laid	date of emergence	incubation period (days)	empty shells	unhatched eggs	pipped eggs (dead)	Dead hatchlings	live hatchlings	clutch total	hatch success rate
AB 1	711 Ocean Ridge	6/6/2005	8/1/2005	56	70	34	5	10	70	109	55.05%
AB 2 *	Club Colony Rd	6/28/2005	8/27/2005	60	34	53	1	3	2	88	35.23%
AB 3 *	Greenville Avenue	7/7/2005	~~~~~	~~~~~	0	85	13	0	0	98	0.00%
										Total	30.09%

Pine Knoll Shores

nest number	location	date laid	date of emergence	incubation duration (days)	empty shells	unhatched eggs	pipped eggs (dead)	dead hatchlings	live hatchlings	clutch total	hatch success rate
PKS 1	131 Dogwood (leatherback)	5/16/2005	~~~~~	~~~~~	0	67	0	0	0	67	0.00%
PKS 2 *	Memorial Park	5/31/2005	8/2/2005	63	124	4	0	1	15	128	96.09%
PKS 3	185 Salter Path Rd	6/5/2005	8/3/2005	59	142	4	0	0	1	146	97.26%
PKS 4	443 Maritime Place	6/7/2005	8/3/2005	57	139	15	0	0	1	154	90.26%
PKS 5 *	Ocean Terrace	6/19/2005	8/16/2005	58	67	22	4	0	12	93	72.04%
PKS 6 *	Ocean Park	6/26/2005	8/19/2005	54	101	13	0	0	1	114	88.60%
PKS 7 *	Hammer Park	7/1/2005	8/21/2005	51	71	4	0	0	1	75	94.67%
PKS 8 *	E Hammer Park	7/3/2005	8/23/2005	51	112	11	0	0	1	123	91.06%
PKS 9 *	Knollwood Drive	7/10/2005	8/30/2005	51	88	19	0	0	4	107	82.24%
PKS 10 *	Genesis East	7/14/2005	9/6/2005	54	110	0	0	1	1	110	99.09%
PKS 11 *	Royal Pavillion	7/15/2005	9/5/2005	52	110	5	0	0	4	115	95.65%
PKS 12 *	Bogue Shore Club	7/23/2005	9/11/2005	50	79	2	1	0	67	82	96.34%
PKS 13 *											
+	Ocean Glen East	7/26/2005	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	0.00%
PKS 14 *											
+	Ocean Park	7/28/2005	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	0.00%
	Trinity Center (green)										
PKS 15		8/9/2005	9/30/2005	52	30	2	0	0	2	32	93.75%
										Total	73.14%

* indicates buried datalogger
 ~~~~~ indicates data not available  
 + indicates nests lost by storms

## Indian Beach/Salter Path

| nest<br>number | location                         | date<br>laid | date of<br>emergence | incubation         |                 | pipped            |                          |                    | hatch              |                 |                 |
|----------------|----------------------------------|--------------|----------------------|--------------------|-----------------|-------------------|--------------------------|--------------------|--------------------|-----------------|-----------------|
|                |                                  |              |                      | duration<br>(days) | empty<br>shells | unhatched<br>eggs | pipped<br>eggs<br>(dead) | dead<br>hatchlings | live<br>hatchlings | clutch<br>total | success<br>rate |
| IB 1 *         | Ocean Club                       | 6/19/2005    | 8/19/2005            | 61                 | 114             | 25                | 0                        | 0                  | 5                  | 139             | 82.01%          |
| SP 1 *         | Big Oak                          | 6/19/2005    | ~~~~~                | ~~~~~              | 0               | 92                | 0                        | 0                  | 0                  | 92              | 0.00%           |
| SP 2 *         | Oak Grove Hotel<br>E of SP beach | 7/8/2005     | 9/3/2005             | 57                 | 125             | 8                 | 0                        | 2                  | 6                  | 133             | 92.48%          |
| SP 3 *         | + access                         | 7/8/2005     | ~~~~~                | ~~~~~              | ~~~~~           | ~~~~~             | ~~~~~                    | ~~~~~              | ~~~~~              | ~~~~~           | 0.00%           |
|                |                                  |              |                      |                    |                 |                   |                          |                    |                    | <b>Total</b>    | <b>43.62%</b>   |

## Emerald Isle

| <i><b>Emerald</b></i> | <i><b>Isle</b></i> | incubation                                 |           |                   |                 |              |                |             |            |       |            | pipped                          |        | dead         |  | live |  | clutch |  | hatch |
|-----------------------|--------------------|--------------------------------------------|-----------|-------------------|-----------------|--------------|----------------|-------------|------------|-------|------------|---------------------------------|--------|--------------|--|------|--|--------|--|-------|
| nest                  | number             | location                                   | date laid | date of emergence | duration (days) | empty shells | unhatched eggs | eggs (dead) | hatchlings | dead  | hatchlings | live                            | total  | success rate |  |      |  |        |  |       |
| EI 1                  |                    | Sea Dunes (leatherback)                    | 5/27/2005 | 8/22/2005         | 87              | 35           | 56             | 5           | 2          | 11    | 96         | 34.38%                          |        |              |  |      |  |        |  |       |
| EI 2                  | *                  | 10119 Sea Breeze                           | 6/13/2005 | 8/18/2005         | 66              | 154          | 6              | 2           | 0          | 132   | 162        | 95.06%                          |        |              |  |      |  |        |  |       |
| EI 3                  | *                  | Beachview Rd                               | 6/13/2005 | ~~~~~             | ~~~~~           | 0            | 92             | 0           | 0          | 0     | 92         | 0.00%                           |        |              |  |      |  |        |  |       |
| EI 4                  | *                  | 6907 Ocean Drive                           | 6/27/2005 | 8/23/2005         | 57              | 88           | 14             | 1           | 0          | 0     | 103        | 85.44%                          |        |              |  |      |  |        |  |       |
| EI 5                  | *                  | Fairfax                                    | 7/1/2005  | 8/25/2005         | 55              | 95           | 7              | 3           | 7          | 0     | 105        | 83.81%                          |        |              |  |      |  |        |  |       |
| EI 6                  | *                  | B/T 2nd & 3rd Street                       | 7/7/2005  | 9/2/2005          | 57              | 96           | 4              | 0           | 0          | 0     | 100        | 96.00%                          |        |              |  |      |  |        |  |       |
| EI 7                  | *                  | Howe Street                                | 7/13/2005 | 9/11/2005         | 60              | 31           | 43             | 1           | 19         | 12    | 75         | 16.00%                          |        |              |  |      |  |        |  |       |
| EI 8                  | *                  |                                            |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | 313 Ocean Drive                            | 7/13/2005 | ~~~~~             | ~~~~~           | ~~~~~        | ~~~~~          | ~~~~~       | ~~~~~      | ~~~~~ | ~~~~~      | 0.00%                           |        |              |  |      |  |        |  |       |
| EI 9                  |                    | Hubert Street                              | 7/14/2005 | 9/12/2005         | 60              | 116          | 5              | 0           | 99         | 17    | 121        | 14.05%                          |        |              |  |      |  |        |  |       |
| EI 10                 | *                  |                                            |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | B/T 1st & 2nd Street                       | 7/25/2005 | ~~~~~             | ~~~~~           | ~~~~~        | ~~~~~          | ~~~~~       | ~~~~~      | ~~~~~ | ~~~~~      | 0.00%                           |        |              |  |      |  |        |  |       |
| EI 11                 |                    |                                            |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | Bryan Street                               | 7/31/2005 | ~~~~~             | ~~~~~           | ~~~~~        | ~~~~~          | ~~~~~       | ~~~~~      | ~~~~~ | ~~~~~      | 0.00%                           |        |              |  |      |  |        |  |       |
| EI 12                 |                    |                                            |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | 1607 Ocean Drive                           | 8/4/2005  | ~~~~~             | ~~~~~           | ~~~~~        | ~~~~~          | ~~~~~       | ~~~~~      | ~~~~~ | ~~~~~      | 0.00%                           |        |              |  |      |  |        |  |       |
| EI 13                 |                    |                                            |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | Third Street Park                          | 8/5/2005  | ~~~~~             | ~~~~~           | ~~~~~        | ~~~~~          | ~~~~~       | ~~~~~      | ~~~~~ | ~~~~~      | 0.00%                           |        |              |  |      |  |        |  |       |
| EI 14                 |                    |                                            |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | Live Oak Street                            | 8/11/2005 | ~~~~~             | ~~~~~           | ~~~~~        | ~~~~~          | ~~~~~       | ~~~~~      | ~~~~~ | ~~~~~      | 0.00%                           |        |              |  |      |  |        |  |       |
| *                     |                    | indicates buried datalogger                |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| ~~~~~                 |                    | indicates data not available               |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
| +                     |                    | indicates nests/dataloggers lost by storms |           |                   |                 |              |                |             |            |       |            |                                 |        |              |  |      |  |        |  |       |
|                       |                    |                                            |           |                   |                 |              |                |             |            |       |            | <i><b>Total</b></i>             | 30.34% |              |  |      |  |        |  |       |
|                       |                    |                                            |           |                   |                 |              |                |             |            |       |            | <i><b>Bogue Banks Total</b></i> | 49.63% |              |  |      |  |        |  |       |