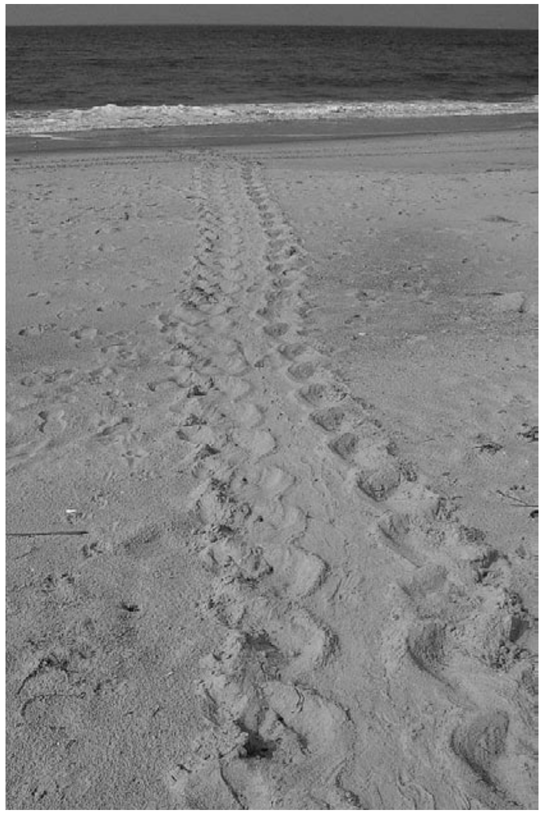
Sea Turtle Monitoring Project Report
Bogue Banks, North Carolina



Loggerhead turtle crawl on Atlantic Beach, NC

2002-2007 Final Report

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NC Wildlife Resources Commission
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Introduction

The study of the effects of beach renourishment on sea turtle nesting on Bogue Banks was initiated following concern that material placed on the beach may be different from what originally existed on the nesting beaches. Differences in sediment may have negative impacts on sea turtle reproduction. For instance, sand temperatures directly affect sea turtle nests: sex determination in hatchlings is dependent upon the temperature at which nests incubate, with higher temperatures yielding greater numbers of females while cooler temperatures result in more male hatchlings (Wibbels 2004). If nourished material is darker than natural material, then nourished beaches could result in warmer nests if turtles lay their eggs in darker nourished sand, as darker sand absorbs more solar radiation (Hays et al. 2001). This is of particular concern as 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 & Provancha 1992; Hanson et al. 1998, Hawkes et al. 2007). Other potential impacts include the possibility that dark sediment could create nest temperatures that are too hot for successful embryonic development (Matsuzawa et al. 2002) or that the nourished material is too compact for successful nest construction by adult female sea turtles.

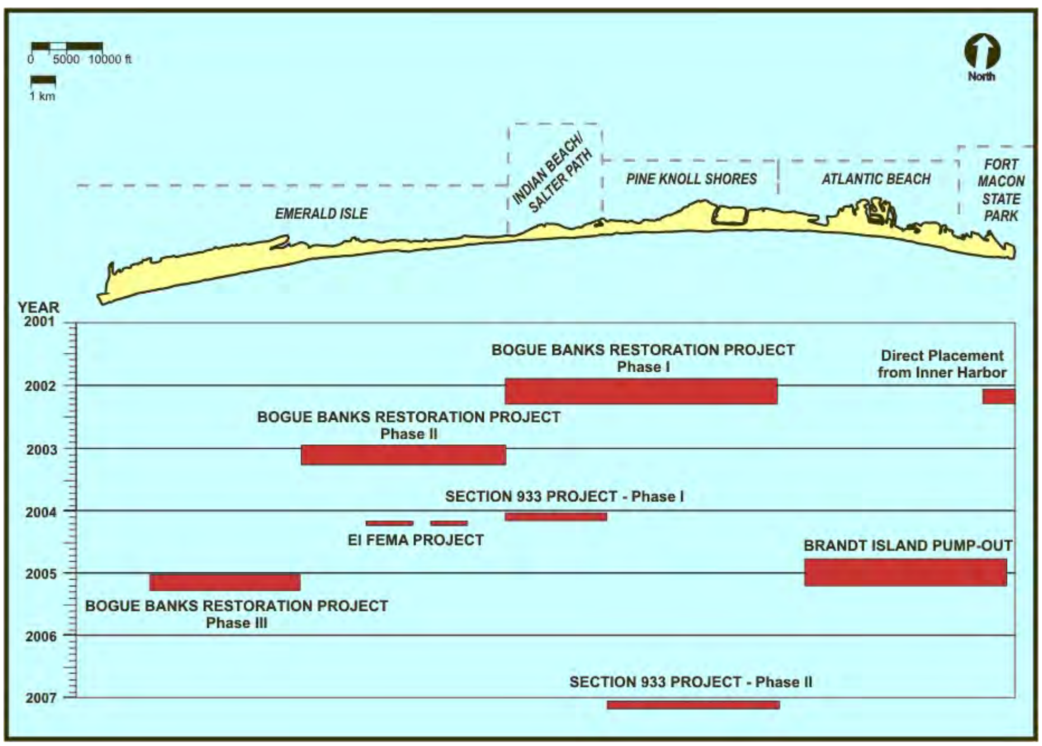

Figure 1. Schematic representation of Tier II nourishment projects on Bogue Banks since 2001. Figure reproduced from www.protectthebeach.com

Initially, Bogue Banks was to undergo three phases of nourishment, with placement of dredged material on roughly one third of the island per year, beginning in the winter of 2001/2002 in Pine Knoll Shores, continuing in the winter of 2002/2003 with material placed in eastern Emerald Isle, and finishing in the winter of 2003/2004 with placement of material in western Emerald Isle. Following the end of Phase III, there would be three years of post-project monitoring. However, this initial schedule was changed for a variety of reasons, including the need for an emergency response to Hurricane Isabel that struck North Carolina in 2003, plus several other dredge disposal events on the island between 2002 and 2007 (see Figure 1). As a result, in the initial years of study, we aimed to compare nests and nest habitat of nourished vs. nonnourished areas of Bogue Banks. In the later years of the study, we used Bear Island, located just to the west of Bogue Banks, as a control site, as Bear Island is a state park and did not received dredge material except for a small section on the eastern end in May 2006.

Methods

Morning patrols for sea turtle activity were conducted daily along the beach by a contracted sea turtle monitor using an ATV from 1 May through 31 August of each year. Unless they were postponed due to lightening or other issues, the patrols began at dawn and were completed no later than 10:30 am. The monitored area extended roughly 18 miles westward from the Atlantic Beach/Pine Knoll Shores town boundary to Bogue Inlet in 2002; from 2003 onwards, monitored was extended from the Ft. Macon/Atlantic Beach boundary to Bogue Inlet (roughly 21 miles). Along the entire beach in Emerald Isle, Salter Path, Indian Beach and Emerald Isle, volunteers were assigned designated zones that they patrolled each morning to record crawl and nesting information. Specific details of each new turtle track were recorded, including whether it was a false crawl or nest, GPS coordinates, street location, date, etc. A crawl was defined as a nest only after carefully moving sand and confirming the presence of eggs. Nests were covered again, cordoned off and protected using four wooden stakes, construction tape and a sign. Nests were observed daily during incubation for evidence of overwash, predation, or human manipulation.

From 2002 through 2007, there was a moratorium on all relocations of nests, regardless of location or perceived threats. This helped to minimize the influence of extraneous variables in the assessment of effects of renourishment on sea turtle nests. Therefore, all nests were left in their original locations for the duration of incubation and emergence periods, except in a few cases when eggs from nests were exposed from erosion and were relocated midway through incubation. For all nests, as day 55 of incubation approached, volunteers fashioned a protective runway intended to aid hatchlings in their journey to the ocean. High edges discouraged hatchlings from crawling laterally along the shore and sand was cleared of debris and smoothed to facilitate the quick entrance of hatchlings into the sea. Staking off the runway created added protection for the hatchlings by keeping spectators at a distance. Many volunteers "sat" with the nests at night to be able to witness the hatching event. In doing so, they were able to provide estimates of the hatching time or number of turtles that emerged and also ensured that passersby on the beach did not interfere with the process. At least three days after the main emergence event, each nest was excavated in order to determine the hatching success rate, record any noticeable characteristics of the nest, and expedite the emergence of any live hatchlings remaining in the nest. Nest contents were segregated into the following groups: whole unhatched eggs (UE), empty eggshells (ES), broken or pipped eggs that contained a dead hatchling (PE), dead hatchlings free from any shell

(DH) and live hatchlings (LH). The following equations were used to characterize the reproductive success of the nest.

$$\text{Total clutch size (CS)} = UE + ES + PE$$
$$\text{Hatching success} = (ES - DH) \div CS \times 100$$

Following nest excavation, any remaining live hatchlings were released to enter the ocean. Occasionally, injured or deformed hatchlings found alive in the nest were taken to the PKS Aquarium for rehabilitation and eventual release. The remaining nest material was then reburied into the original nest chamber. Early evening excavations provided valuable opportunities for public education, as people walking along the beach saw the action and quickly become a crowd of curious observers.

Temperatures were monitored during the nesting season using dataloggers, either Hobo H8, Hobo Pro, or Hobo Pendant (Onset Computer Corporation, USA). These small dataloggers (1.5 cm x 3cm x 1cm) were programmed to record temperatures every two hours (± 1.0°C accuracy, with 0.4 °C resolution). To measure nest temperatures, a datalogger was placed into the middle of each nest as soon as possible after laying, with care taken to avoid rotating the eggs temporarily removed from the nest. To measure sand temperatures, 8 transects were established along Bogue Banks: 2 in Atlantic Beach, 2 in Pine Knoll Shores, and 2 in Emerald Isle. Each transect consisted of 2 dataloggers that were buried at mid-nest depth (45cm), one at the toe of the dune, the second about halfway across the berm. The majority of loggerhead sea turtle nests are laid within the zone encompassed by these two sites.

Finally, a cone penetrometer was used to assess shear resistance of sand in nourished and non-nourished sand. When a turtle crawl was encountered, sand compaction measurements (in PSI) were immediately taken at depths of 6, 12, and 18 inches due North, East, South, and West within 2 feet of the nest or final apparent nesting attempt in the case of false crawls. Initially, only 3 replicate readings at each depth were taken, but starting mid-season 6 replicate measurements were taken to increase statistical accuracy. At sites where the sand was too compacted to get readings at all depths or in all directions, the compaction was recorded as “NA.” In such cases, the minimal value of compaction was assumed to be the same as the readings recorded at preceding depths.

Results

<u>2007 Season Data</u>

In place of a separate annual report for 2007, we report here the specific data collected from May through November 2007. In 2007, the Sea Turtle Monitoring Project collected sea turtle nesting data for a sixth year on the island of Bogue Banks (Carteret County, North Carolina). The project collects and examines data relative to the effects of beach nourishment on sea turtle reproduction during the sea turtle nesting and hatching season (May 1 to November 15). The monitored area includes the ocean-facing beaches of Atlantic Beach, Pine Knoll Shores, Indian Beach/Salter Path, and Emerald Isle.

Table 1. Sea turtle activity on Bogue Banks in 2007

Beach area	False crawls	Nests	Hatchling emergence success
Atlantic Beach	4	1	0%
Pine Knoll Shores	2	3	61.8% ±53.6SD
Indian Beach/Salter Path	1	2	92.9% ±8.5SD
Emerald Isle	20	17	75.4% ±31.6SD
Bogue Banks	**27**	**23**	**71.8% ±33.1SD**

2007 Nesting

In the 2007 monitoring season, 23 nests were confirmed on the island of Bogue Banks (excluding Fort Macon). All nests were laid by loggerhead sea turtles. Of the 23 nests, 17 nests were laid in Emerald Isle, 2 nests were laid in Indian Beach/Salter Path, 3 nests were laid in Pine Knoll Shores, and one nest was located in Atlantic Beach (Table 1). See Appendix I for location data. The ratio of False Crawls to Nests was nearly 1:1.

2007 Sand Temperatures

The sand temperature dataloggers were retrieved from the beach on October 31, 2007 from each of the six transects along Bogue Banks. The two dataloggers used in the Emerald Isle West transect failed in mid June, so no sand temperature data were available from this area for the majority of the season. Tropical storm activity in September 2007 required most of the dataloggers to be removed from the beach for approximately two weeks. In general, sand temperatures were cooler than 29.2 °C, the NC loggerhead pivotal temperature (Mrosovsky 1988), except for late July and early August (Figure 2). The exception was the eastern end of Emerald Isle, where sand temperatures exceeded the pivotal temperature from late June through late August. The two locations on Bear Island were also relatively cool, with temperatures exceeding pivotal for only late July and/or early August (Figure 2).

2007 Nest Temperatures

Dataloggers were placed in 16 nests on Bogue Banks and three nests on Bear Island, to record incubation temperature during the 2007 nesting season. Data from three dataloggers from nests on Bogue Banks were unavailable, due to malfunction, and for the three nests laid on Bear Island, the dates of emergence were not recorded, making it impossible to compare Bear Island and Bogue Banks nest data. For the other nests, temperatures varied during incubation and according to when the nests were laid (Figure 3). Nest temperatures generally increased during the incubation period, due to increasing metabolic activity of embryonic development (Godfrey et al. 1997) and also due to the seasonal increase in sand temperatures (Figure 2).

The thermal influence on sexual differentiation in sea turtle development occurs in the middle third of egg incubation (Mrosovsky & Pieau 1991). Therefore, to better characterize the potential thermal impact of sea turtle nest incubation in nourished material, the nest temperatures of the middle third of incubation were analyzed (Figure 4). The majority of the nests were above the pivotal temperature during their thermosensitive period for sexual differentiation. However, to minimize the influence of seasonal changes in sand temperatures, it is ideal to compare temperatures of nests laid on or around the same day of the season. In the 2007 nesting season, only two sets of nests that were monitored for temperature were laid on the same day: three nests laid 6-7 June, and 2 nests laid on 16-18 June (Appendix I).

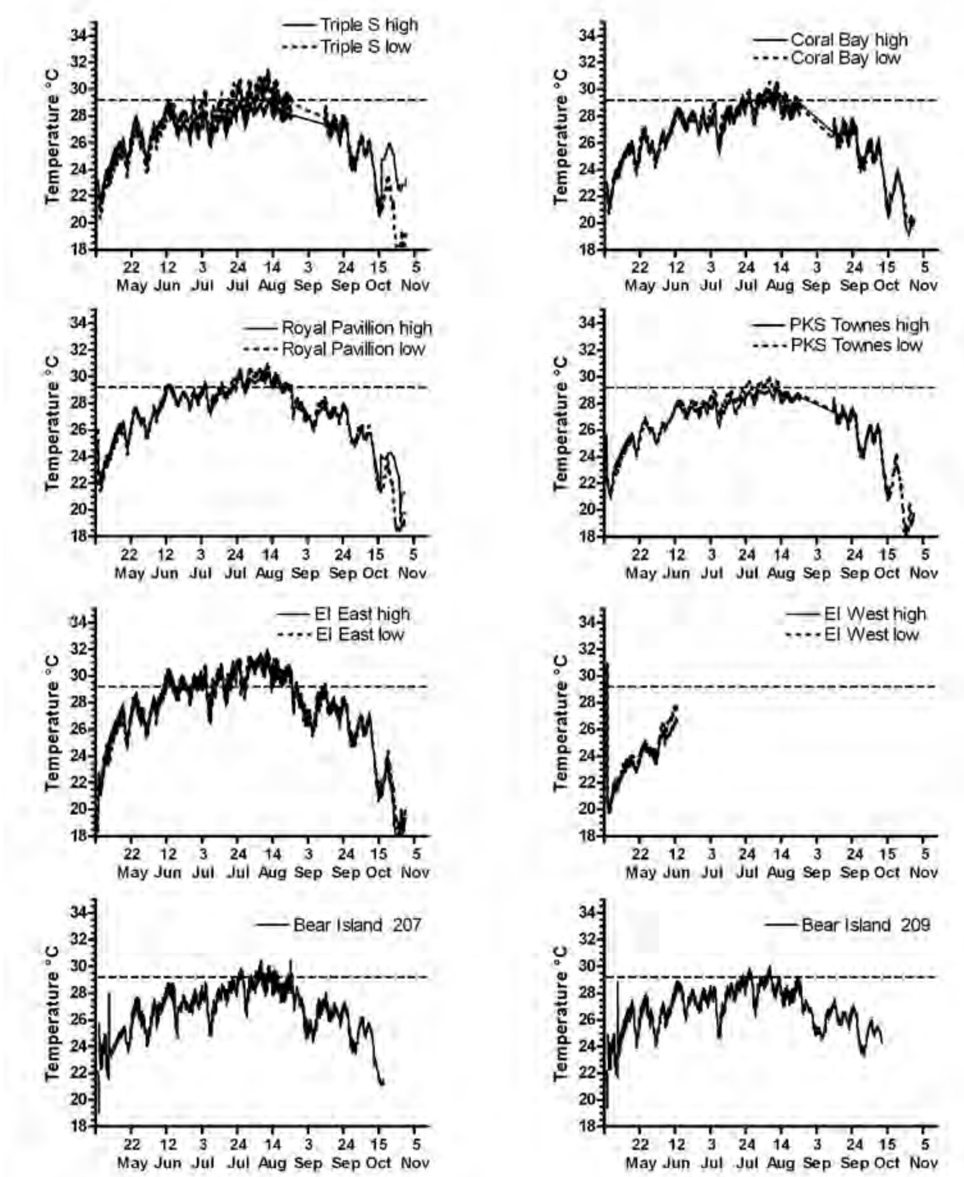

Figure 2. Sand temperatures collected at 6 different transects on Bogue Banks, 01 May through 31 October, with two sites from Bear Island (to the west of Bogue Banks). Dotted line = pivotal temperature (Mrosovsky 1988)

These groups of nests are indicated by the open triangles and open squares in Figure 4. Note that nests laid in the western end of Emerald Isle were cooler than nests laid at similar times but further east on Bogue Banks. This corresponds to the color of the material placed on the beaches of Bogue Banks: western Emerald Isle received lighter material during Phase III of the nourishment project while further east, darker material from other locations was placed on the beach. The mean temperature of nests EI 2 and EI 4 were significantly cooler than nests laid around the same time but further east ($p<0.001$, Kruskal-Wallace nonparametric test, with Dunn's multiple comparison test correction factor).

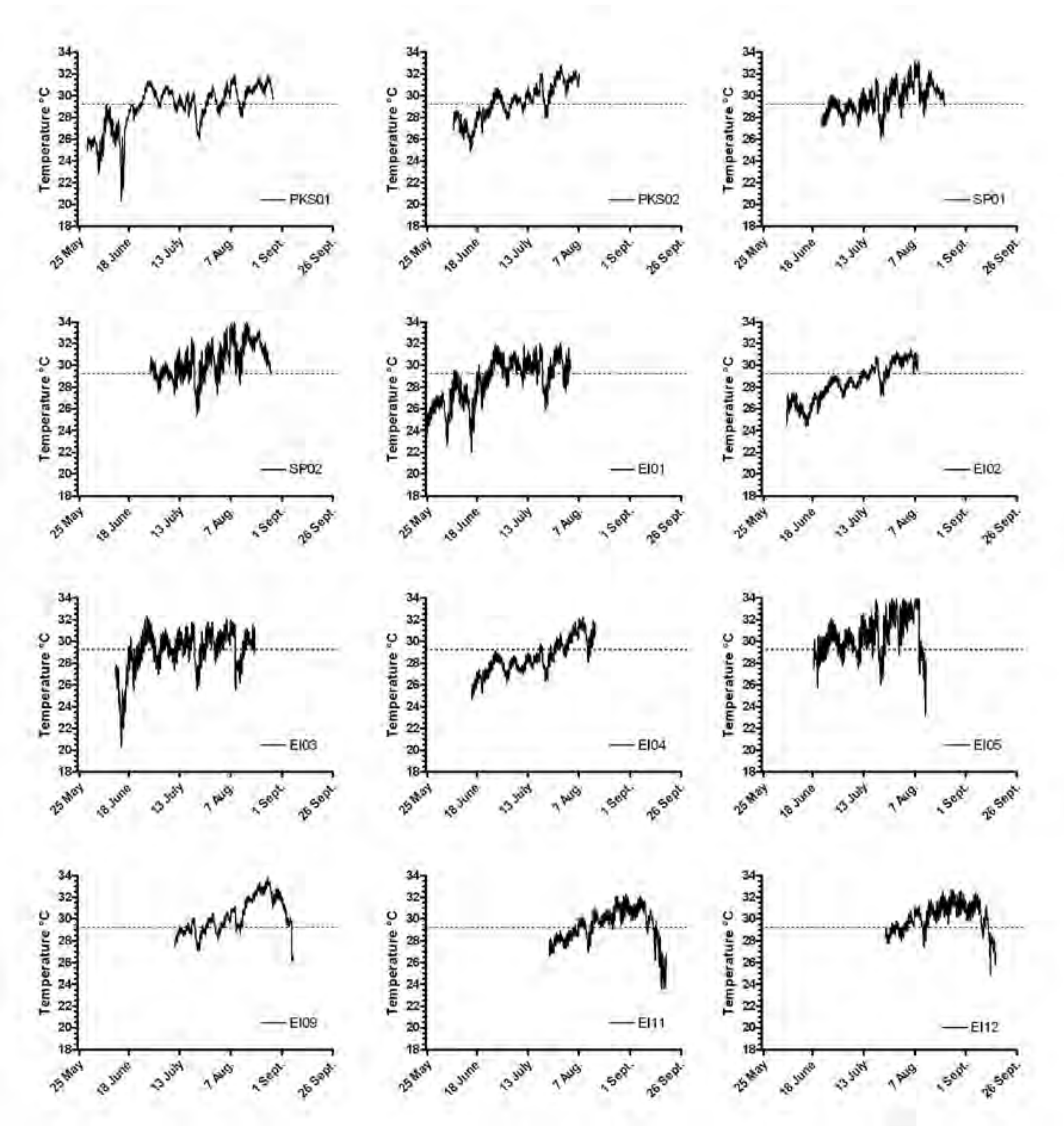

Figure 3. Loggerhead nest temperatures on Bogue Banks and Bear Island in 2006. Dotted line represents the pivotal temperature for NC loggerheads (Mrosovsky 1988)

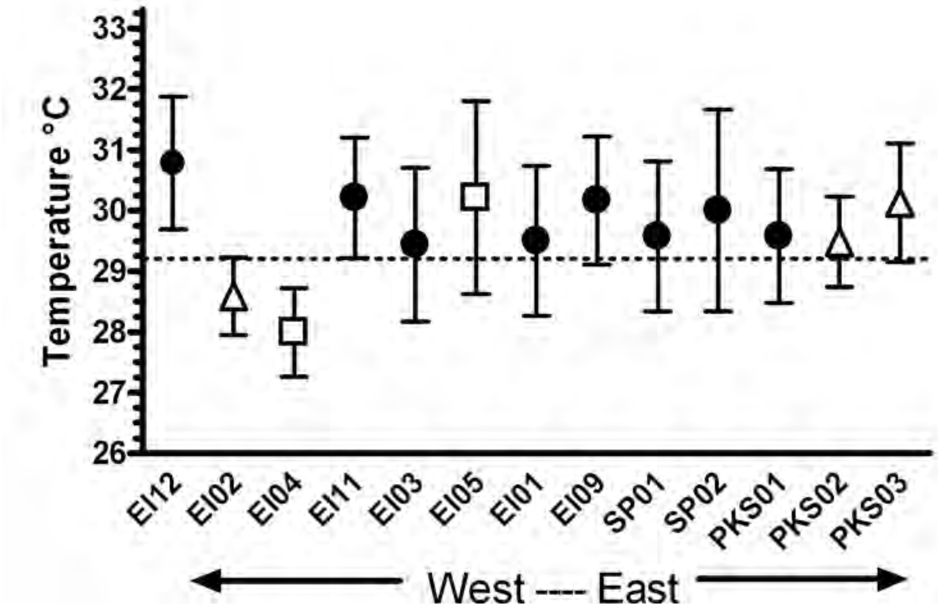

Figure 4. Mean(±SD) temperatures of monitored loggerhead nests during the thermosensitive period for sexual differentiation. Nests are plotted according to east-west placement along Bogue Banks. Similar open symbols indicate nests laid around the same date (see text). Dotted line represents the pivotal temperature for NC loggerheads (Mrosovsky 1988)

2007 conclusions:

There was not discernable impact of nourishment on nesting behavior or hatching success for loggerhead sea turtles in 2007. However, nourished material in Pine Knoll Shores, Indian Beach/Salter Path and eastern Emerald Isle continued to be warmer than western Emerald Isle (which had lighter colored sand). Ongoing monitoring in future years may shed light on how long the impacts of the darker material from the nourishment will impact sea turtle nest temperatures.

2002-2007 Summary Results

Here we provide a general overview the data collected from 2002-2007, for the different category of data: nests and nest success per year, ratio of false crawls to nests, sand temperatures, nest temperatures, and sand compaction. Detailed results from each individual sea turtle season from 2002 through 2006 can be found in the Annual Reports, and 2007 season data are presented above.

Nests and nest success:

The beaches of Bogue Banks provide suitable nesting habitat for all sea turtle species that nest in North Carolina. From 2002 to 2007, there were 349 nesting activities on Bogue Banks, the majority of which were made by loggerhead sea turtles (Table 2). There were a total of 167 nests, and all but three were laid by loggerhead sea turtles. In 2005, there were 2 leatherback nests and one green turtle nest observed on Bogue Banks. False crawl activity is not well understood, although it is known that loggerheads make many false crawls on different nesting beaches worldwide (Miller et al. 2003). Commonly, this species exhibits a ratio of 1:1 nesting events to false crawls (Dodd, 1988). The ratio of nests to false crawls across years varied, from equality in 2002 to more than double the false crawls vs. nests in 2003 to more than double the number of nests vs. false crawls in 2006. Overall, for the study period, the ratio of nest to false crawl was close to 1:1 (Table 2).

Table 2: Turtle nests and false crawls on Bogue Banks, NC

Season	Nests	False Crawls	Ratio
2002	19	19	1:1.0
2003	38	80	1:2.1
2004	21	20	1:0.9
2005	33	23	1:0.7
2006	33	13	1:0.4
2007	23	27	1:1.2
Total	167	182	1:1.1

Hatching success:

Hatching success, expressed as the percentage of eggs in a nest that produce viable turtle hatchlings, is dependent on a variety of parameters, including temperature, gas exchange, moisture, predation, as well as genetic or maternal factors (Carthy et al. 2003). On Bogue Banks, there was variation in annual hatching success of nests laid (Table 3). The primary cause of nest failure was nest inundation from high ocean swash associated with tropical storms or hurricanes, particularly in years 2003-2006. Tropical storm activity in the SE USA is thought to be a major determinant in hatching success for sea turtle nests laid in the region (Van Houtan and Bass 2007). There was no indication that nourished zones were less suitable for egg development in Emerald Isle, Salter Path, Indian Beach and Pine Knoll Shores. However, in one zone of Atlantic Beach, which received muddy silty material in 2004/2005 as part of the Brandt Island Pumpout (see Fig

1), egg incubation for a single nest laid there was not successful, likely due to impeded gas exchange.

Table 3: Annual hatching success for sea turtle nests on Bogue Banks

Year	Mean nest success	Maximum	Minimum
2002	**89.8%**	**96.7%**	**70.2%**
2003	**59.4%**	**98.2%**	**0%**
2004	**56.3%**	**96.7%**	**0%**
2005	**49.6%**	**96.0%**	**0%**
2006	**57.4%**	**98.3%**	**0%**
2007	**71.8%**	**98.9%**	**0%**

Sand Temperature:

Sand temperature was monitored at turtle nest depth in the middle of the beach and at the toe of the primary dune along 8 transects on Bogue Banks. The seasonal temperature profile was similar across years: sand temperatures increased from May 01 until reaching a peak in July and August, following which they declined again. In many cases, the sand temperature was warmer higher up the beach, likely related to the relative distance from the water table on the beach (see Figure 5 for an example).

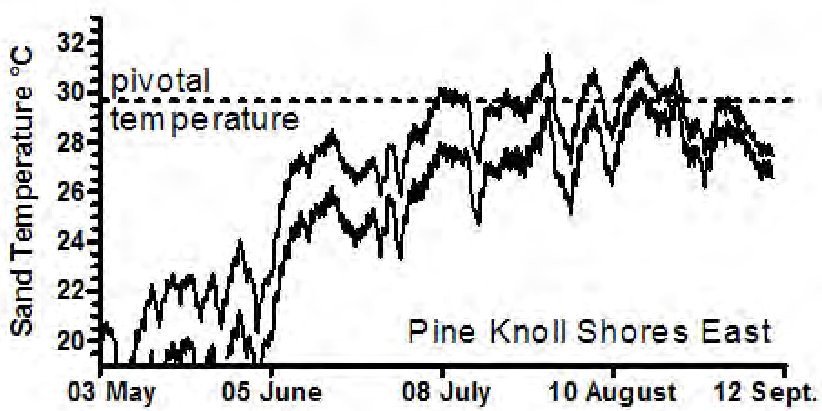

Figure 5. Seasonal sand temperature profile for eastern Pine Knoll Shores in 2005, lower line is middle of beach, upper line is close to toe of primary dune. Dotted line is the pivotal temperature for loggerhead sea turtles in North Carolina (Mrosovsky 1988).

In terms of the impacts of nourishment on sand temperature, there were slightly warmer temperatures in Pine Knoll Shores (nourished) vs. Emerald Isle (non nourished) in 2002, and both Pine Knoll Shores and eastern Emerald Isle (nourished) beaches were more often above pivotal temperature western Emerald Isle sand (nourished) in 2003. By the 2005 nesting season, all beach zones on Bogue Banks had been renourished, so we used Bear Island sand temperatures as a control for 2006 and 2007 (data from Bear Island in 2005 were lost due to datalogger failure). In 2006 and 2007, both sand temperature monitoring stations on Bear Island were cooler than those on Bogue Banks (e.g. see Figure 2 above).

Although sand temperatures are a rough guide of the thermal environment experienced by sea turtle eggs during incubation, the actual temperature regime of a nest is usually warmer than the surrounding sand, due primarily to metabolic warming generated by the developing sea turtle embryos (Miller et al. 2003). Therefore, comparisons of temperatures within nests laid in nourished or nonnourished areas is a better means to uncovering potential impacts of nourishment on turtle eggs.

Nest temperature:

We deployed dataloggers into as many nests as possible during a nesting season on Bogue Banks, to collect data on daily temperature regimes experienced by incubating eggs. Because of the seasonal fluctuation of sand temperatures, we sought to compare temperatures of nests laid around the same date, to standardize seasonal influences on nest temperature. For nests laid near the same time of a particular season, we also sought to compare nests laid in nourished sand (placed in 2002 or later) vs. nests laid in nonnourished sand (either Pine Knoll Shores and Emerald Isle in 2002, western Emerald Isle in 2003 and 2004, or Bear Island in 2006 and 2007. Also, as the thermosensitive period for sexual differentiation in sea turtles occurs during the middle third of incubation (Mrosovsy and Pieau 1991), we restricted our comparisons to temperature data collected during the middle third of incubation for each nest. Despite a moratorium on nest relocation on Bogue Banks for the duration of the study, a few nests that were about to be washed away by the ocean were relocated in mid-incubation. We excluded temperature data (if any were collected) from nests that were relocated.

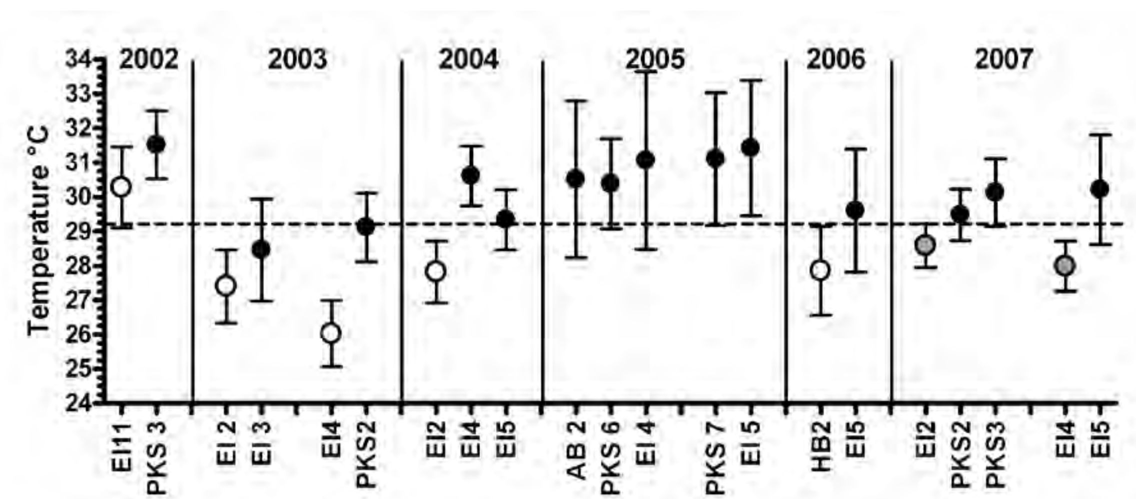

Figure 6. Comparisons of the mean temperatures during the middle third of incubation (the thermosensitive period for sexual determination) for groups of nests laid within 72 hours of each other. For years 2003, 2005, and 2007, two groups of nests (laid on different sets of days) are presented. White dot = nest laid in non-nourished area; black dot = nest laid in nourished area; grey dot = nest laid in nourished material in western end of Emerald Isle. All points are significantly different (p<0.01, Kruskal Wallace nonpaired parametric test with Dunn's posthoc test), except for the two groups in 2005, with the exception of PKS6 and EI4 (p<0.05). AB=Atlantic Beach, EI = Emerald Isle,

HB = Hammocks Beach State Park (Bear Island), PKS = Pine Knoll Shores. Dotted line is the pivotal temperature for loggerhead sea turtles in North Carolina (Mrosovsky 1988).

Overall, we found a consistent pattern of mean nest temperatures during the middle third of incubation to be warmer for nests laid in nourished sand vs. nests laid in nonnourished sand (Figure 6). For 2005 and 2007, there were no data from nests laid in nonnourished areas. For 2005, the study nests were not significantly different in mean temperature, except for PKS6 vs. EI4 ($p<0.05$). For 2007, the two nests laid in eastern Emerald Isle (indicated by grey points in Figure 6) were significantly cooler (mean difference in temperature = 1.6 °C) than nests laid in Pine Knoll Shores or eastern Emerald Isle. The difference between these sites is that the western half of Emerald Isle received sand from Bogue Inlet as part of Nourishment Phase III; this material was not as dark as material placed in Pine Knoll Shores and eastern Emerald Isle during Phases I and II. Together, these data indicate the following:

a. Nests in nourished areas were on average 1.9 °C warmer than nests laid at the same time in nonnourished areas
b. Nourished sand in western Emerald Isle had less of an impact on sea turtle nest temperatures than nourished sand impacts, likely due to the more compatible sand placed on the beach in western Emerald Isle.

The impact of warmer nest temperatures due to nourishment on hatchling sex ratio is likely the production of more female hatchlings from nests. The overall sex ratio production for loggerheads in North Carolina is estimated to be about 55% female (Hawkes et al. 2007). The additional 1.9 °C on the sex ratio of specific nest is related to overall seasonal temperatures; for instance, 2003 was a cooler year in general, and thus nests laid in nourished sand had more but likely not >50% female hatchling production, relative to the nests laid in nonnourished sand (see Figure 6). In 2002, sand temperatures were warmer in general, so there was likely already >50% female hatchling production from nest EI11, laid in a non-nourished area (Figure 6). Therefore, the additional 1.9°C to the nest in the nourished area likely would have made the nest produce 100% females. Unfortunately, we were not able to sample any hatchlings to assess sex ratio directly, so these calculations are based on estimates from previously published studies relating temperature to hatchling sex ratio in loggerheads (e.g. Mrosovsky 1988; Mrosovsky and Provancha 1992). Regardless, increased nest temperatures in nourished sand will result in higher female hatchling production, altering the natural sex ratio.

Sand compaction:

Sand compaction varied greatly both among nests and among crawls in all years (note that no compaction data were collected in 2007), ranging from <150psi to >850psi. There was no specific pattern in compaction readings collected from nourished areas vs nonnourished areas (see Figure 7 for example). A cone penetrometer is not an exact reflection of the same resistance that turtles encounter because of the manner in which a female turtle digs her nest cavity (Davis et al. 1999); moreover, the readings generated by a cone penetrometer are influenced by the mass and technique of the person collecting the measurements. (Ferrell et al., 2003). Other difficulties in collecting compaction data included: not being able to reach all depths because of shell fragments encountered in many sections of nourished areas; not being able to record compaction for nests laid on the dune, for fear of disturbing the sensitive dune habitat or because it appeared that sand would heavily shift and accrete on the nest.

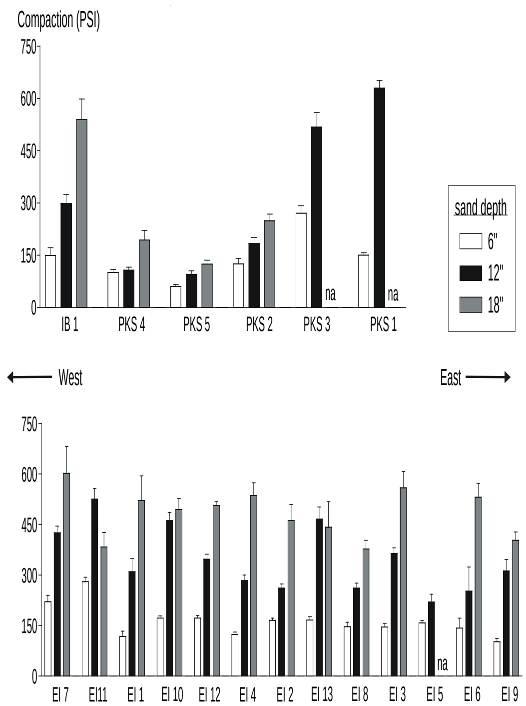

Figure 7. Average sand compaction measurements at nest sites in Indian Beach/Pine Knoll Shores (nourished) and Emerald Isle (non-nourished) in 2002. IB = Indian Beach, PKS = Pine Knoll Shores, EI = Emerald Isle. "Na" refers to where it was not possible to record compaction.

Overall, the cone penetrometer compaction data do not provide a clear index of suitability of nesting habitat for sea turtles, for the following reasons: a. the ambiguity associated with cone penetrative compaction as an index of resistance encountered by nesting female turtles; b. the imprecision associated with data collected from cone penetrometers; c. nesting success and hatching success were not significantly different between nourished and nonnourished zones (see above).

General Conclusions:

The Sea Turtle Monitoring Project on Bogue Banks compared a suite of parameters related to sea turtle reproduction as related to nourishment activities. The overall findings were as follows:

No significant impact:

<u>Nesting success</u> (nest/false crawl ratio)

<u>Hatching success</u> (proportion of eggs that produced viable turtles)

<u>Sand compaction</u> (in psi)

Significant impact:

<u>Sand temperatures</u>: sand temperatures in nourished areas were warmer than nonnourished areas

<u>Nest temperatures</u>: nest temperatures were on average 1.9 °C warmer for nests laid in nourished sand from Phases I and II (Pine Knoll Shores, Indian Beach & Salter Path, and eastern Emerald Isle). This likely increased the number of female hatchlings produced by nests laid in nourished sand.

Recommendations:

A major challenge in this study was having a suitable area or zone to act as a control (or unnourished) area, to compare with nourished areas. As the entire island experienced nourishment activities by 2005, it was necessary to use Bear Island as a control site for the subsequent years. There were logistical challenges to collecting data from Bear Island. Another challenge in the study was the lack of sufficient equipment: we were not able to put dataloggers in all nests, so that our sample size for study (comparing nests laid around the same date in different zones) was limited. A third challenge was the ongoing nourishment/dredge placement activities that continued on the island during and after Phases I, II and III of the study nourishment project (see Figure 1 above). This made it difficult to monitor post-project impacts during the final three years of the study, as was initially intended. Finally, we lacked pre-project data that could have been used as a baseline to compare impacts during and after the project. Therefore, we recommend ongoing monitoring of sand and nest temperatures, as a means to both continue assessing post-project impacts of nourishment on sea turtle reproduction, and constitute a baseline against which to assess impacts of future projects.

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APPENDIX I
SEA TURTLE ACTIVITY DATA FROM BOGUE BANKS IN 2007

Nests		Activity date	Lat.	Long	datalogger	Hatch Date	ES	UH	PE	DH	LH	Emergence Success	Incubation Period
Atlantic Beach													
AB 1	301 Ocean Ridge	8/4/2007	34.69724	76.74946	~~~~	N/A	75	3	0	75	0	0.00	n/a
Pine Knoll Shores													
PKS 1*	Ocean Terrace	5/29/2007	34.69360	76.81966	992539	N/A	0	108	0	0	0	0.00	n/a
PKS 2	W of Ocean Park	6/7/2007	34.69473	76.81112	992541	8/8/2007	141	7	0	7	2	90.54	62
PKS 3	W of Coral Bay West	6/7/2007	34.69605	76.79311	995171	8/3/2007	94	5	0	0	4	94.95	57
Indian Beach / Salter Path													
SP 1	1809 Salter Path Rd.	6/23/2007	34.68339	76.90381	868197	8/19/2007	87	1	0	0	0	98.86	57
SP 2	Summerwinds	6/29/2007	34.68495	76.89345	868196	8/24/2007	86	13	0	0	0	86.87	56
Emerald Isle													
EI 1	607 Ocean Ridge	5/25/2007	34.68084	76.92029	992538	7/30/2007	4	128	2	0	0	2.99	66
EI 2	Land's End	6/6/2007	34.64718	77.08460	995137	8/6/2007	116	9	3	0	15	90.63	61
EI 3	Tammy St.	6/12/2007	34.67339	76.96815	995139	N/A	0	80	0	0	0	0.00	n/a
EI 4	Spinnakers	6/16/2007	34.65035	77.07451	995142	8/13/2007	103	1	5	14	34	81.65	58
EI 5	Ocean Reef	6/18/2007	34.67563	76.95396	868198	8/9/2007	110	10	0	0	3	91.67	52
EI 6	Holiday Trav-L-Park	6/22/2007	34.65501	77.05711	~~~~	8/21/2007	100	3	0	0	0	97.09	60
EI 7	8615 Ocean Ridge	6/29/2007	34.65859	77.04266	~~~~	8/25/2007	105	4	0	0	0	96.33	57
EI 8	E of Channel Drive	7/3/2007	34.64459	77.09315	~~~~	9/2/2007	45	62	2	1	44	40.37	61
EI 9	100 Ocean Ridge	7/11/2007	34.68232	76.91108	995170	9/2/2007	85	7	0	1	0	91.30	53
EI 10	201 Ocean Ridge	7/14/2007	34.68209	76.91240	~~~~	9/3/2007	73	3	2	1	1	92.31	51
EI 11	9801 Ocean Ridge	7/24/2007	34.65080	77.07286	995138	9/16/2007	90	1	0	0	0	98.90	54
EI 12	Emerald Pointe Villas	7/24/2007	34.64424	77.09125	995148	9/13/2007	77	5	2	3	0	88.10	51
EI 13*	Dolphin Ridge	8/5/2007	34.65033	77.07363	~~~~	9/28/2007	90	6	1	2	2	90.72	54
EI 14*	1st Street	8/5/2007	34.68226	76.91021	~~~~	9/26/2007	89	6	0	2	0	91.58	52
EI 14.5	9505 Ocean Ridge	8/15/2007	34.39104	77.04169	~~~~	########	101	6	0	0	3	94.39	67
EI 15	501 Ocean Ridge	8/17/2007	34.40876	76.55073	~~~~	########	62	15	5	1	3	74.39	57
EI 16*	1100 Ocean Ridge	8/30/2007	34.67963	76.92880	~~~~	11/1/2007	50	34	1	0	1	58.82	63

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False Crawls		Activity		
Atlantic Beach		date	Lat.	Long
AB1	Landing	6/8/2007	34.69480	76.70215
AB2	Avenue	7/3/2007	34.69698	76.73296
AB3	of mm 2.9	7/17/2007	34.69726	76.75206
AB4	Beach &	7/27/2007	34.69698	76.77691
Pine Knoll Shores				
PKS1	Knoll	6/18/2007	34.69391	76.81658
PKS2	Inn	7/27/2007	34.69333	76.82464
Indian Beach / Salter Path				
IB1	Summerw	7/14/2007	34.68487	76.89269

False Crawls		Activity		
Emerald Isle		date	Lat.	Long
EI1	12th St.	6/12/2007	34.67976	76.92902
EI2	End	6/16/2007	34.64717	77.08440
EI3	End	6/16/2007	34.64691	77.08509
EI4	Drive, EI	6/16/2007	34.64480	77.09344
EI5	End	6/16/2007	34.64824	77.08108
EI6	Ocean	06/22/07	n/a	n/a
EI7	Ocean	6/28/2007	34.65320	77.06362
EI8	Myrtle	6/29/2007	34.65903	77.03938
EI9	the Sea	7/2/2007	34.65639	77.05057
EI10	Ocean	7/10/2007	34.66481	77.01538
EI11	block	7/11/2007	34.65381	77.06212
EI12	Ocean	7/12/2007	34.66466	77.01534
EI13	Motel	7/23/2007	34.39317	77.03325
EI14	Emerald	8/4/2007	34.64742	77.08378
EI15	Emerald	8/4/2007	34.64699	77.08499
EI16	Emerald	8/4/2007	34.64584	77.08756
EI17	Street	8/5/2007	34.68037	76.92526
EI18	End	8/5/2007	34.64838	77.08148
EI19	the Sea	8/16/2007	34.39395	77.03000
EI20	Ocean	8/17/2007	34.40838	76.53305