

2006 Sea Turtle Monitoring Project Report Bogue Banks, North Carolina

INTERIM REPORT



Emerald Island volunteers and beach visitors at a loggerhead nest excavation in 2006



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Introduction

In 2006, the Sea Turtle Monitoring Project collected sea turtle nesting data for a fifth 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.

The study of the effects of beach renourishment on sea turtle nesting was initiated following concern that material placed on the beach during nourishment 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 & Provanha 1992; Hawkes et al. in press). Other potential impacts include the possibility that dark sediment could create nest temperatures that are too hot for successful embryonic development or that the nourished material is too compact for successful nest construction by adult female sea turtles.

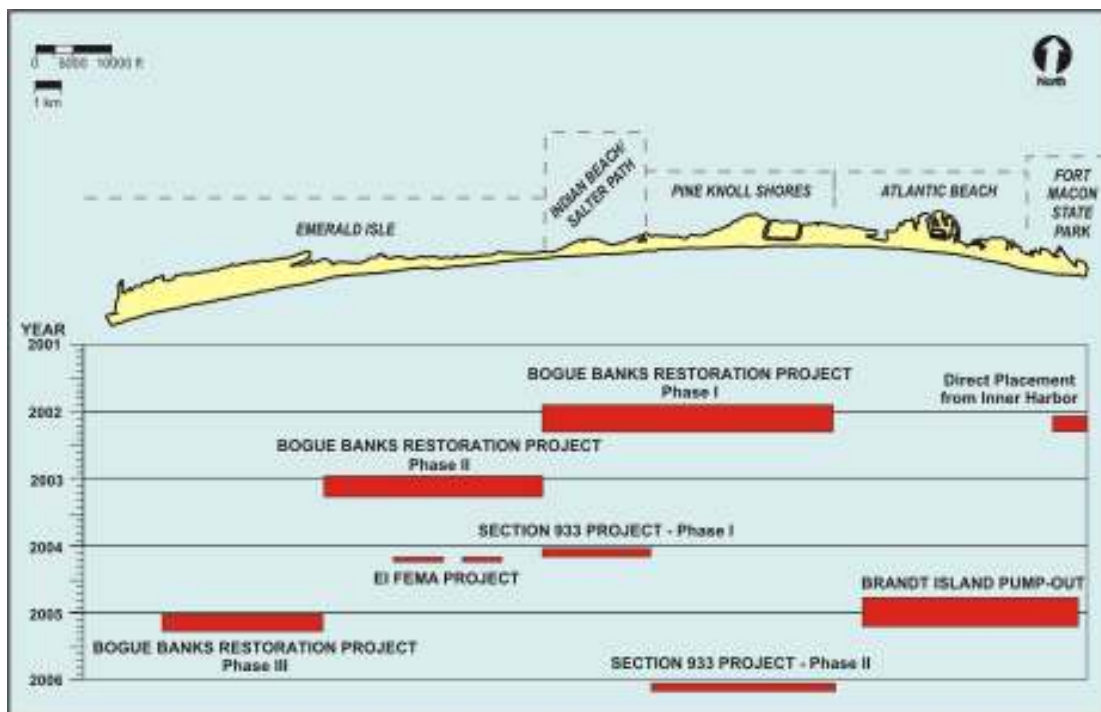


Figure 1. Schematic representation of Tier II nourishment projects on Bogue Banks since 2001. Figure reproduced from www.protectthebeach.com

The U.S. Army Corps of Engineers (USACE) has designed a 50-year Shore Protection Project (Tier I) that would maintain the beaches of Bogue Banks by periodically nourishing the beaches or adding redistributed sediment. This plan has yet to be realized. In the interim, Carteret County has undertaken short-term nourishment projects (Tier II) in order to stabilize beaches on Bogue Banks until the Tier I project is initiated. Tier II nourishment projects began in late 2001 with material placement in the middle of the island (see Figure 1). By the 2006 sea turtle nesting season, dredged material had been placed on all beaches of the island. As a result, Bear Island, within the Hammocks Beach State Park complex, was selected as a non-nourished control to compare with the nourished beaches of Bogue Banks. Bear Island lies just west of Bogue Banks and is separated by Bogue Inlet. Bear Island is undeveloped and has not been the target of the disposal of dredged material on its beaches. It is likely that the same nesting female sea turtles lay their eggs on both Bear Island and Bogue Banks.

Methods

The sea turtle monitoring season began May 1, 2006. Daily patrols were conducted close to daybreak, to help ensure that turtle tracks were discovered before being obliterated by human footprints, wind, tides and/or rain. 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 local 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 patrols for signs of disturbance and ocean washover. The Bogue Banks Monitor collected sand compaction readings at nests and false crawls using a cone penetrometer (Field Scout SC-900). Three sand compaction 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 and 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 (Hobo Pro, Hobo H08 and/or Hobo Pendant-Temp 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 October 2006. Dataloggers were removed from the sand transects in early November in anticipation of winter storm activity. 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 at Mile Markers 207 and 209. Temperatures in three nests laid on Bear Island were also monitored with dataloggers. Note that the datalogger accuracy was verified by calibrating them against known temperatures before the start of the field season.

2006 Season Results

Nesting

In the 2006 monitoring season, 33 nests were confirmed on the island of Bogue Banks (excluding Fort Macon). Of the 33 nests, 20 nests were laid in Emerald Isle, 6 nests were laid in Indian Beach/Salter Path, 5 nests were laid in Pine Knoll Shores, and two nests were located in Atlantic Beach (Table 1). All nests laid in 2006 were laid by loggerhead turtles.

Table 1. Turtle activity on Bogue Banks in 2006

Beach area	False crawls	Nests	Hatchling emergence success
Atlantic Beach	0	2	44.15% ±62.43SD
Pine Knoll Shores	1	5	65.41% ±35.38SD
Indian Beach/Salter Path	1	6	50.89% ±44.16SD
Emerald Isle	11	20	58.72% ±44.47SD
Bogue Banks	13	33	57.42% ±42.28SD

The ratio of nests to false crawls for loggerhead turtles in 2006 was roughly 3:1. Since 2002, the seasonal ratio of nest to false crawl has fluctuated widely (Table 2). In

general, it is assumed that loggerhead turtles exhibit a roughly 1:1 ratio of nests to false crawls (Dodd, 1988), although the ultimate factors driving the behavior of nest site selection (or rejection) remain unknown (Miller et al. 2003).

Table 2. 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
2006	33	13	3:1

The overall hatchling emergence success for Bogue Banks in 2006 was 57.42% (Table 1). Of the 33 nests laid in 2006, six nests were lost to tropical storm Ernesto in September, as a result of increased tidal overwash and sand deposition. Also, the first two nests laid in Emerald Isle resulted in zero hatch success: upon excavation by volunteers (see cover photo), both nests cavities were empty. It is unclear what occurred to the eggs. There were no signs of tampering of these or any other nests during the nesting season, although the eggs may have been stolen. Two nests laid in August (one in Pine Knoll Shores and one in Emerald Isle) were removed from the beach in late October when sand temperatures fell below the minimum required for successful incubation. Eggs from both these nests were relocated to an incubator. Only nine hatchlings were produced from these clutches.

Sand Temperatures

The sand temperature dataloggers were collected on October 31, 2006 from each of the six transects along Bogue Banks. On Bogue Banks, one datalogger was lost during the second half of the season and another malfunctioned. In general, sand temperatures were coolest on Bear Island (non-nourished) and the western end of Bogue Banks (where the nourished material came from Bogue Inlet and was the least dark of nourished material), and warmer for the other sites on Bogue Banks (Figure 2). The sand temperatures on Bear Island rarely moved above 29.2 °C, the NC loggerhead pivotal temperature (Mrosovsky 1988), while sand temperatures throughout Bogue Banks went above pivotal temperature for at least several weeks in June/July. Interestingly, the coolest sand temperatures were for the western end of Bogue Banks and the warmest temperatures were from eastern Emerald Isle through Atlantic Beach. These locations correspond to the color of the nourished material: darker material was placed on the beach during Phases I and II while lighter material was placed on the beach during Phase III (see Figure 1).

Nest Temperatures

Dataloggers were placed in 19 nests to record incubation temperature during the 2006 nesting season. Four dataloggers were lost, either because the nests were destroyed by tropical storm Ernesto or removed as a result of possible nest vandalism. For the other nests, temperatures varied during incubation and according to when the nests were laid.

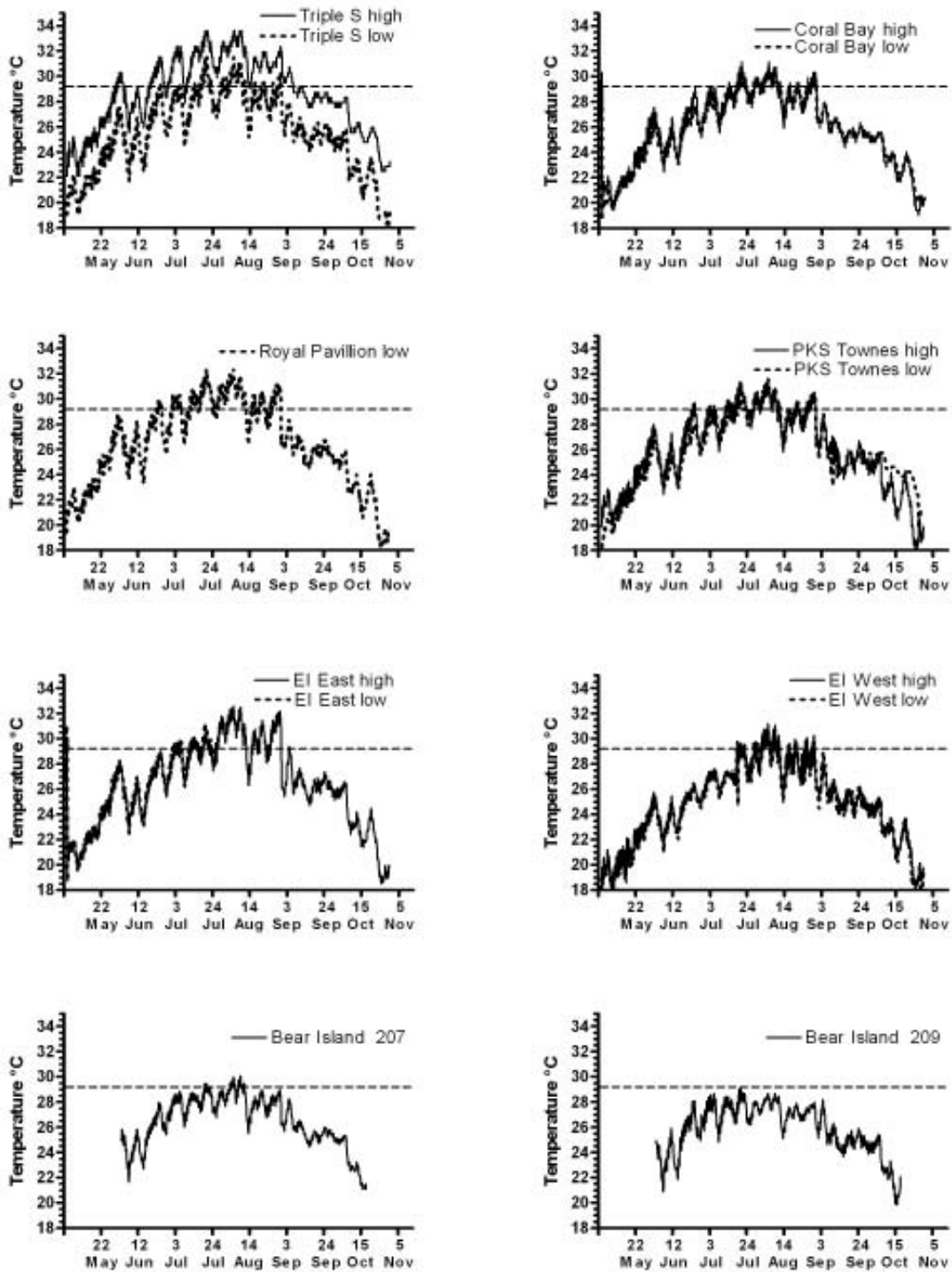


Figure 2. Seasonal sand temperatures at turtle nest depth on Bogue Banks in 2006. Dotted line represents the pivotal temperature for NC loggerheads (Mrosovsky 1988)

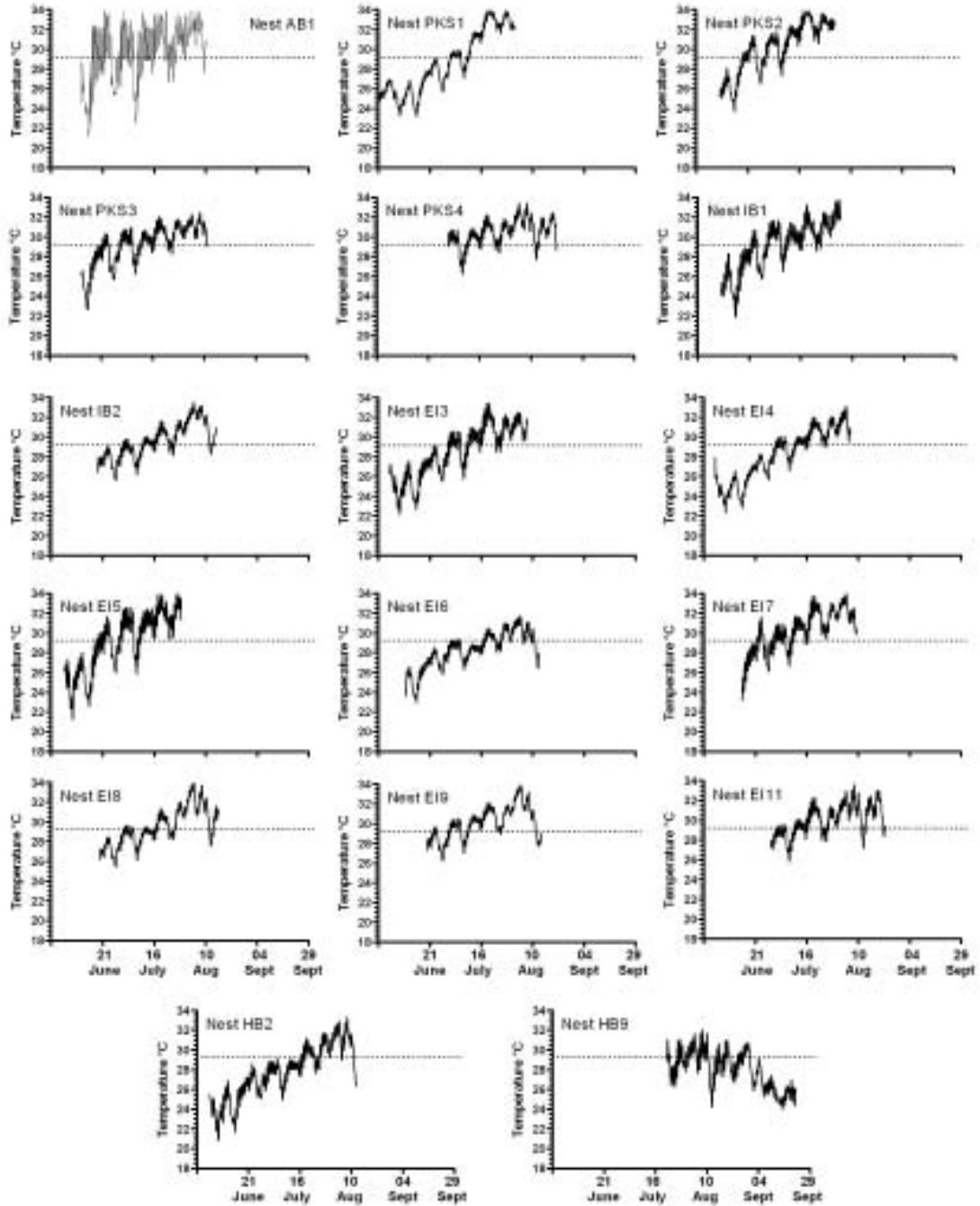


Figure 3. Loggerhead nest temperatures on Bogue Banks and Bear Island in 2006. Dotted line represents the pivotal temperature for NC loggerheads (Mrosovsky 1988)

In order 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 2006 nesting season, only two nests that were monitored for temperature were laid on the same day: Nest HB02 on Bear Island and Nest EI05 on Emerald Isle, both laid 3 June.

When the temperature profiles were overlaid, the nest on Emerald Isle was warmer than the nest on Bear Island (Figure 4). This corresponds to the overall sand color: Nest EI 5 was in the eastern portion of Emerald Isle, that received darker material during Phase II of the nourishment project, while Bear Island remains lighter in color, having never received nourished material.

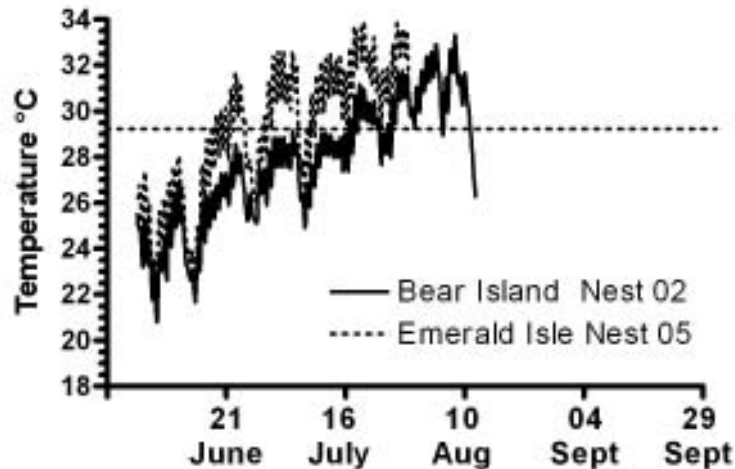


Figure 4. Nest temperature profiles for two nests laid on the same day in 2006. Dotted line represents the pivotal temperature for NC loggerheads (Mrosovsky 1988)

Another consideration is that 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. We restricted our comparisons to nests that were laid within a few days of each other, to minimize the impact of seasonal variation in sand temperature. Nine nests that were laid on 4 June \pm 7 days had their temperatures monitored with dataloggers, including one “control” nest, laid on Bear Island. Overall, when looking at the nests in geographic location, running from east to west, there was a trend for warmer temperatures during the middle third of incubation for nests laid towards the east, and cooler nest temperatures for those laid towards the west (Figure 5). This correlates with the different phases of the nourishment project, as material placed on the beach in Phases I and II, as well as the Brandt Island pumpout, were much darker than the material placed in western Emerald Isle in Phase III. Bear Island remains non-nourished, and has light-colored sand. The mean middle third temperature of nest HB02 was significantly cooler than all other nests ($p < 0.001$, Kruskal-Wallis nonparametric test, with Dunn’s multiple comparison test correction factor). Note that this warming gradient in the nests that are laid towards the east is mirrored by a warming trend in sand temperatures of beach zones that are located more towards the east (Figure 2). The warming trend in nest temperatures was likely to have an impact on sex ratios, as the temperature of the middle third of incubation of the control nest on Bear Island was below the pivotal temperature, while nests laid towards the east of Bogue Banks were generally above pivotal temperature (Figure 5). Nest PKS1 was cooler than other nests laid nearby (e.g. IB1, PKS2, AB1), but it is also the case that Nest PKS1 was laid 28 May, much earlier than

the other nests in Figure 5. This may have contributed to its cooler temperatures during the middle third of incubation.

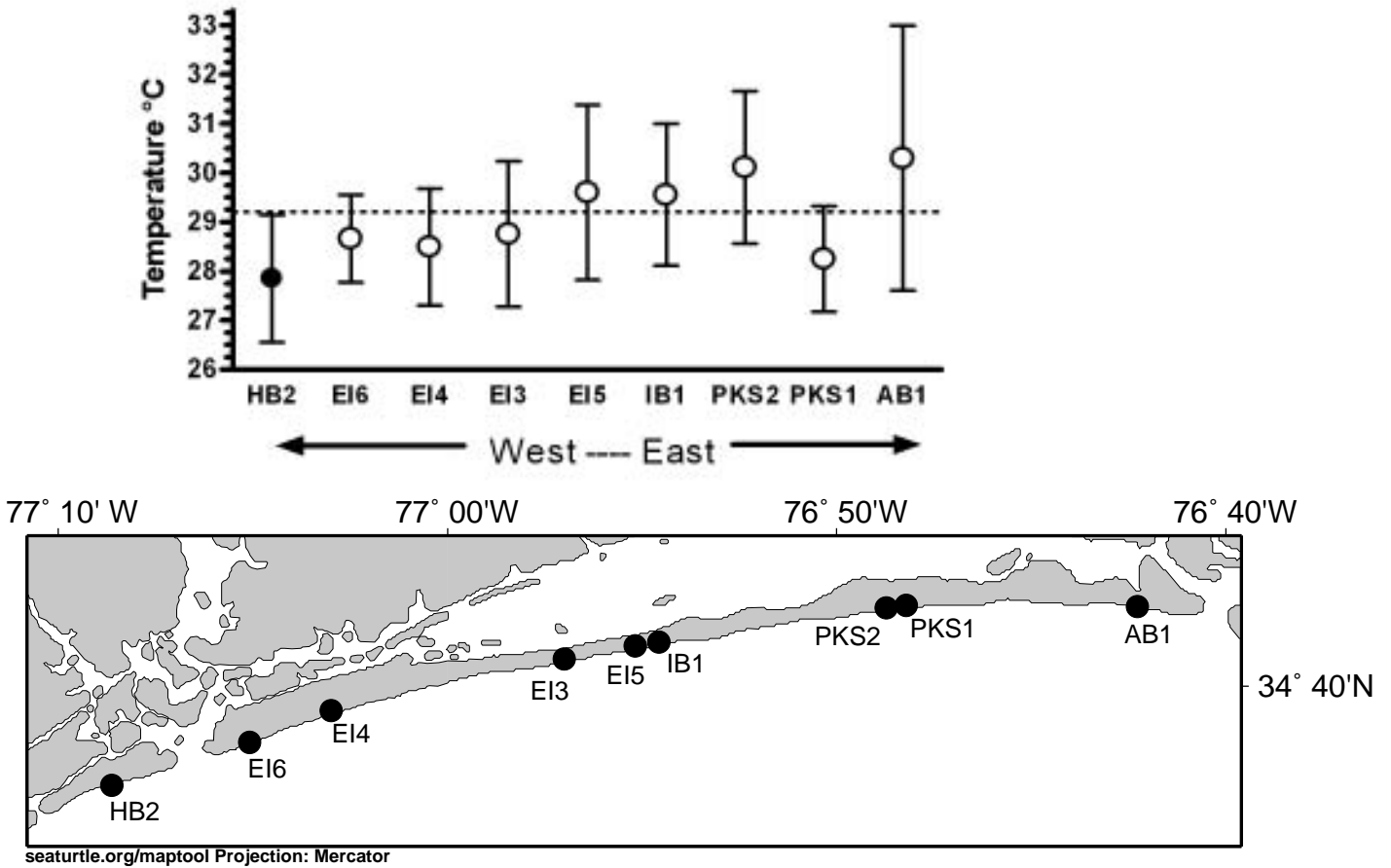


Figure 5. Upper panel: mean temperatures during the middle third of incubation nests laid 4 June \pm 7 days. Dotted line represents the pivotal temperature for NC loggerheads (Mrosovsky 1988). Lower panel: geographic nest locations. Refer to Figure 1 for schematic of different phases of nourishment on Bogue Banks.

Sand Compaction

The cone penetrometer (Field Scout SC-900) that was used to measure sand compaction failed early in the nesting season; compaction data were collected from only six nests in 2006 (Figure 6). As in previous years, there was no clear pattern associated with the sand compaction data. It was impossible to get readings at a depth of 18 inches, as the sand was too compact. Despite this, turtles were able to successfully nest in this material and the eggs produced hatchlings (Appendix I). We did not collect any compaction data from False Crawls in 2006 (Appendix II). Overall, we suggest that compaction data collected with a cone penetrometer may not realistically reflect the relationship between sand compaction and the ability of sea turtles to successfully excavate a nest cavity and/or sea turtle hatchling production (Ackerman 1997).

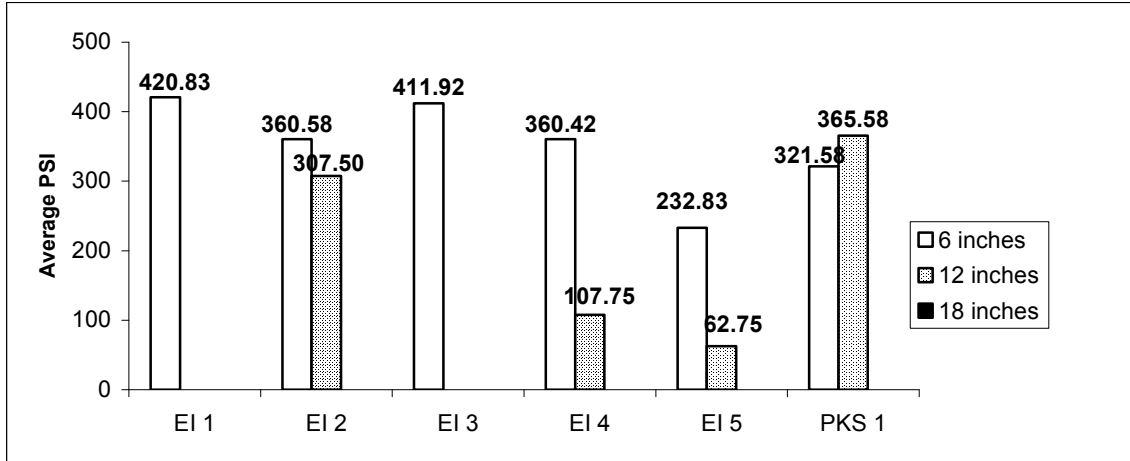


Figure 6. Sand compaction measurements taken from nests laid at the beginning of the nesting season. Mean values are given at the apex of each bar.

Conclusion

The Sea Turtle Monitoring Project has concluded five consecutive years of monitoring the impacts of beach nourishment on sea turtles on Bogue Banks, NC. As all study zones on Bogue Banks have received nourished material at some point in the last five years, it is important that Bear Island serve as a control site for this ongoing study. Regardless of the thermal impacts of nourished material on sea turtle hatchling sex ratios, the nourished zones of Bogue Banks continue to be used as nesting areas by adult females, with no perceived impairment on hatching success. Phase II of “Project 933” is scheduled to be completed before the start of the 2007 nesting season. The Sea Turtle Monitoring Project will continue to assess the effects of beach nourishment on sea turtle reproduction on Bogue Banks.

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Appendix I
Loggerhead sea turtle nests laid on Bogue Banks in 2006

Nest	Date Laid	Date Emerged	Lat.	Long	datalogger	ES	UH	PE	DH	LH	Success
AB 1	06/11/06	8/11/2006	34.69487	76.70452	# 868204	99	12	1	0	2	88.29%
AB 2	07/27/06	lost in TS	n/a	n/a	# 995151	0	0	0	0	0	0.00%
PKS 1	05/28/06	8/2/2006	34.69528	76.80342	# 875037	144	11	1	0	10	92.26%
PKS 2	06/08/06	8/3/2006	34.69455	76.81202	# 875034	104	45	0	1	0	69.13%
PKS 3	06/12/06	8/12/2006	34.69221	76.83633	# 868203	87	39	1	1	3	67.46%
PKS 4	07/01/06	8/23/2006	34.69220	76.83681	# 868202	97	7	0	1	0	92.31%
PKS 5	08/11/06	cold nest	34.69586	76.79566		4	47	1	0	4	5.88%
IB 1	06/08/06	8/5/2006	34.68228	76.90933	# 875044	60	60	9	4	7	39.17%
IB 2	06/19/06	8/16/2006	34.68787	76.87226	# 875035	88	16	1	1	0	82.69%
IB 3	07/02/06	9/27/2006	34.68843	76.86906		116	2	0	0	0	98.31%
IB 4	07/17/06	9/6/2006	34.68795	76.87261		110	18	1	0	0	85.16%
SP 1	08/10/06	lost in TS	n/a	n/a		0	0	0	0	0	0.00%
SP 2	08/19/06	n/a	34.68568	76.89700		0	18	0	0	0	0.00%
EI 1	5/20/2006	n/a	34.65669	77.05032	# 875040	0	2	0	0	0	0.00%
EI 2	6/1/2006	n/a	34.65566	77.05429	# 875041	0	0	0	0	0	0.00%
EI 3	6/2/2006	8/8/2006	34.67638	76.95000	# 875042	58	16	0	0	0	78.38%
EI 4	6/2/2006	8/7/2006	34.06700	77.04968	# 875033	109	39	3	0	4	71.62%
EI 5	6/3/2006	7/30/2006	34.68094	76.91955	# 875032	120	4	1	2	30	94.35%
EI 6	6/10/2006	8/14/2006	34.64680	77.08476	# 875038	59	20	0	1	0	73.42%
EI 7	6/15/2006	8/10/2006	34.66895	76.99472	# 875036	134	4	0	0	5	97.10%
EI 8	6/20/2006	8/17/2006	34.66187	77.02744	# 868205	156	3	0	0	0	98.11%
EI 9	6/20/2006	8/15/2006	34.66888	76.93968	# 868206	113	11	1	0	0	90.32%
EI 10	6/24/2006	lost in TS	34.65498	77.05658	# 868201	0	0	0	0	0	0.00%
EI 11	6/29/2006	8/24/2006	34.67017	76.98755	# 868207	169	2	0	4	5	96.49%
EI 12	7/2/2006	8/27/2006	34.67090	76.98267		63	1	1	0	0	96.88%
EI 13	7/2/2006	8/25/2006	34.66751	77.00111		113	3	0	0	0	97.41%
EI 14	7/3/2006	8/31/2006	34.66369	77.01972		121	1	0	0	0	99.18%
EI 15	7/14/2006	9/13/2006	34.65255	77.06638		100	18	0	1	0	83.90%
EI 16	7/18/2006	lost in TS	34.65032	77.07378		0	0	0	0	0	0.00%
EI 17	7/25/2006	lost in TS	34.67760	76.14151		0	0	0	0	0	0.00%
EI 18	7/27/2006	9/20/2006	34.39968	77.00554		109	8	0	0	0	93.16%
EI 19	7/30/2006	lost in TS	34.39445	77.02804		0	0	0	0	0	0.00%
EI 20	8/10/2006	cold nest	n/a	n/a		5	120	0	0	5	4.00%

Appendix II
 Loggerhead sea turtle false crawls on Bogue Banks in 2006

Date	Beach	location	Lat.	Long
6/9/2006	Emerald Isle	3 plots E of Nina	34.66564	77.01013
6/14/2006	Emerald Isle	2 plots E of 1200	34.67964	76.92973
6/14/2006	Emerald Isle	Spinnakers Reach	34.64930	77.07729
6/15/2006	Emerald Isle	2 plots E of 10100	34.64847	77.08034
6/26/2006	Pine Knoll Sh.	121 Dogwood Cir	34.69438	76.81382
7/1/2006	Emerald Isle	6907 W Ocean Blvd	34.66599	77.00991
7/13/2006	Emerald Isle	Near Islander Motel	34.65533	77.05540
7/14/2006	Emerald Isle	east of Nest 14	34.66370	77.01949
7/18/2006	Emerald Isle	east of Nest 01	34.65668	77.04995
7/25/2006	Emerald Isle	b/t 18th and 19th St.	34.67760	76.14151
7/28/2006	Indian Beach	1807 Ocean Drive	34.68362	76.90162
7/29/2006	Emerald Isle	6300 Ocean Blvd	34.66816	76.99721
8/2/2006	Emerald Isle	9415/9417 Ocean Dr	34.69125	77.04053