FINAL REPORT

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October 1, 2016 – September 30, 2021

Project Title: Optimal nesting microhabitat for Diamondback Terrapins, *Malaclemys terrapin*, in South Carolina

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Project Location: Charleston, SC - Charleston Harbor estuary

Edisto Island and Bennett's Point, SC, ACE Basin NERR

Project Type: Implementation/Research

Project Goal: This project will identify the nest conditions (temperature) optimal for maximum hatching success, hatchling survival, and growth of Diamondback Terrapins (*M. terrapin*) as well as the limits of environmental and biological variables that produce successful nests.

Objective 1 : Identify the range of habitats (physical and biological) of nesting Diamondback Terrapins. Nesting areas will be selected based on observation of nesting activity (identifying crawls, nesting females, and areas of known previous nesting activity) in both natural (limited human activity) and disturbed areas (increased human activity). Environmental habitat parameters will be characterized (microhabitat, vegetation, and temperature).

Accomplishments:

Study Sites - The study sites during the five years of this study were modified as a result of extreme beach erosion and disruptive human activity during the COVID-19 pandemic; modifications included both elimination of sites and additions (Table 1). Changes in the sites were made to optimize data collection within the parameters of this objective of identifying the range of conditions within Diamondback Terrapin nesting habitats. The periods of the study sites were as follows:

- 2017 - Two nesting areas were monitored in the Charleston Harbor (Grice Beach and Plum Island; Fig. 1) and two were selected in the ACE Basin NERR (Botany Bay and Bennett's Point; Fig. 1). Areas were chosen based on data collected from a previous SWG project, evidence of prior nesting activity (observations of tracks or "crawls"), and long-term monitoring of terrapin populations through monthly trammel net surveys since 1995. We selected two sites in 2017 that were classified as "limited disturbance" habitat (Grice Beach and Botany Bay) defined by natural environments unchanged by human development (landscaping, roads, structures) that experienced human activity in the form of boat or pedestrian traffic only. The two sites defined as "disturbed" (Plum Island and Bennetts Point) were characterized by the presence of nearby roads, buildings and landscaping and experienced significant human activity. Initially the assertion was a comparison between the “disturbed” and “limited disturbance” sites would be valuable in assessing the potential for nest success assuming an increase of human-subsidized predators (raccoons, feral cats) would be present in “disturbed” sites.

- 2018 – There were two changes in study sites in the 2018 season. Based on observation from the 2017 season, there was limited nesting activity in “disturbed” areas and a higher incidence of predators observed at the “limited disturbance” site at Botany Bay. For these reasons, we decided there was greater value to focus efforts on Grice Beach and Botany Bay in 2018 and 2019, which allowed for increased camera and temperature logger coverage in these areas. The second modification was a change in the area monitored on Botany Bay Island. In September 2017, Hurricane Irma caused significant erosion on the coast of South Carolina, and the original nesting beach located on the southern portion of the island was cut off due to the breakthrough of an inlet; the nesting habitat in 2018 was moved north (Fig. 2).
- 2019 - Continued beach erosion into 2019 and interference from human activity pushed the monitoring site even further north once more (Fig. 2). Grice Beach continued to be monitored.
- 2020 – An additional monitoring site was added in a residential neighborhood adjacent to Wappoo Creek, Stono River in Charleston, SC (Fig. 3). A citizen scientist (Dale Aren) has been observing and collecting data on Diamondback Terrapin females traveling from the creek and marsh that borders her property since 2017, and in 2020 she allowed us to work on her property to document nesting conditions.
- 2021 – In the last year of the study, Grice Beach was removed from the study. The closing of beaches and boat ramps during the COVID-19 crisis in 2020 resulted in a dramatic increase in human traffic. There were no “crawls” observed on Grice Beach in 2020, presumably due to humans not only occupying the beach, but also recreating in the shallow waters adjacent to the beach. The Botany Bay monitoring location was moved a final time when we observed multiple terrapin crawls just north of Pockoy Island (Fig. 2). This area was also protected and closed to visitors of the beach to allow shorebirds to nest in the habitat. For these reasons, the area was extremely valuable in characterizing nesting habitat.

Figure 1. A map of the four areas monitored in 2017.

Figure 2. A map of the four areas monitored at Botany Bay Island from 2017 – 2021.

Figure 3. A map showing the location of the Wappoo Creek site added in 2020 with Grice Beach and Botany Bay sites for reference.

Temperature – Temperature loggers were deployed from 2017 through 2021 in five study sites along the South Carolina coast in the Charleston Area (Grice Beach, Plum Island, Wappoo) and in the ACE Basin (Botany Bay and Bennett's Point) in the years noted above. Eight HOBO TidbiT v2 temperature loggers (UTBI-001) were employed from 2017 - 2020 and twenty HOBO TidbiT MX (MX2203) temperature loggers were employed in 2021. Both products are built by Onset and have the same range (-20°C to 70°C), accuracy (+/-0.2°C) and resolution (0.01°C) and therefore measurements across models are comparable. The decision to replace the UTBI-001 model with the MX2203 was made when one of the UTBI-001 loggers malfunctioned due to diminishing battery power, despite the battery power percentage measuring over 75% prior to deployment. The non-replaceable batteries in UTBI-001 models are rated for five years and 2020 was the fourth year of use. The MX model batteries are rated for 3 – 5 years, are replaceable, and have the capacity to transmit data through Bluetooth connection allowing for periodic data downloads while the temperature loggers were buried in nesting sites.

The loggers were deployed in May through August each year during the months when Diamondback Terrapin, *Malaclemys terrapin*, nests are incubating. Loggers were programmed to record temperature and time every 10 minutes and they were placed in open areas and shaded areas to capture a complete range of temperatures experienced in nests. Loggers were fastened to a metal stake by twine for easy retrieval and buried in a hole 120 mm – 130 mm deep, the approximate nest depth dug by wild female terrapins. Temperature data from HOBO TidbiT v2 loggers were downloaded through HOBOware software (Onset) and the TidbiT MX logger data were downloaded through HOBOconnect (Onset) via Bluetooth. Both versions of Onset software converted data files to MS Excel and those files were imported into JMP 16.1.0 (SAS Institute, Inc.) for statistical analysis. The mean, standard deviation, minimum, maximum, and range of daily temperatures were summarized by year and month over 904 logger days (Table 1, Fig. 4).

Table 1. Mean, minimum, maximum and range of temperatures summarized by year (n= 904 logger days).

Year	Mean Temperature °C +/- SD	Mean Minimum Temperature °C +/- SD	Mean Maximum Temperature °C +/- SD	Mean Range Temperature °C +/- SD
2017	27.84 +/- 2.70	26.15 +/- 2.29	29.94 +/- 3.58	3.78 +/- 2.25
2018	29.72 +/- 2.16	27.35 +/- 1.99	32.64 +/- 2.78	5.29 +/- 1.98
2019	29.77 +/- 1.67	27.34 +/- 1.93	32.75 +/- 2.58	5.41 +/- 2.83
2020	28.33 +/- 3.03	26.40 +/- 2.61	30.82 +/- 4.12	4.42 +/- 2.98
2021	28.62 +/- 1.77	26.01 +/- 1.51	32.28 +/- 3.57	6.27 +/- 3.76

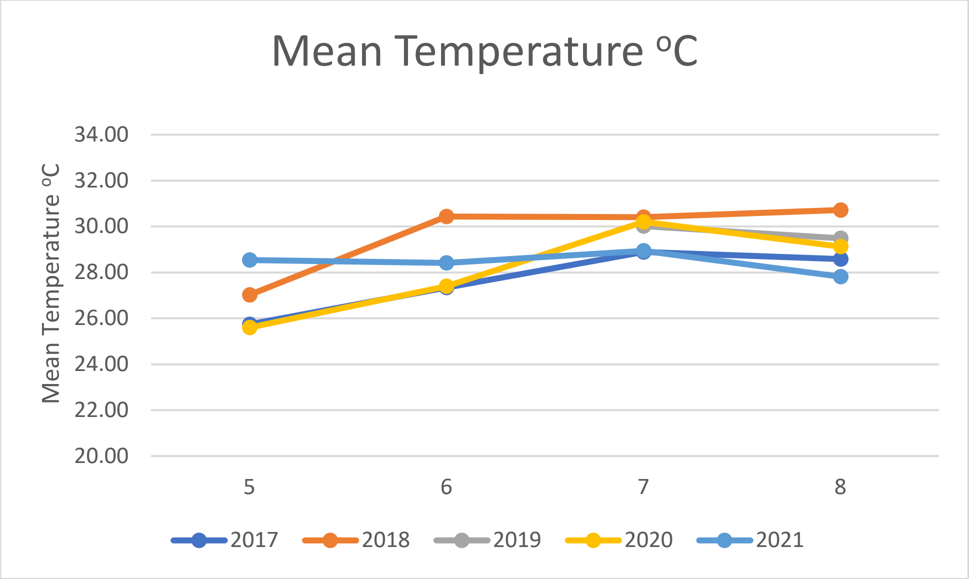

Figure 4. Mean temperatures plotted by month and year (n=904 logger days).

As Diamondback Terrapins have temperature dependent sex-determination with predominantly males being produced < 28°C and females being produced at temperatures >30°C (Jeyasuria and Place 1997), the mean temperatures seen over the course of the study would produce both sexes; however, males would most likely be produced only in nests laid in the earliest part of the nesting season.

Logger temperatures were compared in areas near vegetation versus those in open habitats with more sun exposure over the five-year study (2017-2021). The mean daily temperatures, daily maximum temperatures, and daily temperature ranges recorded in open habitats were significantly higher than those in vegetated habitats (unequal variance t-tests, $p<0.0001$, n=904; Fig. 5).

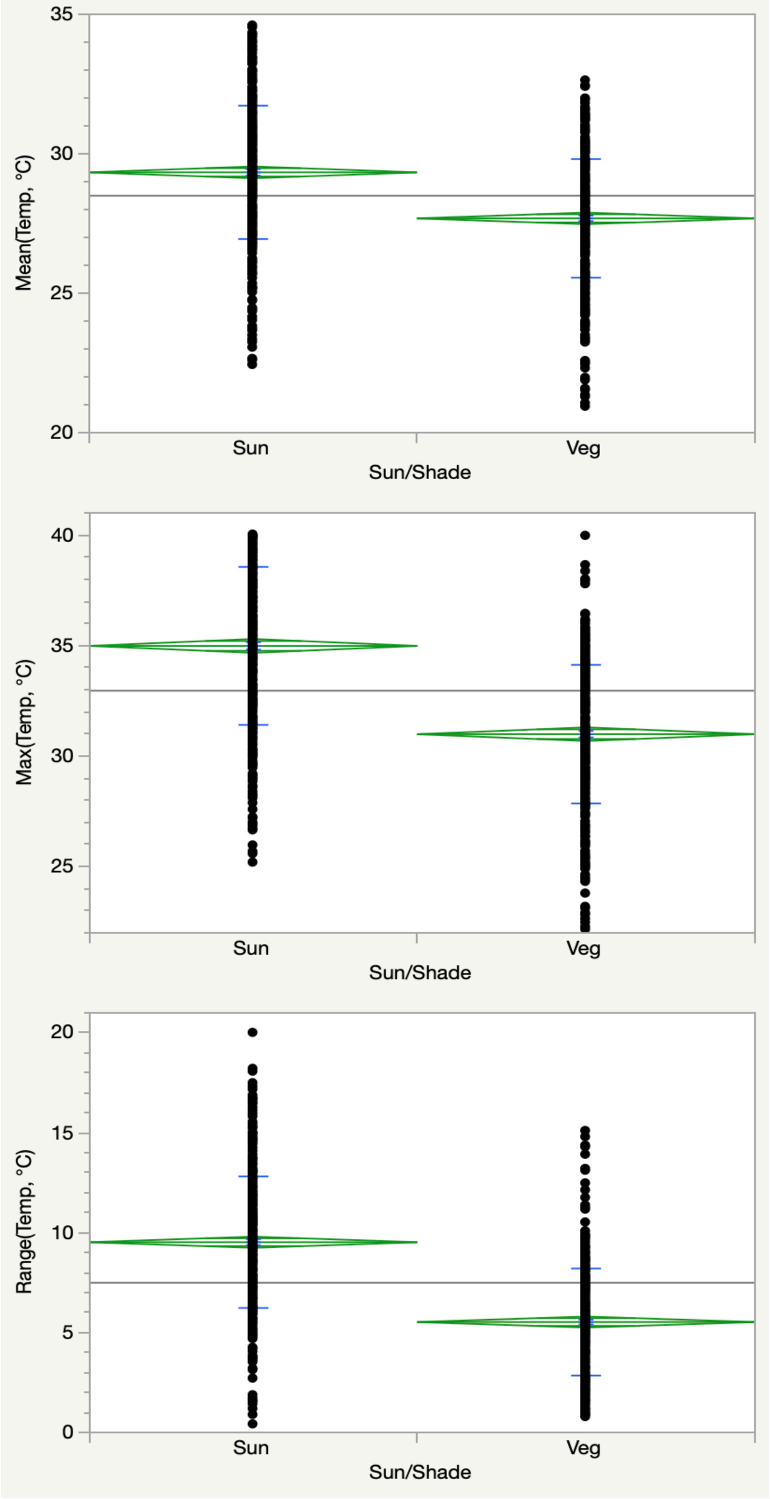

Figure 5. Mean daily temperatures, maximum daily temperatures, and daily temperature range recorded over 904 logger days for loggers in open habitat (sun) and vegetated habitat (veg).

Predator Activity - Wildlife cameras (either a Browning Strike Force or Stealth Cam Scouting camera) were deployed between May and August from 2017 through 2020 in each of the four study locations (during the years indicated above). Camera sites were selected based on locations of terrapin "crawls" and visual assessment of the areas to confirm suitable nesting habitat and best coverage of that habitat (Fig. 6). The cameras were programmed to take a series of still photos at 5 to 30-minute intervals from dusk to dawn (time-lapse), capture images upon being activated by motion, or a combination in order to best characterize predators present. One camera at each site was placed in an area that offered some shade, and the other was placed in a more exposed area. The HOBO TidbiT temperature loggers were tethered to the stakes used to mount the cameras. Each set-up was checked every 2-3 weeks to replace memory cards and batteries as needed.

Figure 6. a) Camera location on "limited disturbance" site (Grice Beach) and "disturbed" site (Plum Island).

After reviewing photographs from wildlife cameras in 2017, we determined that the locations did not have sufficient camera coverage. Since Plum Island and Bennett's Point had the fewest images of predators and because those sites did not provide habitat suitable for hatchling terrapins, we focused effort on Botany Bay and Grice Beach in 2018. Both of those areas provided both suitable nesting and hatchling environments. Predator images captured in 2018 did not significantly increase, so in 2019 we devised a new strategy to describe the potential predator assemblage.

Due to the limited scope of each camera and the expanse of habitat at each site, we used "baited" areas to attempt to draw potential predators into the scope of the cameras in 2019. Cameras were deployed in each of the two study locations (Grice Beach and Botany Bay; Fig. 3) in open dune habitat on July 24, 2019 and adjacent to vegetated habitat on July 31, 2019. These shorter deployment times were meant to focus on the initial vulnerability of recently laid nests marked by scent (as described below). Camera sites were selected based on locations of terrapin "crawls" and visual assessment of the areas to confirm suitable nesting habitat and best coverage of that habitat. These baited areas were designed so each of three cameras placed 3-5 m apart was directed to look towards a similar central point in a triangular configuration and would capture images triggered only by movement (Fig. 7). A "nest" was dug in the center of each camera set-up and a chicken egg was placed in the nest and buried. The chicken eggs were used to provide visual evidence that depredation had been attempted by predators. Approximately 120-130 mL of water that had been collected from containers of egg-laying female terrapins was poured in and around the false nest to provide additional sensory cues (hormones, pheromones) to attract predators. Two HOBO TidbiT v2 temperature loggers were placed in the site at a depth of 20-130 mm as previously described and programmed to record temperatures every 10 minutes.

Figure 7. Camera deployment to capture potential predators on Grice Beach.

This deployment technique did document four new potential predators: armadillos, bobcats, crows and minks (Fig. 8). Depredation of a false nest was only noted on one occasion on July 24, 2019 on Grice Beach in the open dune location by crows less than 1 day from the time of nest "deployment" (Fig. 9). In 2020 cameras were only deployed on Botany Bay because the human activity on Grice Beach was so high, images of people would have overwhelmed the memory cards and not provided any useful information. Visual observations of predators were only noted from the Wappoo Creek residential nesting site in 2020-2021; the citizen scientists frequently witnessed crows, snakes and raccoons attempting to depredate terrapin nests within 0-4 days post nest. Overall, cameras provided qualitative evidence of predators and disturbances encountered by terrapins on nesting beaches. There wasn't evidence that areas initially defined as "disturbed" had higher predator activity due to human-subsidized food availability; in fact, predator activity at the Botany Bay site was notable probably due to seasonal attraction of predators to the beach that hosts large groups of nesting shorebirds and sea turtles each year.

Figure 8. Images of potential predators of diamondback terrapin nests captured by wildlife cameras.

Figure 9. Image of crows depredating an experimental terrapin nest on Grice Beach.

<u>Objective 2:</u> Build nest boxes in chosen habitats to incubate eggs under natural conditions. Monitor temperature in nests throughout incubation.

<u>Accomplishments</u>:
Forty-one adult female terrapins were collected for this study during trammel net sampling by the Inshore Fisheries Section of the SCDNR between April and June 2021 during the months when terrapins are observed congregating and mating. Females were retained from St. Helena Sound, the Charleston Harbor, the Ashley River, and the Wando River. Female terrapins were brought to the Waddell Mariculture Center where they were held in flow through water systems and fed shrimp, ribbed mussels and periwinkles. Terrapins were brought back to the laboratory to be measured (carapace length, carapace width, plastron length, shell depth; Table 2), weighed, and implanted with a PIT tag. Each female was palpated to assess whether shelled eggs were present. Females were retained in tanks until shelled eggs could be felt through palpation; if eggs did not develop after 4 weeks, females were released at the point of initial capture.

Table 2. Sizes of female terrapins caught over various sampling dates defined by females from which eggs were collected (A) and females that did not contain eggs.

A)

Capture Date	Capture Location	# Females	Carapace Length Range (mm)	Plastron Length Range (mm)	Carapace Width Range(mm)	Carapace Depth Range (mm)	Mass (g)
4/9/21	AR	8	160 - 211	144 - 180	126 - 151	69 - 80	651 - 1227
4/15/21	CH	3	170 - 184	145 - 162	123 - 129	65 - 74	628 - 857
5/14/21	CH	2	163 - 165	145 - 152	122 - 154	70 - 73	762 - 811
5/25/21	LW	3	167 - 193	153 - 169	125 - 143	74 - 77	742 - 1052
6/8/21	LW	4	175 - 192	157 - 173	131 - 149	74 - 77	893 - 1099
6/10/21	AB	1	184	165	140	79	1022
6/11/21	AR	6	170 - 195	152 - 172	130 - 143	72 - 79	825 - 1245
			181 +/- 11	**160 +/- 9**	**136 +/- 9**	**74 +/- 7**	**915 +/- 153**

B)

Capture Date	Capture Location	# Females	Carapace Length Range (mm)	Plastron Length Range (mm)	Carapace Width Range(mm)	Carapace Depth Range (mm)	Mass (g)
4/9/21	AR	7	163 - 205	140 - 176	120 - 154	67 - 87	640 - 1222
4/15/21	CH	4	158 - 184	138 - 162	117 - 148	65 - 79	611 - 926
6/8/21	LW	1	173	157	130	69	809
6/10/21	AB	1	179	155	136	77	993
6/11/21	AR	2	180 - 183	161 - 166	135 - 139	74 - 75	930 - 954
			177 +/- 15	**155 +/- 12**	**133 +/-12**	**74 +/- 4**	**847 +/- 194**

Eggs were collected from females by inducing with 2 units of oxytocin per 100 g body weight (Tucker et al. 2007). Females were weighted just prior to injection, injected in the rear right leg, and then placed in a shallow freshwater container in order to provide a gentle environment for eggs once laid. Females were reinjected after 2-3 hours if there were still eggs present as could be felt through palpation. The time from injection to egg-laying varied from 30 minutes to multiple days. As each egg was released, they were collected and placed into a shallow plastic container with holes in the lid and perlite material inside to hold appropriate moisture. The containers were labeled with the unique female PIT tag number, the number of eggs collected and the date, and placed into an incubator at 28-29°C until eggs could be transported to the nesting site. Eggs were generally collected the day prior to placing them in one of two nesting locations (Botany Bay and Wappoo Creek). However maximum time between egg collection was 3 days and occurred if females did not lay all of the eggs in their clutch in a 24-hour period. Following egg collection, we collected a tail tip for future genetic analysis from each female terrapin, and they were all released at the site of capture.

Eggs were transported via plastic containers with perlite by clutch in a small cooler to mitigate temperature. At Botany Bay, the eggs were placed in created "nests" north of the path from the parking lot to the beach. The large shorebird nesting area served as the study region for most of the clutches. This area was marked by signs warning not to enter the area due to shorebird nesting activity and was defined by posts and line. This area was characterized by clumps of grasses (primarily American Beachgrass, *Ammophila breviligulata*) and small shrubs (Seashore Elder, *Iva imbricata*) that offered very little shade. The substrate was white sand and some mixed crushed shell. The area was above the main slope of the beach, just behind a gentle dune line and was bordered on the western edge by Spartina marsh. Sea turtles used this area heavily for nesting as well. Between May and the end of June, evidence of approximately 20 Diamondback Terrapin crawls (tracks to and from nesting sites) were witnessed by biologists on trips to bury eggs and monitor previously created nests. Crawls were also reported by shorebird and sea turtle biologists as they patrolled the beaches. Most of these crawls came and returned to the direction of the Atlantic Ocean rather than from the marsh edge. However, depredated nests were observed on two occasions in the dirt and grass covered parking lot adjacent to the marsh. Depredated nests were also observed on numerous occasions and were often found with predator tracks leading to the nest, mainly raccoon tracks. Therefore, this nesting area was an exceptional choice for this study investigating nesting temperature effects on hatching success, survival, and initial growth as it serves as a nesting beach chosen by wild female diamondback terrapins, and therefore the nesting temperatures recorded are also reflective of temperatures experienced in wild nests. Several crawls and female terrapins were observed in an area just south of the shorebird nesting area also directly adjacent to the front beach but characterized by maritime forest and soils composed of organic material in addition to sand. This area did offer significant shade from palmetto trees, saw palmettos and low shrubs.

The second nesting site was in the neighborhood that has been monitored for five years by a citizen scientist in the Charleston area. The neighborhood is adjacent to salt marsh on the Stono River. At high tide, female terrapins have easy access to the property through flooded marsh and several creeks and return to nest in successive years. They are observed by the homeowners until a nest is laid. The nest is then marked and the females captured by hand, scanned for a PIT tag, implanted with a tag if none is detected, measured (CL, PL, Width), weighed and released back to the marsh. Terrapins most often choose to dig nests along a gravel path around a manicured garden adjacent to the marsh (Fig. 10). The soil is well drained but retains moisture from watering while mulch and gravel reduce evaporation; ample shade provided by landscaping and native live oak trees also allows for retention of moisture in the soil.

Over the course of the 2021 nesting season, 27 clutches were collected for a total of 183 eggs. Eighteen total nests were buried on Botany Bay but only twelve made it the entire study period; two nests were predated upon at the beginning of the study and four more were depredated even after the cage design was improved. Observation of these nests indicated that predation in these nests was due to ghost crabs that burrowed under the cages. Nine nests created at the Wappoo Creek site survived the entire incubation period without being disturbed by predators.

Figure 10. Female nesting at the Wappoo Creek study site.

The first two nests on Botany Bay were covered with flat, 15 mm opening mesh with 200 mm stakes that were pulled from the sand by predators five days after they were buried and depredated. Successive cages used on Botany Bay were the same as used for sea turtle nests (Fig. 11): 50 mm x 75 mm opening size wire mesh was cut into 0.5 m x 0.5 half "boxes" that could be buried deeply in the sand to make it difficult for predators to disrupt. The wire mesh placed directly on top of the nests with 150-200 mm stakes method was proven successful in the Wappoo Creek suburban nest location over the past five years on natural terrapin nests due to the more compacted soil, so that method was employed (Fig. 11). All nests in the Wappoo Creek Site survived the entire incubation period without disturbance from predators. All created nests were dug to 120-130 mm deep to approximate natural nests, and a HOBO TidBiT MX2203 temperature logger was placed at the same depth beside the nests and tethered to the cage (Fig. 12). Temperature loggers were placed next to nests to reduce the potential of egg damage should the temperature logger be pulled from the ground by force (this happened on several occasions from disturbance by humans and predators). Eggs were collected from the nests between 45-55 days post the initial dig date, and the final few days of incubation were completed in incubators set to 28.5^{o}C in order to retain all hatchlings and not lose them to emigration from the nests.

Figure 11. On the left is a cage used to protect nests at Botany Bay and at the right is the design used at the Wappoo Creek site.

Figure 12. Eggs and HOBO TidbiT MX2203 temperature logger in experimental nest on Botany Bay, SC.

Mean clutch size was 6.74 eggs/clutch (range 2-10 eggs/clutch). Mean female mass was 915 g and the smallest female that produced eggs was 628 g. Mean hatching success across 21 nests that endured the entire incubation period was 75.6% (Botany Bay 70.8% and Wappoo Creek 82.0%). Three nests were not viable and did not produce any hatchlings; if these three nests are removed from analysis, the overall hatching rate rises to 88.2%. There was no significant trend in hatching success with female mass ($P>0.05$). However, a Standard Least Squares model (JMP, SAS Institute, Inc.) showed that Site, Mean Maximum Daily Temperature, and Mean Daily Temperature Range were significant effects in predicting hatching success ($p<0.0001$, $R^2=0.709$). A 100% hatch rate occurred in nests with mean daily temperatures between 27.3°C-29.9°C, a mean maximum no greater than 35.2°C, and a mean daily range no greater than 9.2°C. Hatching rate decreased significantly with increasing mean maximum daily temperatures and mean daily range in temperatures (Fig. 13). The mean, maximum and range of daily temperatures were significantly higher at the Botany Bay site (unequal variances t-tests, $p<0.0001$), and hatching success was significantly lower there. Mean time to hatching was 56.7 days with incubation time ranging from 49 -62 days. Botany Bay clutches hatched significantly sooner (t-test, $p<0.0036$) at 54.8 days compared to 59 days until hatching began for Wappoo Creek clutches.

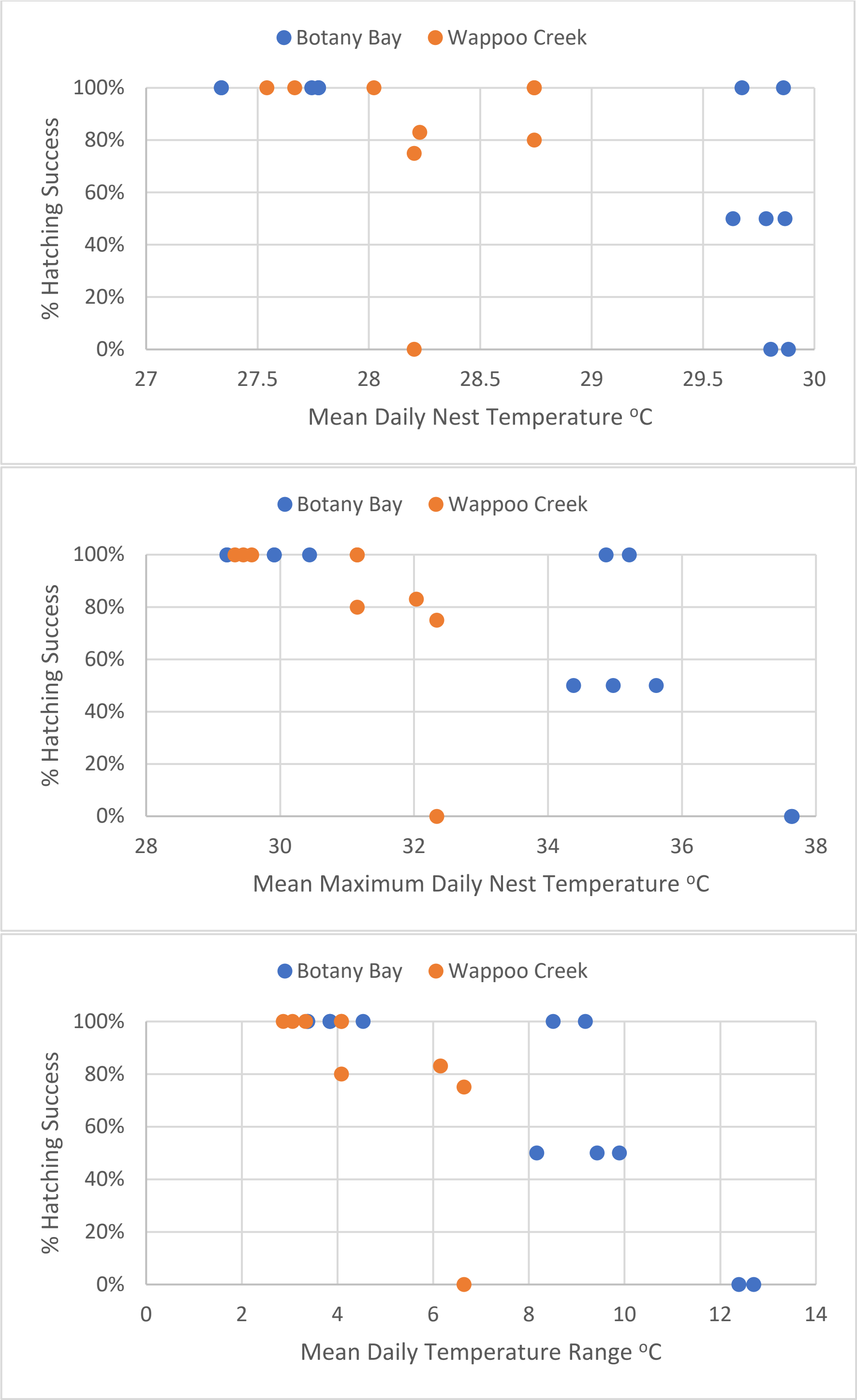

Figure 13. Hatching success of each nest by the mean daily nest temperature, mean maximum daily temperature, and mean daily temperature range (°C) over the course of the nesting period by site.

<u>Objective 3.</u> Assess survival and growth of hatchling terrapins hatched in varying nesting temperatures and raised in hatchery tanks.

<u>Accomplishments</u>:
Hatchlings (n=112) were retained in incubators until the yolk sac was completely resorbed. Hatchlings were measured with calipers (Carapace Length, Carapace Width, Plastron Length, Depth; Table 3) and weighed just prior to placement in 20-gallon aquariums. Terrapin hatchlings were fed an Aquatic Turtle Hatchling diet (ZooMed) three to four times a week to satiation. All hatchlings were measured two times per month until their release on November 10, 2021 at the point of female capture. Tail tips were collected from each hatchling for future genetic analysis.

There was no significant difference in final hatchling weight when clutch mean incubation temperature was considered (n=18 nests, p>0.05; Fig. 14) and there were no mortalities of hatchlings during the course of the study.

Table 3. Mean mass (g), carapace length, carapace width, plastron length and depth (mm) of hatchlings at first measurement and just prior to release.

	Mean Mass (g) +/- SD	**Mean CL (mm) +/- SD**	**Mean CW (mm) +/- SD**	**Mean PL (mm) +/- SD**	**Mean Depth (mm) +/- SD**
First measurement (6-10 days old)	8.91 +/- 2.05	34.6 +/- 1.2	28.7 +/- 1.2	29.4 +/- 2.1	17.0 +/- 0.7
Last measurement (83-111 days old)	15.80 +/- 4.33	40.2 +/- 3.3	32.4 +/- 2.6	33.2 +/- 2.8	19.0 +/- 1.4

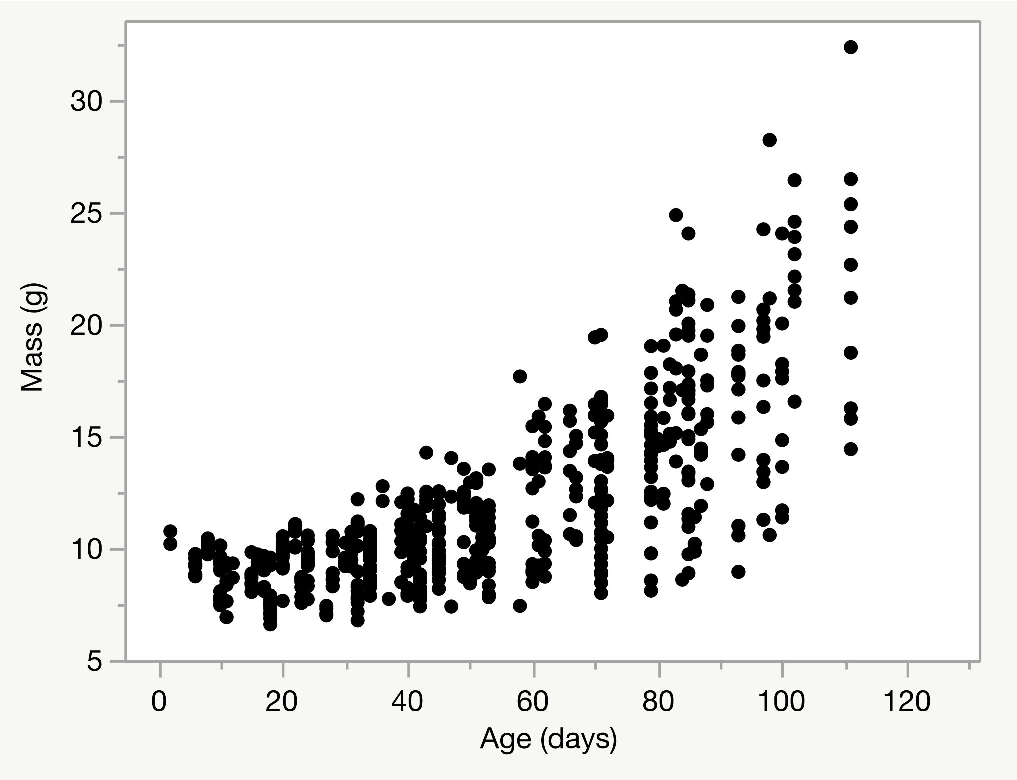

Figure 14. Mass of hatchlings by age (days) or days post hatch (n=112).

Recommendations: Botany Bay did not prove to be a refuge from predators as initially suspected, probably due to predators cueing to feed on this beach as seabirds and sea turtles use this area to nest. Furthermore, the extreme erosion of Botany Bay Island that made it necessary to move the study site repeatedly is drastically affecting the available nesting habitat for terrapins. Extreme high tides have been shown to decrease nest success in terrapin nests in northeast Florida (Butler et al. 2004). Coastal erosion throughout the range of terrapins will likely greatly reduce available suitable nesting habitat. Focusing efforts on conservation of areas less susceptible to erosion and efforts to mitigate for erosion responsibly would be most efficient.

The nesting study showed significant decreases in hatching success with increased temperatures. There were significantly higher temperatures and greater temperature ranges recorded throughout the five years of the study in open areas exposed to full sun versus vegetated habitat. The Botany Bay site, which has greater open habitat with little vegetation, exhibited significantly higher daily mean temperatures, maximum temperatures, and daily range of temperatures compared to the Wappoo Creek study area, which has significant vegetative cover to provide shade. Preserving vegetated habitats such as hammock islands in nesting beach areas that provide thermal refuge could be vital in preserving Diamondback Terrapin populations in the future.

Areas of increased temperatures will likely suffer decreased hatching rates sooner as climate changes causes nest temperatures to rise. Monitoring temperatures in various nesting habitats at nesting depth can be used to model potential hatching success by extrapolating from a smaller group of Diamondback Terrapin nests on natural beaches, and similar methods have been used to model hatching success in

Hawksbill (*Eretmochelys imbricata*), Green Turtles (*Chelonia mydas*) and Leatherback (*Dermochelys coriacea*) sea turtle nests (Laloë et al. 2016; Tanabe et al. 2020). The method of "planting nests" of induced eggs employed in this study is necessary to accumulate data on wild hatching success since Diamondback Terrapin nests are highly elusive and crawls often disappear in soft sand, making them poor markers of nest site.

Close the grant.

Significant deviations: Due to the erosion at Botany Bay, the location of the survey has changed each year. The change in location from 2017 to 2018 was due to the creation of a new inlet which cut the original study area away from the main island. The 2018 (1 km NE from initial site) study location has been altered significantly due to increasing erosion, and in the 2019 season it was experiencing wash-over from tides and wave activity. Upon consultation with biologists working on the island monitoring sea turtle nests, the study location was moved northeast (2.6 km from 2018 site) where hundreds of sea turtle nests were located and where terrapin activity had been noted (Fig. 5). COVID-19 sampling restrictions also shifted the nesting study from 2020 to 2021 and instigated increased human disturbance at Grice Beach, making it impossible to conduct the study there after 2020. However, the need to make alternate plans also created the opportunity to work with the citizen scientist, Dale Aren, in 2020-2021 on her property that is frequented by wild female terrapins during nesting season.

Estimated Federal Cost: $159,469. Financial report to follow from MRD Grants Administration. Recommend closing the grant.

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