Utilization of Restored and Original Salt Marsh Habitat by Diamondback Terrapin

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ABSTRACT: The diamondback terrapin (*Malaclemys terrapin)* is an estuarine species residing along the Atlantic and Gulf Coastline, more specifically from Massachusetts to Corpus Christi, TX. Recently, this species has become the topic of conservation and research due to being harvested as a food source during the first half of the 20th century. Today, threats to this species include habitat loss via land conversion and development, road and boat mortality, and drowning in crab traps. In addition, grid-ditching for mosquito control may have an influence on this species. Due to government mandates, the once grid ditched areas have been "restored" to a marsh habitat, which all lie adjacent to the "untouched" original marshland[1]. Diamondback terrapin migrate through these estuarine, freshwater and salt marsh habitats, from mating areas to nesting locations each year. Using road encounter and hand-capture data from 2019 collections, we assessed terrapin utilization of "restored" vs "original" marshland areas at two different locations along Barnegat Bay, NJ. During peak migration season, we had a total of 88 road encounters on Great Bay Boulevard (GBBLVD) in Tuckerton, NJ, and 187 road encounters on Cedar Run Dock Road (CRDR) in West Creek, NJ. Using a null model, we discovered terrapin are more likely to move through original marsh (Z-test, p= 0.0168) on GBBLVD, however, no habitat usage preference was observed for CRDR, (Z-test, p= 0.0891). The research conducted herein can be utilized by conversationalists and researchers as additional knowledge for protection of this species through preservation and education efforts in the region.

INTRODUCTION.

Diamondback terrapin are an estuarine species found to inhabit brackish coastal waters, residing in swamps, lagoons, and tidal creeks, among others[1]. They reside mostly along the Atlantic and Gulf Coastline, from Massachusetts to Corpus Christi, TX[1]. Female terrapin may reach a maximum of 25 cm, while their male counterparts reach only 14 cm, making them more difficult to catch and observe for research studies[1]. Coloration is highly variable between terrapin; however, adult terrapin carapaces are generally a shade of grey with lighter colored concentric rings[1]. Recent threats to the continued survival of this species have made them the topic for conservation and research in the Atlantic Coastline region. Some of the main threats to this species include habitat loss, due to land conversion and development into homes and businesses along the inhabited area, road and boat mortality due to lack of education about the species in the area, causing little to no precaution when driving or boating near estuarine habitats, and drowning in crab traps due to bycatch in the nets and lack of above ground oxygen for terrapin respiration[1]. Another threat to terrapin survival is being used for as companion animals, despite their usage as pets being illegal in New Jersey, where the research was conducted herein[1,2]. Another earlier threat to terrapin was being used for terrapin stew in the United States[1]. Diamondback terrapin were exported in large quantities to several European countries for the making of this delicacy. In the late 19th century, during the peak of this food trend, 400,000 pounds of turtles were harvested annually[1]. By 1920, Diamondback terrapin populations had diminished severely, where only 823 pounds were harvested that year on the Chesapeake Bay[1]. Prohibition, as a main ingredient in the soup was alcohol, and the Great Depression in the United States helped reduce demand for Diamondback terrapins[1]. The main threat studied herein around Barnegat Bay, NJ, is the effects of grid ditching during the first half of the 20th century. Grid ditching was performed in the marshland areas around New Jersey in hopes of containing mosquito population, in an effort to stop the spread of zoonotic infectious diseases to humans[3]. This technique resulted in destruction of 90% of the Atlantic coastal marshes. Since then, this once lost marsh habitat has been "restored" and now sits adjacent to the "untouched" marshland. The focus of this research is to study the long-term effects of this grid ditching and subsequent habitat restoration by utilizing terrapin road encounter data to determine whether diamondback terrapin prefer the "original" or "restored" marsh habitat[1]. The importance of this research is to assess the population dynamics within the species in a certain area, to better allow for conservation and education programs to be formed in the region, to ensure survival of this species, and allowing them to be removed from the "species of special concern" list in New Jersey[3]. In addition, previous studies looking at the effect of terrapin soup in the early 20th century have shown that terrapin possess a vital role in the ecosystem and survival of other species and plants in their native habitat[4]. The research methodology conducted herein utilized an ongoing 3-year mark-recapture study, led by Dr. John Wnek, with the data represented here from the 2019 collection year. A simple method of road encounter capturing and measurement recording was used to assess the health of the terrapin, before being implanted with a PIT-tag, used to identify the terrapin, in addition to notching on the carapace, before being released back to the area which they were found.

MATERIALS AND METHODS.

Research data collection began on May 28th, 2019, the beginning of the mating season for diamondback terrapin. The date of the last data collection was done on July 12th, 2019 and indicated the end of mating season in that region. The research was conducted in Barnegat Bay, NJ, more specifically, on Cedar Run Dock Road (CRDR) in West Creek, NJ, and Great Bay Boulevard (GBBLVD) in Little Egg Harbor, NJ. Data between the two regions within Barnegat Bay was used separately when drawing conclusions between the two habitats. Road patrols were conducted every day from the indicated beginning of breeding season to the last day of breeding season, and were done in the morning between 7-8 am, when peak migration would occur, to match with the rising of the sun, midday, around 12-1 pm, when terrapin were most active, and 4-5 pm when they would be migrating back to the marshland waters. During each road patrol, any terrapin that were caught were marked using a non-toxic erasable sharpie with a unique number, in order, to correctly document the coordinates of where the terrapin was caught using a Garmin GPS hand-held coordinate device that was pinged at each place a terrapin was caught. All terrapin were placed in plastic holding vessels that allowed for easy transport back to Ocean County Vocational Technical School (OCVTS), where further documentation of health and PIT-tagging was performed. Once at OCVTS, each terrapin was taken from the holding vessels and data about carapace length, width and height, plastron length, weight, sex, approximate age, and subsequent comments about carapace and plastron health and overall condition of the terrapin were recorded and transcribed onto one Excel datasheet. Measurements about length, width and height were all done using an adjustable frame square ruler, measured in millimeters, while weight was measured in grams. Age was determined by counting the number of concentric circles found in any given scute on the terrapin's carapace. A unique 6-number notch code was carved into the turtle's carapace, using an industrial style file or Dremel and documented in the Excel spreadsheet as well. A Biomark brand passive integrated transponder tag was injected into the rear right leg using a Biomark specialized tool to hold the PIT-tag, after cleaning of the area was done with isopropyl alcohol and cotton balls. The ID number on the PIT-tag was then recorded in the Excel spreadsheet after implantation, to ensure accuracy and would allow for future recollection of the terrapin's ID, if it would be caught again in future research studies. Once all terrapin had been recorded, measured, tag implanted and notch engraved, they were taken back to the area which they were found and released. Any injured terrapin caught during road encounters were treated for their subsequent injuries, where after recovery they had the aforementioned data obtained and were released back into the habitat area where they were initially found, respectively. Additional information such as weather, temperature, tidal stage and time caught were also recorded for each terrapin. Once all data was compiled for the 2019 breeding year, each road encounter on either CRDR or GBBLVD was plotted according to GPS coordinates on Google Earth Pro, respectively. Once all coordinates had been plotted, distances in yards were measured straight from each point of encounter to mainland start and tip of peninsula, separately, using the ruler tool found in Google Earth Pro. Additional distances in yards from restored marsh end to mainland start and restored marsh end to tip of peninsula were also recorded separately for CRDR and GBBLVD, to be used for data interpretation. A null model was then created to assess the utilization of "restored" vs "original" marshland at two separate locations within Barnegat Bay, NJ.

RESULTS.

Using data from the 2019 collection year only, it was found terrapin are more likely to move through original marsh (Z-test, p= 0.0168) on GBBLVD, however, no habitat usage preference was observed for CRDR, (Z-test, p= 0.0891).

Image 1. Satellite snapshot image of Great Bay Boulevard. Shows documentation of all terrapin caught in the 2019 year only, and their subsequent locations. HC= Hand Capture; RC= Road Capture

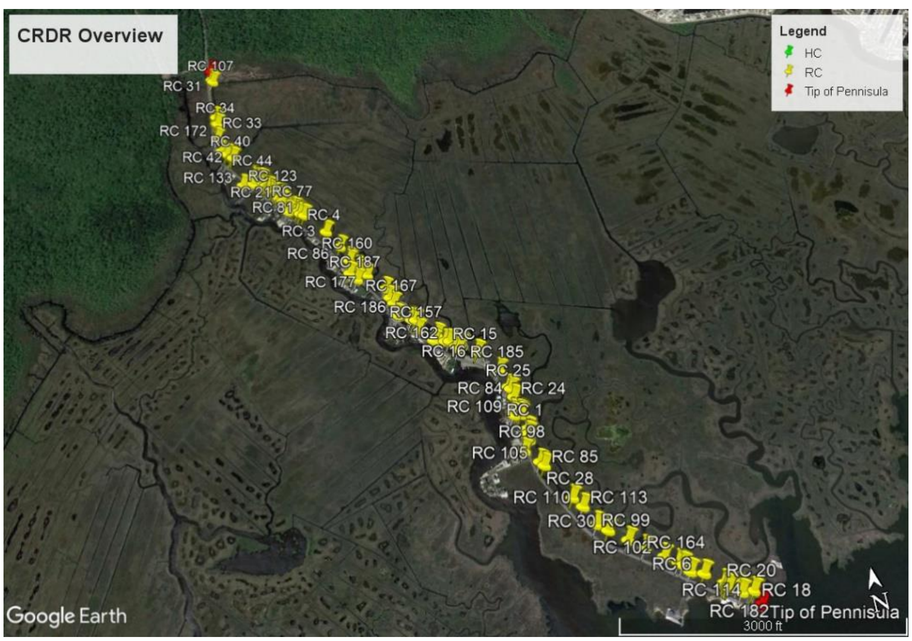


Image 2. Satellite snapshot image of Cedar Run Dock Road. Shows documentation of all terrapin caught in the 2019 year only, and their subsequent locations. HC= Hand Capture RC= Road Capture

Table 1. Details the latitude and longitude for each road capture found on GBBLVD, including distance from the mainland. These points were plotted onto Google Earth with each point labeled respectively.

Method:	**Latitude:**	**Longitude:**	**Distance in yards from mainland:**
RC 1	39.54771,	-74.332	4824.55
RC 2	39.54940,	-74.3332	5049.89
HC 1	39.54939,	-74.3322	5035.02
RC 3	39.54746,	-74.3317	4789.11
RC 4	39.55255,	-74.3357	5481.08
RC 5	39.55063,	-74.3342	5222.92
RC 6	39.52203,	-74.3188	1580.06
RC 7	39.52092,	-74.3189	1444.9
RC 8	39.52118,	-74.3189	1476.53
RC 9	39.54776,	-74.332	4829.74
RC 10	39.54939,	-74.3332	5051.99
RC 11	39.54939,	-74.3332	5049.89
RC 12	39.54369,	-74.3288	4284.46
RC 13	39.79492,	-74.119	39514.87
RC 14	39.55376,	-74.3366	5646.77
RC 15	39.5313,	-74.3192	2702.51
RC 16	39.53893,	-74.325	3656.74
RC 17	39.5446,	-74.3295	4406.08
HC 2	39.50953,	-74.32	58.23
RC 18	39.51145,	-74.3199	291.88
RC 19	39.54101,	-74.3267	3929.49
RC 20	39.56021,	-74.3407	6507
RC 21	39.57799,	-74.3447	8684.23
RC 22	39.5319,	-74.3198	2773.71
RC 23	39.51892,	-74.3191	1201.39
RC 24	39.54659,	-74.331	4672.02
RC 25	39.55174,	-74.335	5372.1
RC 26	39.53575,	-74.3227	3250.18
RC 27	39.51892,	-74.3191	1200.88
RC 28	39.51176,	-74.3198	329.48
RC 29	39.53614,	-74.3229	3299.47
RC 30	39.59505,	-74.3368	10561.91
HC 3	39.59505,	-74.3464	10730.37
RC 31	39.54255,	-74.328	4133.69
RC 32	39.522283,	-74.3188	1610.51
RC 33	39.5565,	-74.3387	6019.62
RC 34	39.549933,	-74.3337	5124.15
RC 35	39.546467,	-74.331	4656.76

Table 1. ***(Cont'd)***

RC 36	39.5249,	-74.3186	1929.22
RC 37	39.517667,	-74.3193	1048.53
RC 38	39.52495,	-74.3186	1935.12
RC 39	39.55555,	-74.338	5891.51
RC 40	39.547217,	-74.3315	4756.49
RC 41	39.547217,	-74.3315	4756.49
RC 42	39.650683,	-74.2528	18319.29
HC 5	39.64825,	-74.2478	18220.71
RC 43	39.538117,	-74.3245	3553.51
RC 44	39.547233,	-74.3315	4758.85
RC 45	39.53184,	-74.3196	2765.23
RC 46	39.54039,	-74.3265	3851.72
RC 47	39.53808,	-74.3246	3548.95
RC 48	39.53339,	-74.3211	2955.9
RC 49	39.51323,	-74.3197	508.74
RC 50	39.53183,	-74.3196	2765.23
RC 51	39.53183,	-74.3196	2765.23
RC 52	39.53183,	-74.3196	2765.23
RC 53	39.53362,	-74.3211	2977.2
RC 54	39.57458,	-74.3442	8271.87
RC 55	39.52128,	-74.3189	1488.34
RC 56	39.57066,	-74.3435	7797.39
RC 57	39.53295,	-74.3207	2901.62
RC 58	39.54727,	-74.3315	4763.3
RC 59	39.5676,	-74.3429	7425.02
RC 60	39.54926,	-74.3332	5034.31
RC 61	39.54505,	-74.3298	4465.05
RC 62	39.55015,	-74.3338	5153.1
RC 63	39.54441,	-74.3294	4381.46
RC 64	39.51599,	-74.3194	845.15
RC 65	39.53083,	-74.3189	2646.06
RC 66	39.55469,	-74.3373	5773.37
RC 67	39.56322,	-74.3419	6890.04
RC 68	39.56316,	-74.3419	6885.08
RC 69	39.55581,	-74.3383	5928.58
RC 70	39.55603,	-74.3383	5954.71
RC 71	39.52569,	-74.3184	2025.94
RC 72	39.52947,	-74.3183	2484.44
RC 73	39.55423,	-74.337	5710.9
RC 74	39.55579,	-74.3381	5922.67
RC 75	39.55663,	-74.3388	6037.51
HC 6	39.534,	-74.3232	3052.51
RC 76	39.53105,	-74.319	2672.62

Table 1. ***(Cont'd)***

RC 77	39.56066,	-74.3411	6570.43
RC 78	39.55206,	-74.3354	5418.15
RC 79	39.51789,	-74.3192	1075.96
RC 80	39.51055,	-74.32	184.12
RC 81	39.53965,	-74.3257	3751.84
RC 82	39.54284,	-74.3281	4171.18
RC 83	39.54532,	-74.33	4501.25
RC 84	39.54539,	-74.3301	4506.1
RC 85	39.53388,	-74.3212	3015.93
RC 86	39.5433,	-74.3285	4232.43
RC 87	39.55929,	-74.3403	6389.9
RC 88	39.5457,	-74.3303	4552.33

Table 2. Details the latitude and longitude for all terrapin caught on CRDR and their respective distances from the mainland. These points were plotted on Google Earth and their points labeled, respectively.

Road capture:	Latitude:	Longitude:	Mainland to point (yards)
1	39.65018	-74.252670	2,159.76
2	39.6599	-74.260710	775.9
3	39.65837	-74.259060	1,006.01
4	39.65837	-74.259060	1,006.01
5	39.65547	-74.256830	1,404.15
6	39.64481	-74.247630	2,958.78
7	39.65328	-74.254680	1,738.54
8	39.6507	-74.252810	2,105.46
9	39.6507	-74.252810	2,105.46
10	39.64443	-74.247020	3,024.50
11	39.6507	-74.252810	2,105.46
12	39.65071	-74.252800	2,105.26
13	39.64432	-74.246980	3,040.35
14	39.66054	-74.261170	692.78
15	39.65294	-74.253850	1,810.65
16	39.65294	-74.253850	1,810.65
17	39.65718	-74.258290	1,171.27
18	39.64403	-74.246030	3,112.66
19	39.65328	-74.254680	1,738.54
20	39.64403	-74.246030	3,112.66
21	39.65996	-74.260730	769.14
22	39.6507	-74.252810	2,105.46
23	39.66096	-74.261490	634.58
24	39.65121	-74.252860	2,037.69

Table 2. ***(Cont'd.)***

25	39.65149	-74.252900	2,009.97
26	39.65149	-74.252900	2,009.97
27	39.6568	-74.258010	1,218.41
28	39.64777	-74.251670	2,461.46
29	39.65061	-74.252770	2,107.11
30	39.64661	-74.250680	2,630.20
31	39.66566	-74.263070	48.48
32	39.66394	-74.263110	252.42
33	39.66367	-74.263130	288.56
34	39.66364	-74.263090	292.68
35	39.66227	-74.262860	457.85
36	39.66208	-74.262630	483.33
37	39.66208	-74.262630	483.33
38	39.66208	-74.262630	483.33
39	39.66208	-74.262630	483.33
40	39.66208	-74.262630	483.33
41	39.66208	-74.262630	483.33
42	39.66207	-74.262620	483.33
43	39.66122	-74.261820	483.33
44	39.66106	-74.261780	615.69
45	39.66102	-74.261630	624.99
46	39.661	-74.261650	626.15
47	39.661	-74.261650	626.15
48	39.64403	-74.246020	3112.66
49	39.64403	-74.246020	3112.66
50	39.66066	-74.261350	675.21
51	39.66066	-74.261350	675.21
52	39.66066	-74.261350	675.21
53	39.66066	-74.261350	675.21
54	39.66057	-74.261220	685.96
55	39.66039	-74.261100	710.64
56	39.66039	-74.261100	710.64
57	39.66024	-74.260890	733.43
58	39.66024	-74.260890	733.43
59	39.66024	-74.260890	733.43
60	39.66024	-74.260890	733.43
61	39.66024	-74.260890	733.43
62	39.66024	-74.260890	733.43
63	39.66013	-74.260770	750.25
64	39.66013	-74.260770	750.25
65	39.64429	-74.246910	3,045.09
66	39.66008	-74.260750	755.11
67	39.65966	-74.260490	810.79

Table 2. ***(Cont'd.)***

68	39.65966	-74.260490	810.79
69	39.65956	-74.260300	828.15
70	39.65956	-74.260300	828.15
71	39.64429	-74.246910	3,045.09
72	39.64429	-74.246910	3,045.09
73	39.65664	-74.258400	1,214.40
74	39.6533	-74.254470	1,749.72
75	39.6533	-74.254470	1,749.72
76	39.65954	-74.260250	831.48
77	39.65954	-74.260250	831.48
78	39.65937	-74.260120	854.71
79	39.65937	-74.260120	854.71
80	39.65927	-74.260040	869.05
81	39.65918	-74.259880	883.88
82	39.64429	-74.246910	3045.09
83	39.66081	-74.261520	650.61
84	39.65121	-74.252830	2,038.91
85	39.6489	-74.252400	2,306.35
86	39.6577	-74.258590	1,096.69
87	39.64948	-74.253020	2,219.46
88	39.65316	-74.254590	1,755.39
89	39.66089	-74.261830	635.70
90	39.66089	-74.261830	635.70
91	39.64997	-74.252690	2,178.78
92	39.64997	-74.252690	2,178.78
93	39.65381	-74.255330	1,651.91
94	39.66082	-74.261930	642.17
95	39.65545	-74.256930	1,407.21
96	39.65456	-74.256270	1,534.48
97	39.64948	-74.253020	2,219.46
98	39.64948	-74.253020	2,219.46
99	39.64621	-74.250040	2,697.59
100	39.64997	-74.252670	2,178.78
101	39.65451	-74.256230	1,538.90
102	39.64552	-74.248900	2,824.63
103	39.64685	-74.251050	2,590.13
104	39.64997	-74.252690	2,178.78
105	39.64904	-74.252530	2,289.16
106	39.65157	-74.252970	1,995.03
107	39.66557	-74.263020	5,745.00
108	39.66081	-74.261520	650.61
109	39.65064	-74.253060	2,090.27
110	39.64745	-74.251370	2,509.82

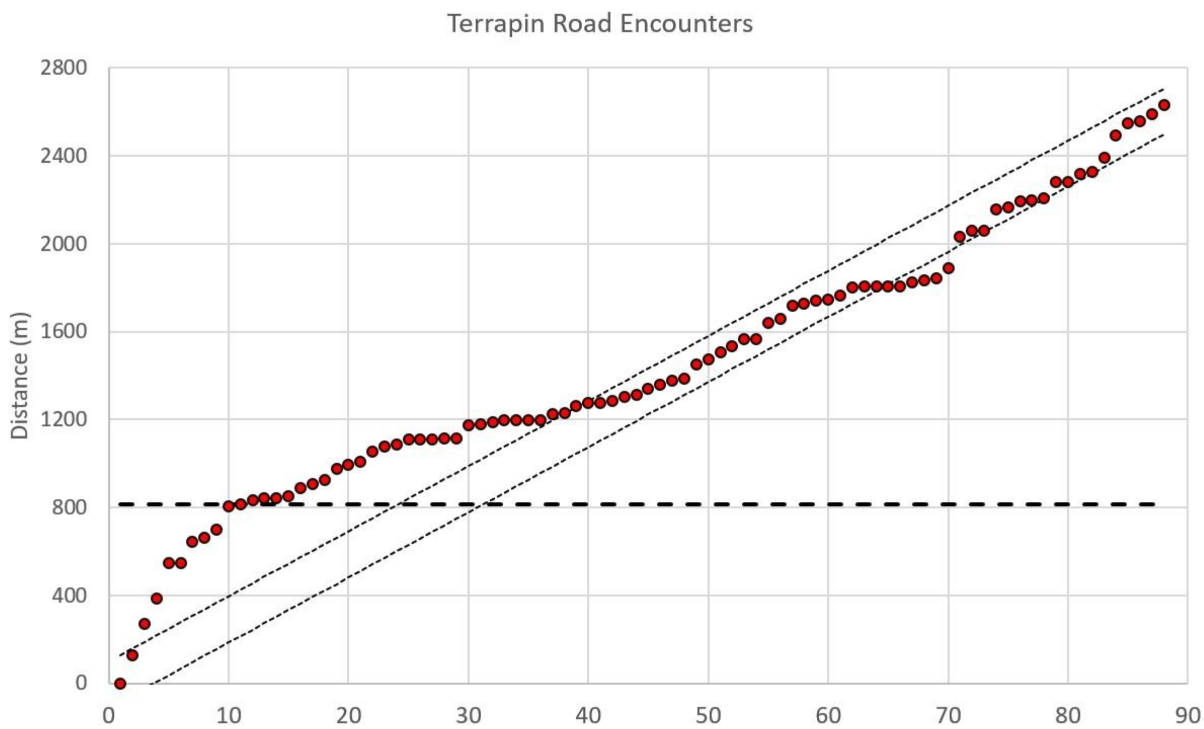
Table 2. ***(Cont'd.)***

111	39.6533	-74.254470	1,749.72
112	39.64587	-74.249530	2,758.89
113	39.64745	-74.251370	2,509.82
114	39.64403	-74.246020	3112.66
115	39.6533	-74.254470	1,749.72
116	39.64429	-74.246910	3,045.09
117	39.65478	-74.256780	1,485.38
118	39.6533	-74.254470	1,749.72
119	39.6533	-74.254470	1,749.72
120	39.6533	-74.254470	1,749.72
121	39.6533	-74.254470	1,749.72
122	39.6533	-74.254470	1,749.72
123	39.66032	-74.260990	722.59
124	39.64997	-74.252690	2,178.78
125	39.66047	-74.261250	697.84
126	39.6533	-74.254470	1,749.72
127	39.65478	-74.256780	1,485.38
128	39.6566	-74.257840	1,245.70
129	39.64403	-74.246020	3112.66
130	39.64495	-74.248110	2,919.84
131	39.65076	-74.253060	2,076.70
132	39.65946	-74.260570	832.21
133	39.66085	-74.262360	637.00
134	39.65364	-74.255520	1,662.15
135	39.65076	-74.253060	2,076.70
136	39.65478	-74.256780	1,485.38
137	39.65478	-74.256780	1,485.38
138	39.6533	-74.254470	1,749.72
139	39.6533	-74.254470	1,749.72
140	39.6533	-74.254470	1,749.72
141	39.6533	-74.254470	1,749.72
142	39.65478	-74.256780	1,485.38
143	39.65478	-74.256780	1,485.38
144	39.65478	-74.256780	1,485.38
145	39.6533	-74.254470	1,749.72
146	39.65478	-74.256780	1,485.38
147	39.6533	-74.254470	1,749.72
148	39.64429	-74.246910	3,045.09
149	39.64429	-74.246910	3,045.09
150	39.64495	-74.248110	2,919.84
151	39.64495	-74.248110	2,919.84
152	39.64429	-74.246910	3,045.09
153	39.64495	-74.248110	2,919.84

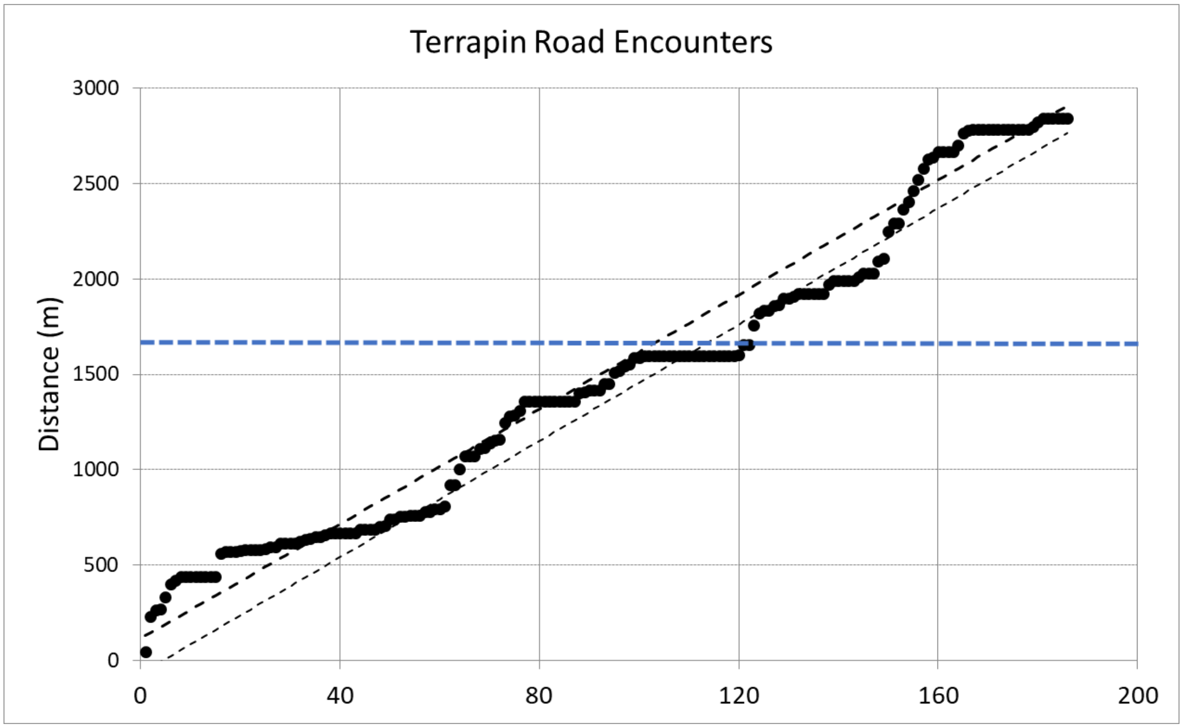
Table 2. ***(Cont'd.)***

154	39.6533	-74.254470	1,749.72
155	39.6533	-74.254470	1,749.72
156	39.65414	-74.256020	1,588.25
157	39.65414	-74.256020	1,588.25
158	39.65478	-74.256780	1,485.38
159	39.65478	-74.256780	1,485.38
160	39.65711	-74.258310	1,171.18
161	39.65581	-74.257040	1,362.80
162	39.6535	-74.254880	1,700.92
163	39.66006	-74.260840	753.51
164	39.64527	-74.248440	2,874.93
165	39.64517	-74.248310	2,885.22
166	39.64425	-74.246550	3,064.53
167	39.65523	-74.256820	1,436.51
168	39.65447	-74.256070	1,551.51
169	39.65711	-74.258310	1,171.18
170	39.64978	-74.252710	2,199.55
171	39.66244	-74.263080	436.11
172	39.66302	-74.263190	364.34
173	39.66098	-74.261590	630.25
174	39.65447	-74.256070	1,551.51
175	39.65447	-74.256070	1,551.51
176	39.65353	-74.255060	1,692.02
177	39.65644	-74.257680	1,267.83
178	39.64429	-74.246910	3,045.09
179	39.65927	-74.260040	869.05
180	39.64429	-74.246910	3,045.09
181	39.64429	-74.246910	3,045.09
182	39.64407	-74.246490	3,087.72
183	39.64429	-74.246910	3,045.09
184	39.6533	-74.254470	1,749.72
185	39.65128	-74.253150	1,922.06
186	39.65478	-74.256780	1,485.38
187	39.65636	-74.258140	1,261.34

From the tables and pictures listed above, we were able to calculate the distance from the tip of peninsula to mainland start for each location. For GBBLVD the total distance from tip of peninsula to mainland start was 8,628.64 yards. The distance from mainland start to where adjacent restored marshland ends was 2,650.75 yards. This data was then compiled to form a null model graph to assess the preference of habitat for terrapin on GBBLVD. For the data set pertaining to CRDR, the total distance from tip of peninsula to mainland start was 3,159.26 yards. The distance from mainland start to where the adjacent restored marshland ends was 1,810.28 yards. The null model was used by the theory if we randomly assigned turtles to positions along the peninsula, we would get our "expected" pattern of distances for each terrapin if there was no preference of habitat. Using a randomization routine derived from a "flat" probability distribution and iterated 1,000 times, the distances were then averaged for the terrapin, ranked 1 through 88, as seen in the "observed" data set. Deviation was then calculated to give the upper and lower bounds. This same theory was applied to both CRDR and GBBLVD to give an interpretation of each data set.



Graph 1. Null model graph for GBBLVD road encounters. This applies the theory listed above in graphical format to show the correlation of habitat preference for diamondback terrapin on GBBLVD. Red dots are captured turtles, ranked from zero distance (the mainland) to maximal distance (the tip of the peninsula), in meters. Upper thin dotted line is the upper bounds of the "expected" distribution based on the null model. The lower thin dotted line is the lower bounds. The thick dashed line represents the break point where habitat transitions from restored marsh (below 800 m) to original marsh.



Graph 2. Null model graph for CRDR road encounters. This applies the theory listed above in graphical format to show the correlation of habitat preference for diamondback terrapin on CRDR. Black dots are captured turtles, ranked from zero distance (the mainland) to maximal distance (the tip of the peninsula), in meters. Upper thin dotted line is the upper bounds of the "expected" distribution based on the null model. The lower thin dotted line is the lower bounds. The thick blue dashed line represents the break point where habitat transitions from restored marsh to original marsh, 1650 m.

Limitations to the study include the usage of only one year for both GBBLVD and CRDR, as collection was only made for GBBLVD in the 2019 calendar year. Additionally, research points for CRDR in 2017 and 2018 proved inaccurate in some GPS coordinates, whereas all collection points made in 2019 were found to be accurate. This ensures a more reliable result, however, is not as inclusive to trends over subsequent years in regard to population reproduction. 88 total terrapin were encountered via road findings on GBBLVD in 2019, whereas 187 total terrapin were encountered via road findings on CRDR in 2019.

DISCUSSION.

Great Bay Boulevard

Based on the average ranked distances for turtles on GBBLVD, we would have expected to get about 27 turtles on restored marsh, if it were random with no preference for habitat selection. However, our observed value was 10. Using a z-test to statistically assess the distance, the observed vs expected is statistically different, with a p value of 0.00168. This means there are fewer terrapin captured in restored marsh than expected at random, and more in the original marsh. This interpretation reveals that terrapin in this area of Barnegat Bay, NJ, have a habitat preference of original marshland, compared to the "restored" marshland, lying adjacent to it. This result can be used in further research studies conducted in the same area to assess further population dynamics on GBBLVD, such as relative abundance of terrapin in each habitat area, to see if the trend continues each year, and can be used in conservation when picking areas to have designated protected breeding areas, where researchers move eggs in an "at risk" area to a protected area with netting and fencing around the nest to ensure survival of newly hatched terrapin.

Cedar Run Dock Road

Using the same method described above for interpretation of GBBLVD, the z-test for CRDR was not statistically significant (*p*= 0.0891). This interpretation provides that there is no statistical difference between the observed and expected terrapin in restored marsh. In comparison to GBBLVD, the reason for the lack of statistical significance could be a result of having about twice as many terrapin captured on CRDR, where if that many were captured on GBBLVD it could alter the results to show no difference in habitat preference.

Suggestions for future studies could include the effect of habitat preference over a multiple year time span, to account for changing weather each year, while still capturing terrapin from the start of breeding season to the end of breeding season to get the most comprehensive results. Further questioning raised by this research is the effect of multi-year span habitat preference due to weather or natural disaster such as flooding that may consequently affect the survival and preference of terrapin in that region. Additionally, whether distance more northward may have an effect on terrapin preference due to change in temperature, as terrapin are more likely to venture out for breeding and nesting in warmer weather. CRDR is 21,648 yards farther North than GBBLVD and may cause differential changes in habitat preference.

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