Title
Road ecology of the northern diamondback terrapin, Malaclemys terrapin terrapin

Authors
Szerlag, Stephanie
McRobert, Scott P.

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Road Ecology of the Northern Diamondback Terrapin, *Malaclemys Terrapin Terrapin*

Stephanie Szerlag (Phone: 215-350-6827, Email: ss298823@sju.edu, sszerlag@hotmail.com), Graduate Student, and **Scott P. McRobert** (Phone: 610-660-1833, Email: smcrober@sju.edu), Advisor, Saint Joseph's University, Department of Biology, 5600 City Avenue, Philadelphia, PA 19131, Fax: 610-660-1832

Abstract: Diamondback terrapin populations along the East Coast have suffered due to a number of factors since the early 1900's. Overexploitation from commercial harvesting, drowning in fishing gear, and loss of habitat has had a negative impact on the terrapin (Roosenburg 1991). Terrapins in several areas, specifically in New Jersey, are now threatened by an additional source of mortality, road mortality (Wood and Herlands 1997, Hoden and Able 2003), which could cause further declines in the abundance of this species.

Road mortality and ecology of the northern diamondback terrapin, *Malaclemys terrapin terrapin*, in the Jacques Cousteau National Estuarine Research Reserve was examined and compared to traffic patterns during the nesting seasons (May-July) of 2004 and 2005. Traffic-measuring devices were stationed on sections of Great Bay Boulevard (GBB), an access road through salt-marsh habitat to obtain traffic-volume estimates. A total of 1201 terrapins were observed on the road with 104 road mortalities (8.66%). In 2004, a significantly greater proportion of road kills was found in the section of the road with the highest traffic volume.

However, we did not see this same pattern in 2005 as road mortalities across the sections were fairly evenly distributed. There was a positive correlation between road kills and increasing traffic volume throughout the day observed in 2004. Three hundred terrapins were tagged with passive-integrated transponder (PIT) tags over the course of the study. The tagging portion of this study indicated that some females may have been returning more than once in the season to lay multiple clutches along the roadside and demonstrated nest-site philopatry by returning to the area where they were initially tagged.

The information gathered suggests that terrapins are attracted to the roadside as it meets the requirements for a suitable nesting habitat. Future mitigation, such as drift fencing and increased patrolling of the roads, is needed to help reduce road mortalities. Fencing will be proposed to be installed in the areas of greatest road mortality and of greatest nesting activity along Great Bay Boulevard for 2006.

Introduction

Road mortality is becoming a significant problem for the northern diamondback terrapin, *Malaclemys terrapin terrapin*. Since terrapins are a "Species of Special Concern" in New Jersey (N.J. Department of Environmental Protection, Division of Fish and Wildlife, N.J. Endangered and Non-Game Species Program website 2005), understanding the impact of road mortality is critical (Forman et al. 2003). Great Bay Boulevard (GBB), an 8.1-km paved access road running through fairly pristine salt-marsh habitat in the Jacques Cousteau National Estuarine Research Reserve (JCNERR), is the site of many deaths each summer. Since suitable nesting habitat exists along the side of the boulevard, adult female terrapins are at risk from collisions with vehicles. Accordingly, this detailed survey was conducted to evaluate the relationship between traffic, road occurrence, and road mortality along this road for 2004/2005.

The field work was conducted at Rutgers University Marine Field Station, Institute for Marine and Coastal Sciences, Tuckerton, New Jersey.

Methodology

Surveys of Great Bay Boulevard in the JCNERR were conducted during the terrapin-nesting season from May-July of 2004/2005. Transect sections were chosen based on bridges that divide the road and cross over the subtidal marsh creeks (figures 1 and 2). Approximately five-six days per week, eight to 10 surveys were completed each day for a total of 299 samples in 2004 and 272 samples in 2005.

TRAX I Plus Traffic Counters/Classifiers (Jamar Technologies Inc.) were stationed in the middle of the six transect sections of the road to measure traffic patterns.

GPS data points were recorded for all terrapins and plotted on aerial images using ArcView GIS to obtain distances to nearest major and extension creeks and bridges. Comparisons of road mortality between sections and were tested using Pearson Chi-Square Analysis. Spearman's Rank Order Correlation was used to test mortality rate and mean traffic volume during the hours of the day. Three hundred terrapins were tagged with 2 x 12-mm passive-integrated transponder (PIT) tags (Biomark Inc).

Figure 1. Map of the Jacques Cousteau National Estuarine Research Reserve in New Jersey, where Great Bay Boulevard is located.

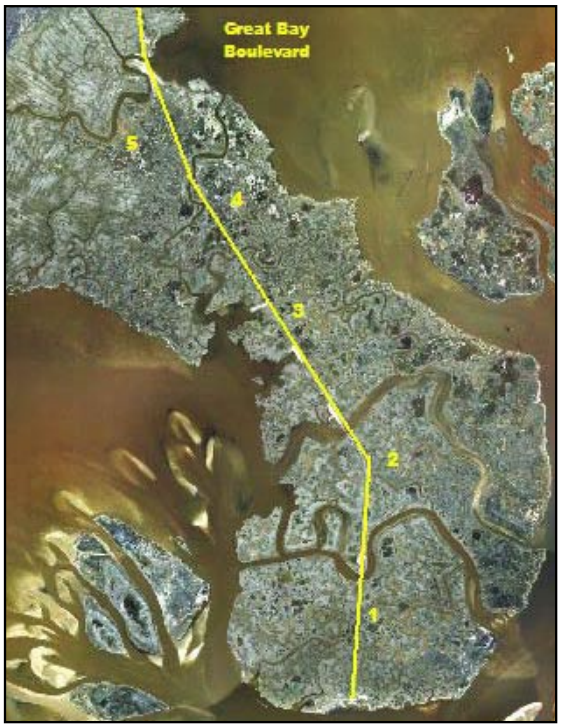

Figure 2. Aerial image of Great Bay Boulevard with defined transect sections within the Great Bay Wildlife Management Area of the Jacques Cousteau National Estuarine Research Reserve.

Results

- Numerous terrapins were observed each nesting season (N, 2004 = 601 and N, 2005 = 600) with peaks of nesting along the road around the lunar phases.
- Road mortality in 2004 was found to be significantly greater ($p < 0.001$) in section 6 and exhibited the highest traffic volume. In 2005, no differences were found between sections, except that section 2 had significantly less mortality ($p < 0.005$) (table 1).
- Most road-killed terrapins in section six were killed near creeks and bridges that intersect Great Bay Boulevard (table 2, figure 3).
- Road-mortality rates correlated positively with average traffic volume by hour in 2004 during our survey times of 0900-1600 ($p < 0.03$).
- Sixty five of 300 (21.67%) tagged terrapins were recaptured. One female crossed GBB a minimum of 5 times in the 2004 season.
- Some demonstrated possible multiple clutching and nest-site philopatry within and among years.

Table 1. Summary results of terrapin occurrences, mortalities, and average traffic volume (vehicles/day) by transect section on Great Bay Boulevard during the nesting seasons of 2004 and 2005

Transect Section	Live (2004)	Dead (2004)	Mean Traffic Volume (2004)	Live (2005)	Dead (2005)	Mean Traffic Volume (2005)
1	57	2 (3.39%)	233.70	83	4 (4.60%)	250.38
2	101	9 (8.18%)	262.71	96	**1 (1.03%)***	337.71
3	189	13 (6.44%)	363.36[a]	153	20 (11.56%)	621.39
4	84	8 (8.70%)	363.36[a]	91	13 (12.5%)	707.22
5	91	10 (9.90%)	464.00	84	7 (7.69%)	749.41
6	25	**11 (30.56%)****	936.00	42	6 (12.5%)	905.97
Total	547	53 (8.83%)		549	51 (8.5%)	

** ($P < 0.001$, $x^2 = 22.44$, df = 1)
* ($P < 0.005$, $x^2 = 8.299$, df = 1)
[a]*Estimated traffic volumes.*

Table 2. Summary results of terrapin road mortalities in relation to nearest creeks and a bridge along transect section 6 of Great Bay Boulevard

	Mean	Range	N
Straight-line distance (m) to nearest creek (major or extension) from:			
2004 road mortalities[a]	69.87	14.74-334.89	11
2005 road mortalities[b]	93.42	10.57-283.31	6
Straight-line distance (within 150 m) to nearest bridge from:			
2004 road mortalities[a]	130.25	93.36-148.87	6 (54.5%)
2005 road mortalities[b]	141.05	132.97-149.13	2 (33.33%)
[a]*Data from GPS telephone pole locations.* [b]*Data from GPS actual locations.*			

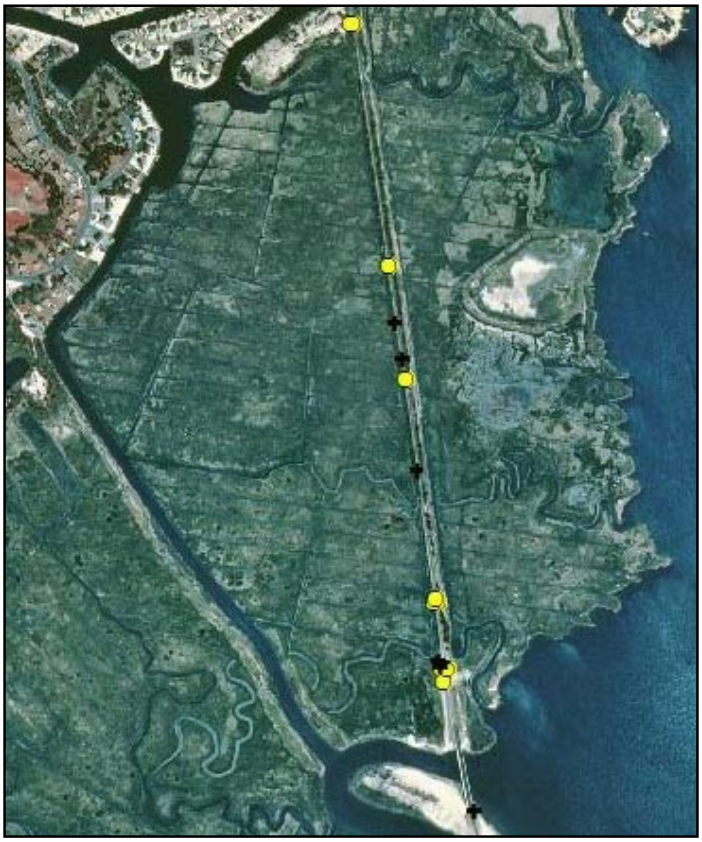

Figure 3: Aerial image of transect section 6 of Great Bay Boulevard 2004 (circles) and 2005 (plus signs) road mortalities. It appears some terrapins are being killed closer to the bridge and where the extensions of the creeks meet the road.

Discussion

Our findings are similar to past studies proposing that there are greater road mortalities of herpetofauna where there is greater traffic volume. Snakes have been observed to be more vulnerable to road mortality as traffic peaks during certain time periods (Rosen and Lowe 1994). A correlation has been shown between the number of mortalities and the number of vehicles on a road (Bernardino Jr. and Dalrymple 1992). It has been calculated that, for amphibians, the probability of being killed increases with greater traffic volume (Hels and Buchwald 2001). Fahrig et al. (1995) also suggested that the proportion of dead frogs and toads increased with traffic intensity, while the number of live animals surrounding the roadway decreased.

This study, which has provided us with new information regarding areas of greatest nesting and highest mortality rates, will assist in determining mitigation strategies. A project to install drift fences to reduce terrapin mortality along Great Bay Boulevard has been proposed for the 2006 breeding season.

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Research was conducted in accordance with the Saint Joseph's University Institute Animal Care and Review Committee (IACUC protocol #: PR-0503) and under the State of New Jersey, Department of Environmental Protection, Division of Fish and Wildlife permits #0423 and # 0521 issued to Rutgers University Marine Field Station and its seasonal employees.

Biographical Sketch: Stephanie Szerlag received her B.S. in biology, marine option at Millersville University of Pennsylvania in 2001. She is currently a M.S. in biology graduate student at Saint Joseph's University and plans to defend her thesis in December 2005. This document serves as background material and as partial preparation of her thesis manuscript.

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