ABSTRACT

Title of Document: EXCLUDING MAMMALIAN PREDATORS FROM DIAMONDBACK TERRAPIN NESTING BEACHES WITH AN ELECTRIC FENCE

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Over the past century, diamondback terrapin (*Malaclemys terrapin*) populations in the Chesapeake Bay region of the United States have declined from their historic abundance. One factor contributing to the decline is increased predation on terrapin nests by raccoons (*Procyon lotor*) and foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*). We studied the use of electric fences to deter these predators from nesting beaches along the lower Patuxent River, Calvert and St. Mary's Counties, Maryland. Over the two-year study, the predation rate within treatment (fenced) plots was 40% (4 of 10 nests) compared to 69% (20 of 29 nests) in control plots. We believe that electric fences have potential as a conservation technique for reducing mammalian predation on diamondback terrapin nests.

EXCLUDING MAMMALIAN PREDATORS FROM DIAMONDBACK TERRAPIN NESTING BEACHES WITH AN ELECTRIC FENCE

By
Team Saving Testudo

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Chapter 1: Introduction

The University of Maryland's motto, "Fear the Turtle," refers to the diamondback terrapin (*Malaclemys terrapin)*, a unique reptile integrated into the history, economy, and culture of the state of Maryland and the East Coast of the United States. Unfortunately, the diamondback terrapin population is in decline, and the species is currently listed as threatened in Massachusetts and as a species of concern in at least four states along the East Coast (Natural Heritage…2008). It is clear that, in the Chesapeake Bay ecosystem, humans have had a substantial and negative impact on the terrapin and its environment. There is a great need to reverse this trend—after all, who can fear a turtle that no longer exists?

The diamondback terrapin has long been part of the East Coast watershed ecosystem. The species "terrapin" refers to a broad group of brackish water turtles that are further divided into several subspecies based on region and morphology. Terrapins inhabit the estuaries, coastal rivers, and mangrove swamps all along the East Coast and the Gulf of Mexico and have played a role in local society for over two centuries. Terrapins, once abundant, were an integral part of Native American lives and legends. Some tribes, including the Cherokee, maintain legends that include turtles in creation tales. The terrapin name comes from Native American languages; they were called "torope" by Virginia Algonquians, "turepe" by Abenakis, and "turpen" by Delawares, which means "edible" or "good tasting." In addition, when European colonists first arrived, terrapins, so abundant that they annoyed fishermen who ended up catching them instead of fish, were quickly noted as a good source of meat, a quality that would eventually lead to their decline (Brennessel 2006).

Terrapin popularity was at its highest in the 1800s when terrapins became widely used in soup and stews. As their popularity increased, so did their price, and during the 1850s, some fisheries priced a dozen large terrapins at more than $100. Considered gourmet and upscale, they were a favorite at the White House, especially under President William Howard Taft's term. Many terrapin recipes were available, but a favorite was terrapin soup. The demand spread across the world, and terrapins were exported to Europe and South America in substantial numbers (Brennessel 2006).

In the late 1800s and early 1900s, people began to create commercial terrapin farms. Terrapins were caught by "tarpinners" who used long poles to tap in the mud for the turtles. "Tarpinners" also used dogs and boats to drag rakes through the mud in hopes of trapping the terrapins. The commercial terrapin farms were unsuccessful, mainly due to the inability of caretakers to raise large numbers of the reptile (Brennessel 2006).

After being used in fine cuisine for many decades, terrapin populations received some relief as interest in them began to decline in the 1920s. They were no longer as abundant, and the exorbitant prices made them unpopular during the harsher times of Prohibition, the Great Depression, and two major wars. The demand for the diamondback terrapin, a reptile that had been a major part of the East Coast culture for some 200 years, was gone—unfortunately, it had already harmed the diamondback terrapin population.

In 1932, the University of Maryland, College Park, paid a tribute to the reptile by making it the university's official mascot. Then, in 1994, the state of Maryland made the diamondback terrapin the state's official reptile. Because of these new honors, the diamondback terrapin was thrust into the national spotlight and awareness of its troubled existence began to spread.

While they are currently well known for their historical and traditional value to the state of Maryland, terrapins also play an essential role in the ecosystem of the Chesapeake Bay watershed. The well-being of the watershed could be damaged without the diamondback terrapin population in the food chain to ensure the balance of the ecosystem. Because terrapins make up such a high percentage of the biomass within the ecosystem, they contribute to maintaining the food, nutrient, and energy balance (Appendix A). In addition, secondary consumers in the food chain, such as the terrapins, play a vital role in maintaining the balance of the salt marsh ecosystem in which they live. Terrapins prey upon primary consumers such as mollusks and snails; these primary consumers feed on salt grasses and other vegetation. If the populations of primary consumers are not regulated by secondary consumers, they grow too large and the primary consumers will destroy the marsh vegetation. Without vegetation, the salt marsh habitat can become quickly eroded, turning into uninhabitable mud flats (Silliman and Bertness 2002).

There are many factors that contribute to the diamondback terrapin's population decline in the Chesapeake Bay. First, because terrapins are considered a delicacy in some food markets and restaurants, they are being harvested for cuisine. Additionally, some fishermen use crab and eel pots for their livelihood; the unintended side effect is that these devices catch terrapins, trapping them underwater and eventually causing them to drown. Also, loss of sandy habitat due to shoreline stabilization efforts to protect human commercial and residential development makes it difficult for terrapins to nest. Lastly, terrapin populations are declining as a result of increased predation on their nests, and humans indirectly cause or contribute to this factor. Urbanization attracts predators such as raccoons (*Procyon lotor*) and foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), which can lead to higher predator densities in urban areas compared to rural areas (Adams 1994). The increased presence of these predators may greatly affect female terrapins during the nesting process when the turtles are highly vulnerable. Terrapins nest during the day and are in full view of any potential predators. Raccoons and foxes ravage terrapin nests and consume the eggs, depleting the possibility of a regeneration of the terrapin population. This combination of factors and several other causes have nearly taken the diamondback terrapin from the Chesapeake Bay ecosystem.

Because of human actions, the future of the diamondback terrapin is uncertain. Although a moratorium passed by the Maryland legislature in early 2007 prohibits the commercial harvest of terrapins (Appendix B), the species is still in trouble. We cannot ignore the call to make a difference in the survival of this one species, especially in light of the fact that hundreds of others are vanishing each year. Our research was conducted with the underlying purpose of promoting terrapin population growth and making a small, but meaningful difference in the preservation of the culture and tradition of the state. Our interest in the terrapin led to an extensive review of the scientific literature on the species and four field trips that are discussed in Chapter 2.

Chapter 2: Literature Review, Field Trips, and Current Study

To gain knowledge about terrapins and to formulate a research question, we conducted a scientific literature review and made field trips to a terrapin workshop, a wildlife research center, and potential research sites. Relevant studies provided useful information on the terrapin including, but not limited to, background on the species, nesting habits, and population decline factors. Some studies were reviewed but not cited in the text (Appendix C). In addition, the field trips provided us with the opportunity to discuss terrapin-related issues with experts in the field.

Scientific Literature Review

Terrapin Biology

The diamondback terrapin's anatomical features and biology make it a unique asset to the Chesapeake Bay ecosystem. Terrapins exhibit sexual dimorphism, physical differences between two sexes of the same species of an organism. One of the main distinguishing differences in diamondback terrapins is the great disparity in the size between mature males and females. Males mature at a much quicker rate than their female counterparts. Between the age of 4 to 7 years, males weigh an average of 275 g, with their plastron length (the bottom of the shell structure) reaching about 10 cm. Female terrapins, on the other hand, do not mature until around 8 to 13 years, when they reach an average weight of 1,000 g and an average length of 16 cm. Diamondback terrapins in the Chesapeake Bay area are known to be the largest subspecies, with females reaching 17.5 cm in length and 1,100 g (Figure 1). Males and females can also be differentiated by the size of their head and tail. Females have a much larger head than their male counterparts, but their tails are shorter and narrower (Brennessel 2006).

Figure 1. Female diamondback terrapin native to the Patuxent River, Maryland. (Team Saving Testudo Research Collection)

The markings on their shell, unique to each individual terrapin, help researchers determine the age of the terrapins with which they work. The scutes, which can be compared to scales on other organisms, make up the pattern on the carapace and the plastron. These scutes expand and grow with the terrapins to continue to accommodate them as they mature. Due to their period of hibernation each year, which typically occurs between the months of December and April, terrapins and their scutes grow inconsistently throughout the year. This leads to the deposition of keratin and pigment during each growth period, forming growth rings similar to those seen in trees. Each scute ring refers to one year of growth in a terrapin. However, as they age and the growth rate begins to decrease, the rings become more difficult to distinguish and age is harder to determine (Brennessel 2006).

Terrapins prefer brackish (somewhat salty) water. The absorption of excess salt from the surrounding environment is one of the major problems marine animals face. Because diamondback terrapins live in water of varying salinity, they must rely on osmoregulation, the regulation of the water concentration in their bodies' fluids, to maintain their internal levels of fresh water and salt concentrations. Terrapins have several adaptations that allow them to live in a constantly changing environment. One adaptation is a post-orbital salt gland, known as the lachrymal gland, which allows terrapins to produce salty tears. The lachrymal gland works in a manner similar to the kidneys, allowing terrapins to produce tears with high salt concentrations, thus excreting excess salt from their body. Also, a terrapin's skin and tissues are fairly impermeable to both sodium and water, simultaneously preventing salt from entering the body when the terrapin is in water with high salt concentrations and retaining water in the body's tissues (Brennessel 2006).

Although diamondback terrapins can excrete excess salt in various ways, they still rely on an external source of fresh water. When it is available in the environment, either through low-salinity water or rain, terrapins drink large amounts of fresh water to rehydrate (Brennessel 2006).

Habitat

Diamondback terrapins have a relatively large geographical range. They can be found along the coast of the Atlantic Ocean and the coast of the Gulf of Mexico, from Cape Cod in Massachusetts to Corpus Christi Bay in Texas (Ernst and Bury 1982). There are seven subspecies of the diamondback terrapin that live in certain areas along the coast (Ernst et al. 1994). The northern-most subspecies, *M. t. terrapin,* is the terrapin that resides in the Chesapeake Bay watershed (Burger and Montevecchi 1975).

These terrapins are unique among North American turtle species because they are indigenous to the brackish salt marshes along the coast (Ernst et al. 1994). Brackish water is a varying mix of salt water and freshwater that is often found along the ocean coast where freshwater rivers and streams run into the ocean. Brackish waters range in salinity from 0.5 to 30 g of salt per liter or 0.5 to 30 parts per thousand (ppt) (Por 1972). The Chesapeake Bay and other similar estuaries are prime examples of these brackish water conditions (Figure 2).

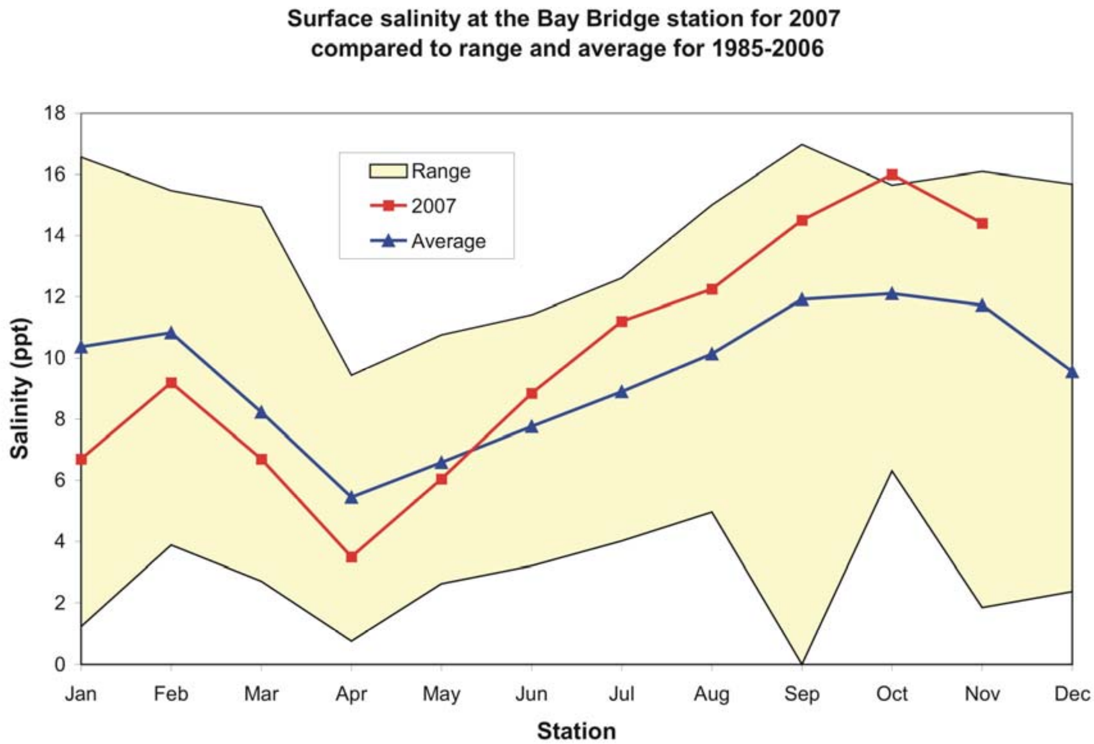

Figure 2. Average salinity of the Chesapeake Bay from 1985-2006.
Image taken from Maryland Department of Natural Resources website:
http://www.dnr.state.md.us/bay/index_2007drought.html

Nesting Behavior

The yearly activity cycle of the diamondback terrapin correlates with the temperature of the water. In the mid-Atlantic region, terrapins can be found hibernating in small creeks beginning in mid to late November when the temperature lowers to about 6 to 10° C. They emerge between April and May to prepare for the nesting season once more (Yearicks et al. 1981).

Females prefer to lay eggs in sandy areas with no vegetation. Large sandy areas have higher soil temperatures, and the lack of vegetation reduces the chance that eggs will be destroyed by roots (Lazell and Auger 1981). However, this also increases the risk of desiccation and wind erosion so females are very cautious when choosing a nesting site to protect their eggs. Terrapins occasionally nest in clusters because of natural topography constraints or the lack of suitable sites due to human construction of waterfront buildings. This limitation and the resulting nest clusters make terrapin nesting sites easier to find by both humans and predators.

Terrapins lay eggs more than once per season in the Chesapeake Bay region. They have the capacity to lay eggs up to five times in a season, although two to three times is more common (Hildebrand 1932). It takes 14 to 17 days for a clutch of eggs to develop. In the Chesapeake Bay region, the diamondback terrapin prefers to nest on narrow sandy beaches where a female will, two to three times a year, deposit a clutch of about 13 eggs (Roosenburg and Dunham) (Figure 3).

Figure 3. Uncovered terrapin nest showing a freshly laid cluster of eggs.
(Team Saving Testudo Research Collection)

Females also show great fidelity to a suitable nesting site, a phenomenon known as philopatry. Once a fitting nesting beach has been found, females are known to return to it every nesting season (Brennessel 2006). Once the female has found her preferred nesting site, she smoothes out an area and begins digging a small hole about 4 cm in diameter (Brennessel 2006). She then makes a teardrop-shaped nest with a small hole at the top and a larger chamber underneath. Average depth from the surface to the bottom of the shaft is 12 cm and from the surface to the bottom of the nest, 16 cm (Figure 4).

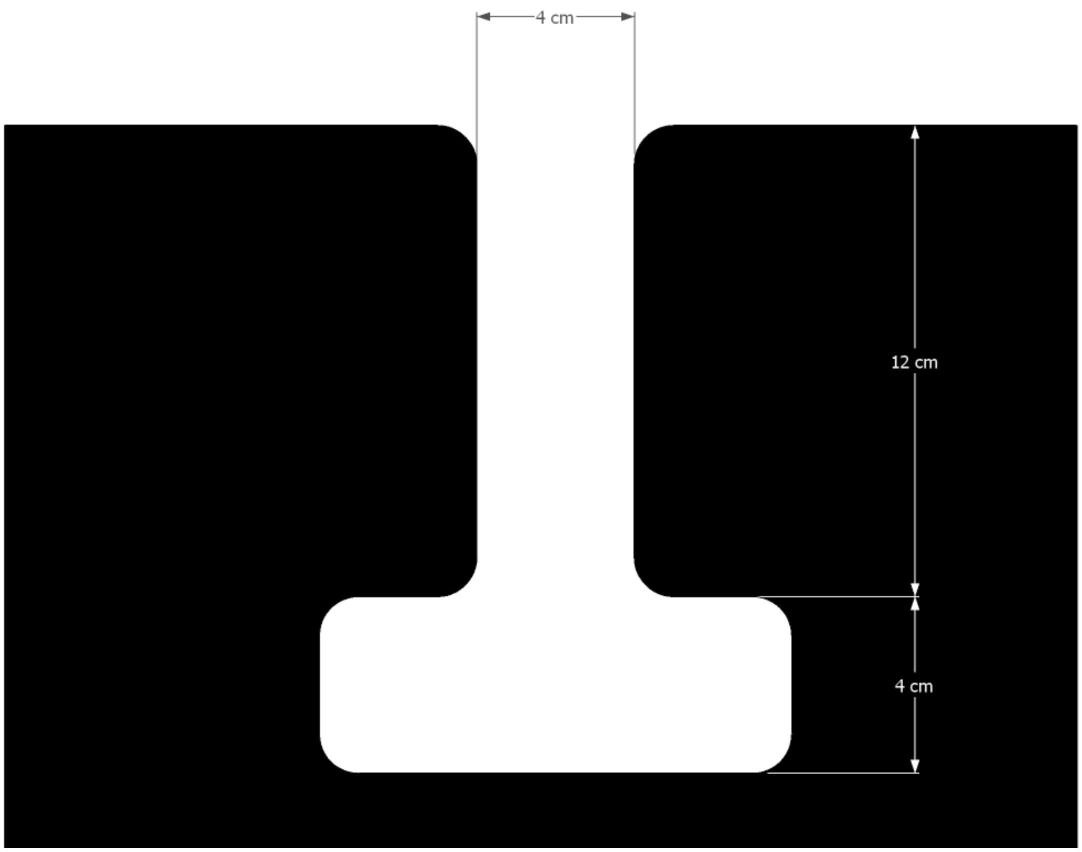

Figure 4. Cross sectional diagram of a terrapin nest.

Hatchling success rates are highest in nests that are moderately deep, about 18 cm. A deeper or shallower nest will not see the same survival rates (Palmer and Cordes 1988). If the nest is too deep, the eggs have a smaller chance of surviving due to low temperatures and lack of oxygen. However, if the nests are too shallow they can be easily depredated and are subject to higher temperatures and erosion.

In areas with high predator populations, nesting female terrapins occasionally must chose between their mortality and the survival of the eggs they are laying. In areas with greater mammalian predator presence, it was found that terrapins nest closer to the shoreline, a less desirable nesting site in terms of nest survival rates. When female terrapins are at less risk of direct predation, they tend to nest farther from the shore, which is more ideal (Spencer 2002).

The distance a female will travel onto land to nest varies by region. Terrapins along the Chesapeake Bay prefer to keep as close to the shoreline as possible, usually traveling less than 10 m to nest, whereas females in the northeast travel much farther, some making round trips of about 1,600 m across expanses of marsh and sand dunes in the Cape Cod region (Auger and Giovannone 1979). However, no matter how far the female travels, the trip is still very dangerous. Human habitation along coastal watersheds where terrapins nest has increased along with dangers associated with humans such as motor vehicles and pets that can disturb or even kill nesting females.

Overall Factors of Decline

Unfortunately, opportunities to learn about the diamondback terrapin may be diminishing because of population decline. The decline in their population is mainly due to human factors. In the late 19th and early 20th centuries, terrapins were heavily harvested, drastically reducing the population. Terrapins, considered a delicacy in some areas, were commercially harvested as food (Donnelly et al. 1988). They were also harvested for the pet trade. Today, they face even more and greater dangers from humans according to the Maryland Diamondback Terrapin Task Force (Appendix A). Using Maryland records of terrapins from 1878 to 2001, testimony from experts, overall trends, and specific long-term research work from the Patuxent River, the Task Force concluded that the most prevalent threats to the diamondback terrapin are increased commercial harvesting, habitat loss due to human development and erosion, increasing accessibility of nests for predators, and the threat of drowning in crab pots in the Chesapeake Bay. It found that the current population is not large enough to sustain a commercial market and that the species is in decline.

Overharvesting

Overharvesting is a contributing factor of population decline because of a high demand for terrapins as food and pets. In the late 1800s, the terrapin was considered a delicacy in many food markets, including that of the United States. Terrapin soup and other dishes made with terrapin meat were very popular. This spurred fishermen to over-harvest the terrapin for high profits. By the turn of the century, fishermen began to notice a decline in the population of the terrapin, but the continued high value of the turtle on the food market stimulated ongoing over-harvesting. By the early 1900s, there were not enough terrapins left to fill the food supply or support fishermen. Some populations were completely wiped out, such as in Long Island, New York (Brennessel 2006).

Terrapin populations were given a chance for recovery when high prices, low availability, and a failing economy drove the terrapin out of favor in the United States in the early to mid-1900s. However, interest in the terrapin as a food has re-emerged in recent years. Their renewed status as a highly valued commodity has once again begun to diminish their populations and endanger their survival (Brennessel 2006).

With the decline of terrapins becoming increasingly severe, legislators have begun to take notice. According to a recent study by Willem Roosenburg of Ohio University, there has been a population decline of 75% for reproductive age female terrapins in the Patuxent River in only the last decade (Staff and Wire…2007). With statistics like these and given the fact that both Virginia and Delaware had already banned the commercial harvesting of the species; a moratorium was placed on the commercial harvest of diamondback terrapins in Maryland (Appendix B). The bill passed the House and Senate with an overwhelming majority in 2007. Regulators also made it illegal to keep terrapins as pets (Staff and Wire...2007).

With this ban, the responsibility for the diamondback terrapin was transferred from the Fisheries Service to the Wildlife and Heritage Service of the Maryland Department of Natural Resources. This policy change came in the winter of 2008. Because the terrapin was no longer legally commercially harvested, protection of the species was moved to the new service where there will be tighter restrictions and stricter monitoring of their take for research and educational purposes, instead of harvesting (Scott Smith, Department of Natural Resources, personal communication).

It is unknown how much harvesting continues today even with the new protective legislation. It is unlikely that the ban has put an end to the harvesting. However, even if the commercial harvesting does not continue, many other factors still threaten the diamondback terrapin.

Bycatch

Also contributing to the population decline is bycatch as terrapins get caught in crab pots and drown. Crab pots, which are traps designed to rest on the estuary bottom, are one of the major causes of the decrease in population (Figure 5). These traps are usually baited to attract crabs, but unfortunately, the bait also attracts terrapins. Once a creature enters the funnel-shaped entrance, it is unable to escape. Terrapins and other animals that are unintentionally caught in the traps are referred to as bycatch. Unlike crabs, terrapins do not have gills and cannot breathe underwater. As a result, many terrapins drown in traps before they can be released by crabbers. Additionally, ghost traps, traps that have been lost or abandoned, are deadly for the numerous terrapins that are unlucky enough to get caught in them (Bishop 1983; Roosenburg et al. 1997). These various traps tend to kill male terrapins and young females because mature females are usually too large to fit into the traps. Without these males and young females, mating occurs less often and the feasibility of replenishing the terrapin population diminishes. This population skew has unfortunate implications for the long-term survival of the population (Dorcas et al. 2007).

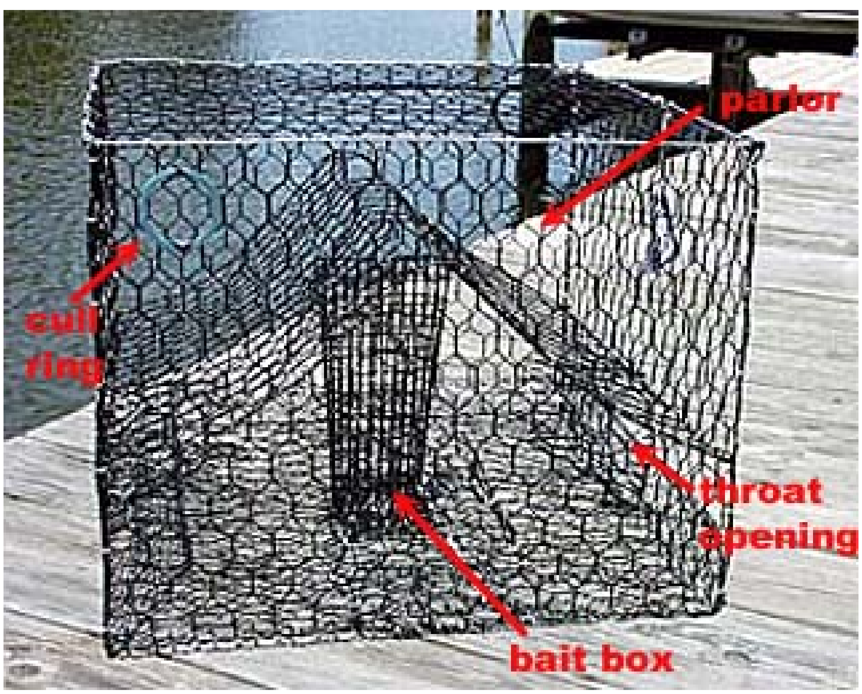

Figure 5. Typical crab pot.

Image taken from North Carolina State website:
http://www4.ncsu.edu/~dbeggles/education/synergy/bluecrab/bscrab.html

As concerns about bycatch mortality have increased, many researchers have tried to determine the impact of crab pots on the terrapin population. Bishop (1983) measured the mortality rate for diamondback terrapins due to crab pots in Ashley Bay, South Carolina. Bishop found that turtles rarely drowned in commercial pots because crabbers usually checked their pots often enough to release terrapins before they ran out of air. He concluded that despite deaths from bycatch, the terrapin population in South Carolina was not at significant risk unless the terrapins became over-harvested by the fishing industries that hunt terrapins (Bishop 1983). Most terrapin biologists today, however, agree that the terrapin population is at risk and that crab pots are dramatically harming the terrapin population. Working in the Chesapeake Bay, Roosenburg et al. (1997) found capture rates similar to the ones Bishop found, but predicted much higher mortality rates ranging from 15% to as high as 78% of the population. Through discussions with other turtle biologists along the East Coast, Roosenburg and his associates learned that terrapin populations have been decreasing in South Carolina, New Jersey, Florida, and Louisiana – all coinciding with an increase in the crabbing industry in those areas (Roosenburg et al. 1997). Although there is substantial evidence from these locations supporting the theory that the terrapin populations are declining, it is still difficult to prove that this decline is due to crab pot mortality. Other underwater traps also may kill terrapins, particularly if not checked frequently (Figure 6).

Figure 6. Terrapins caught and drowned in an underwater trap.
(Team Saving Testudo Research Collection)

Recently, a team of scientists published the first study that definitively connected crab pot bycatch to the terrapin population decline (Dorcas et al. 2007). Because crab pots in general only catch and kill male and young female terrapins, crab pot mortality should have a distinctive effect on population dynamics: the average body size of individuals should increase and there should be more females than males. Dorcas's team collected data from a population in Kiawah Island, South Carolina, over a period of twenty years. They concluded that the average body size had increased for both males and females and that there was a much higher female to male sex ratio. His findings were consistent with the hypothesis that crab pots were significantly affecting the terrapin population. Dorcas and associates also found that the effect of crab pots on terrapin population was most dramatic in areas with recreational fishing as opposed to commercial crab fishers. Commercial crabbers check their traps more regularly and are therefore able to release more terrapins before they drown (Dorcas et al. 2007). They are also much less likely than recreational fishers to leave ghost traps. This same pattern of terrapin mortality was observed by both Bishop (1983) and Roosenburg et al. (1997). Roosenburg et al. (1997) further noted that in the Chesapeake Bay, commercial fishers are required to set traps farther from shore in water that is deeper than the preferred habitats of the terrapin. There are no similar restrictions on recreational crabbers in the Chesapeake Bay who tend to set traps in shallow water where more terrapins are caught.

Just as crab pots are harmful to the terrapin population, ghost traps are also considered detrimental, although it is difficult to determine their actual effect. Bishop (1983) found ghost pots with 15 and 28 dead turtles and Roosenburg et al. (1997) reported a ghost pot with 49 dead terrapins. Turtles tend to aggregate and may use each other to find food sources during normal foraging. Unfortunately, this means that when one or two get caught in a trap they attract others; this attraction is especially strong during the breeding season (Bishop 1983). Although it is possible to count the number of captured terrapins in ghost traps, it is difficult to quantify the full effects of ghost pots because the exact number of these abandoned traps is unknown and they are hard to locate.

Crabbing is a multimillion-dollar industry and a large part of the culture in many coastal regions, especially the Chesapeake Bay. The established nature of crabbing can make it difficult to balance environmental considerations with the economic and recreational desires of residents. Roosenburg et al. (1997) suggested a solution by designing a crab pot that allowed terrapins to breathe so they would not drown before they could be released by crabbers (Figure 7). The base of the pot was the same as a normal crab pot, but there was an upper story to the trap that rested above the water level so terrapins could surface. The trap was designed to be tied to a large wooden stake so that it remained upright. When tested, the design was very effective at preventing terrapin death (Roosenburg et al. 1997). Unfortunately, because these traps are substantially larger than normal traps, they create a greater inconvenience for crabbers. Therefore, it is not likely that crabbers will be willing to use this design (Dorcas et al. 2007).

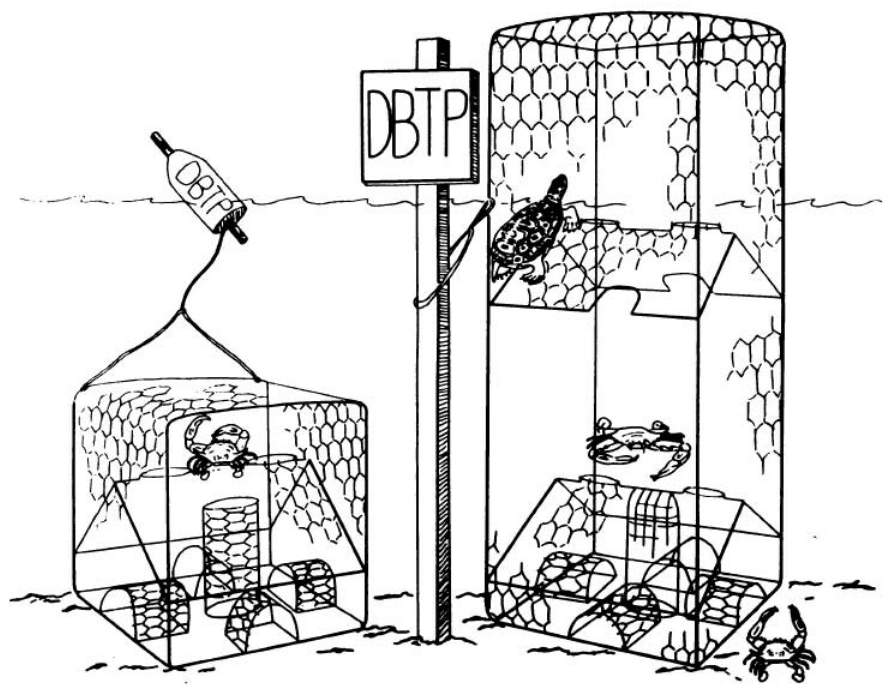

Figure 7. Typical crab pot and Roosenburg's modified crab pot. (Roosenburg et al. 1997).

Another more feasible solution is a bycatch reduction device (BRD) (Wood 1997). Wood worked to reduce terrapin bycatch deaths in New Jersey's Great Bay. His design was cheap and simple; the original device was constructed out of coat-hangers (Wood 1997). The BRD consisted of an inflexible wired rectangle that was inserted into the small end of the funnel-shaped openings in the crab-pots (Figure 8). This device effectively blocked most terrapins from entering while still allowing even the largest crabs to be trapped. There have been many studies that demonstrate the efficacy of BRDs. Roosenburg and Green (2000) found that a BRD with the dimensions of 4.5 cm x 12 cm was the most effective size for preventing terrapin bycatch in the Chesapeake Bay. This finding was confirmed by Butler and Heinrich (2007) who found that BRDs reduced bycatch by 73.2%. Both studies also cautioned that the optimal size for BRDs depends on the size of the individual terrapins in a particular area and may need to be adjusted for regional differences. If used properly, BRDs do not have any effect on the size, number, or sex of the crabs that are caught in the crab pots, but effectively reduce the number of terrapins becoming caught in the deathtraps.

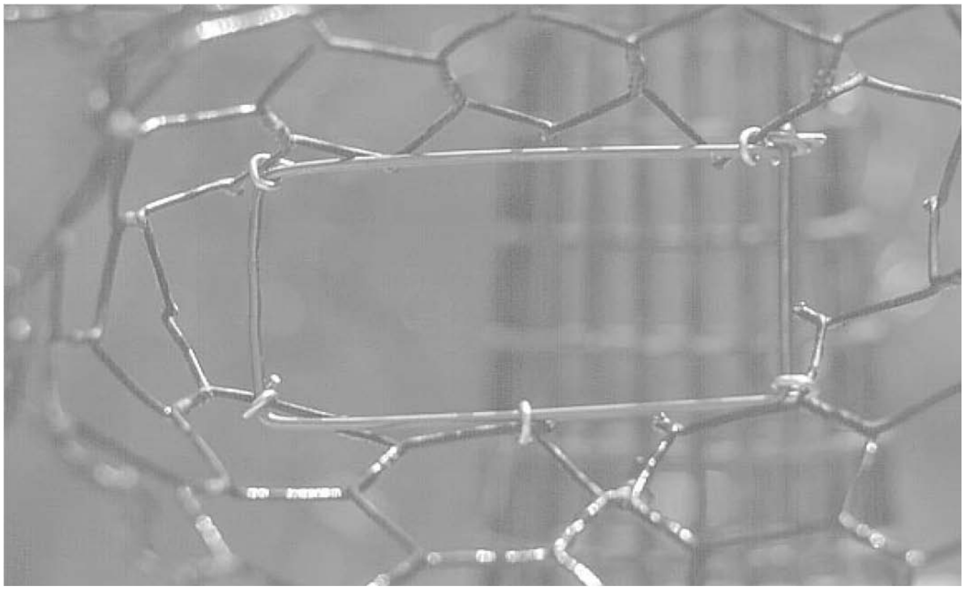

Figure 8. Wood's design for a BRD.
(Wood 1997).

Habitat Loss

Habitat loss from construction of waterfront houses and other development makes it more difficult for terrapins to reproduce as successfully as possible because optimal beaches are eliminated. Most terrapin habitats have shrunk due to human activity, particularly urban development. The human population of Maryland has more than doubled since the 1950s and is forecasted to increase by another million individuals within the next 30 years, creating a major strain on the ecology of the Chesapeake Bay (Chesapeake Bay Watershed… [updated 2008]).

Since colonial times, there has been record of the degradation of salt marshes. Salt marshes were often drained to grow salt meadow cordgrass (*Spartina patens*), also called salt-marsh hay, which was a valuable commodity at the time. Marshes have also been drained for other reasons including mosquito control and conversion of land to a more usable form for human recreation. Alterations to the land of this nature result in a loss of habitat for terrapins because it offers protection and food (Bossero and Draud 2004). However, since the 1970s tidal wetlands have received state and federal protection.

Also contributing to the loss of salt marsh habitats for terrapins is the restriction of tidal flow along shorelines. In many cases, the erosion of beaches, dunes, and marsh uplands occurs naturally, although humans may accelerate shoreline changes. Human dike construction restricts the flow of sediments and drowns marsh plants, harming and sometimes destroying the terrapins' habitat. Additionally, bulkheads, a form of light-duty seawall to protect waterfront property from erosion, create some of the largest problems for terrapins. Bulkheads are built to retain soil and prevent land from eroding and sliding towards the water (Figure 9). However, they also prevent the natural deposition of sand along the shoreline. This results in a change in the shoreline's profile and composition, damaging marshes through active erosion, preventing access to nest sites, or destroying beaches that may have originally been considered ideal nesting sites for diamondback terrapins and many other species.

Figure 9. Steel bulkhead along a new shoreline development.
Image taken from Waterside Construction website:
http://www.watersideconstruction.com/Waterside%20Construction%20Bulkheads.htm

Overall, marshes are especially valuable for terrapins because they provide adequate sources of food and cover. Terrapins are also known to make nests against bulkheads, and, as a result, their eggs are usually drowned by high tide levels (Living Shorelines…[date unknown]). The destruction of this habitat further threatens the status of the terrapin populations (Bossero and Draud 2004).

The species' habitat has been put at risk by the increasing development of coastal areas. As the human population continues to grow at a high rate, there is an increased demand for adequate living space. Shorelines are a perfect example of a habitat that has been disturbed due to increased human development. As the cities and suburbs become more populated, people seek other areas to develop; shorelines have always been a popular option. In Maryland, homes and other buildings have become a common sight along the shores of the Chesapeake Bay and the Patuxent and Potomac rivers. Bulkheads are used against the shores to minimize private property loss through erosion and runoff. Furthermore, as more houses are built, more construction occurs in order to provide the new residents with grocery stores, schools, and other community buildings. This leads to the paving of roads and streets, which are impervious surfaces where water can no longer infiltrate and percolate into the ground (Chesapeake Bay Watershed… [updated 2008]). Because of this, greater levels of sediment and chemicals flow into streams and create a lethal contamination of the water in some areas. Impervious surfaces have increased by more than five times since the 1990s, which could be dangerous to the overall health of the watershed because of the chemicals and foreign material that is introduced to the water (Chesapeake Bay Watershed… [updated 2008]). As human populations increase and land is developed in order to accommodate the influx of people, the Chesapeake Bay watershed is slowly being destroyed, harming terrapins and the other animals that inhabit those waters (Figure 10).

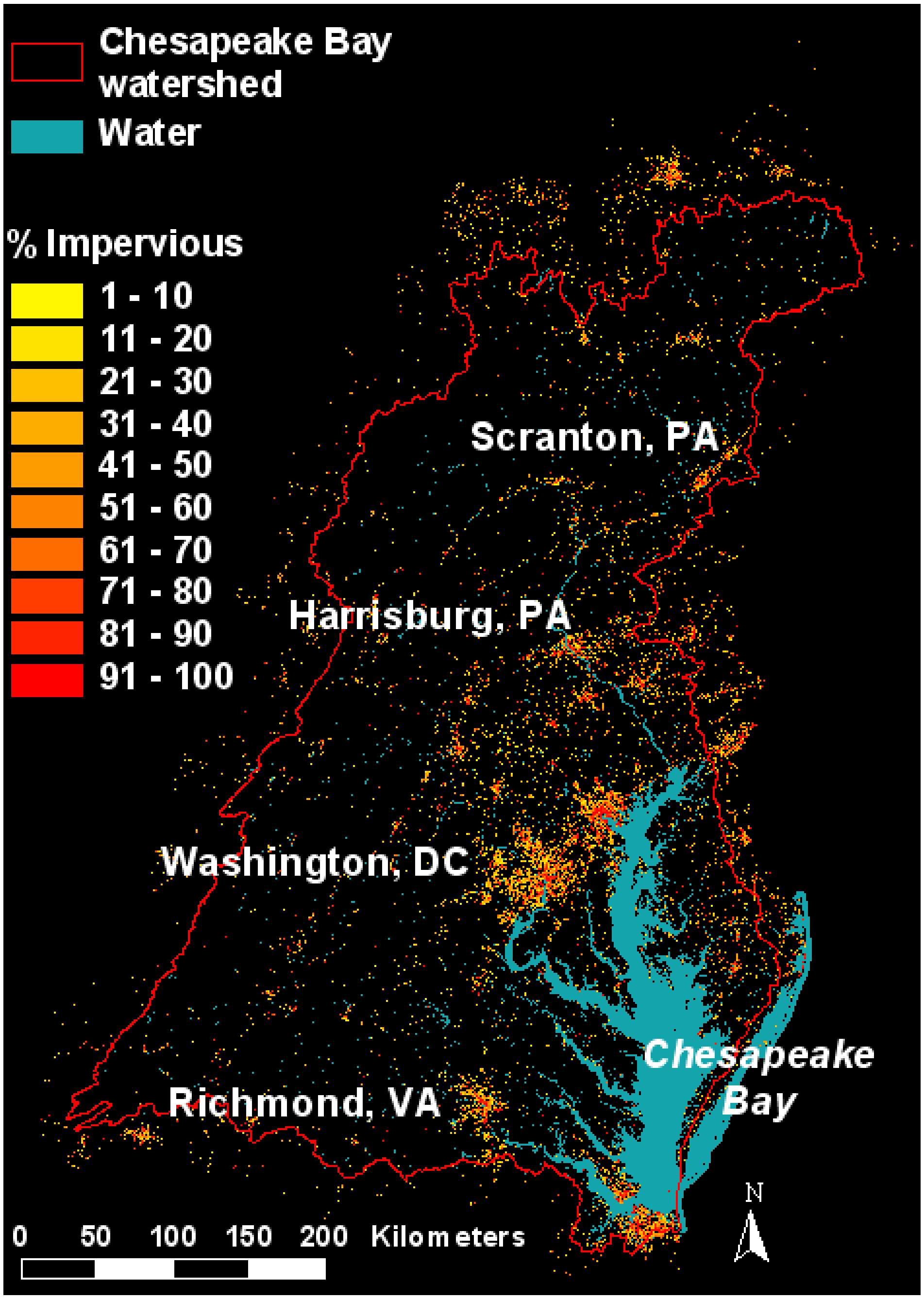

Figure 10. Percentage of impervious surfaces in the Chesapeake Bay region in 2000. Image taken from Woods Hole Research Center: http://www.whrc.org/midatlantic/mapping_land_cover/products/impervious_surfaces.htm

Homes, seawalls, resorts, and highways have replaced traditional terrapin nesting areas. However, some efforts have been made to preserve or recreate nesting beaches for terrapins. One example of successful creation of nesting beach habitat can be found at Horsehead Wetlands Center (now Chesapeake Bay Environmental Center), in Maryland (Brennessel 2006). Marshes must also be restored in order to give terrapins some of their territory back.

Mammalian Predators

Three of the main mammalian predators of terrapin eggs in Maryland are red and gray foxes, and raccoons (Roosenburg 1990; Roosenburg 1991). These species are found throughout the East Coast and pose a significant challenge for terrapin conservation efforts. Because these predators have such a large impact on terrapin nest survival, it is important for terrapin researchers to have, at the least, a basic understanding of these animals' behaviors and biology. Any comprehensive conservation plan must take these nest predators into consideration.

The red fox is a reddish-colored canine with a pointed nose, large ears, and a long, bushy, white-tipped tail. It is about the size of a small dog, with a total length between 89 and 111 cm and a weight between 3.4 and 6.4 kg.

Red foxes have benefited from the clearing of forests and have increased their numbers and the range of their habitat. They are found over most of eastern North America and are most prevalent in farmland areas that contain wooded areas, marshes, and streams. Red foxes also occupy metropolitan areas and thrive in broken land areas (Whitaker, Jr. and Hamilton, Jr. 1998). A family of red foxes may occupy an area ranging from 60 to 600 hectares. Since small prey is usually abundant in small areas, a red fox family can thrive in these areas, so much so that they may form year-round extended-family groups in their territory. The foxes' mating season usually occurs between January and February, and four to 10 young are born in March or April (Whitaker, Jr. and Hamilton, Jr. 1998).

The red fox usually requires about 2.3 kg of food each week and is a nocturnal predator with a very diverse diet. Because they have grown accustomed to urbanization, red foxes consume human garbage in addition to natural prey such as squirrels, mice, and rabbits (Adams 1994). They are major predators on duck nests in some areas. They will also eat fish, fruits, and seeds. In addition, foxes also consume terrapin eggs when they are available (Lariviere and Pasitschniak-Arts 1996).

The gray fox is a canine with a pointed nose and ears, a bushy tail, and an overall grizzled appearance. Its fur is a mixture of white, gray, and black and consists of black tipped hairs that form a stripe down its back to its tail. Gray foxes have a total length between 80 and 112 cm and a weight between 3 and 7 kg. Typically, the male foxes are slightly larger than the females.

Gray foxes live in wooded and rocky environments from Canada to South America. Like the red fox, the gray fox's mating season usually occurs between January and February, and the young are born in March. The gray fox is a nocturnal predator with a very diverse diet that varies among regions and seasons. In the eastern United States, mammals make up the majority of the winter diet while in the summer, invertebrates and plants are most prevalent (Fritzell and Haroldson 1982).

Raccoons are medium-sized mammals that have a black facial mask which covers their eyes and cheeks. They are usually a shade of gray and have a long bushy tail with black rings. Adults usually weigh between 5 and 7 kg and have an average length of 81.2 cm. Mating occurs between January and March, and female raccoons have a gestation period of about 63 days. Usually, three to seven live young are born around April or May (Whitaker, Jr. and Hamilton, Jr. 1998).

The population of raccoons in North America was very low during the 1930s. However, their numbers steadily grew during the 1940s, and the raccoon populations are now stable. This increase in population may be attributed to several factors. Firstly, the growth of cities is beneficial to raccoons and the mammals thrive in urban and suburban areas. Secondly, raccoons also benefit from an increase in agricultural crops such as corn. Finally, the declining populations of wolves, a natural predator of raccoons, has allowed for the replenishment of the raccoon population (Zeveloff 2002).

Raccoons live in a wide variety of habitats, but are mostly found in moist or wet areas such as freshwater and saltwater marshes. The population densities of raccoons vary from site to site. For example, in North Dakota, their density ranges from 0.5 to 1 per km^2, whereas in eastern Virginia's tidewater region, their density may be 17.2 per km^2 (Zeveloff 2002).

Raccoons are nocturnal predators and have a diverse, omnivorous diet, consuming a wide range of both plants and animals. They eat invertebrates, particularly arthropods such as insects, crustaceans, and spiders. Although crayfish is a favorite food for these animals, raccoons that live along marshes and coastlines will also eat crustaceans such as shrimp, crabs, clams, oysters, and mussels. Amphibians are usually present in raccoon habitats, although they are not consumed very often. Reptiles, such as snakes, lizards, and turtles, also do not make up a significant part of their diet but may still be consumed (Zeveloff 2002). Furthermore, a significant part of their diet consists of berries, nuts, and seeds, and they have also been known to prey on sea turtle hatchlings and their eggs when available. However, because they have a varied diet, raccoons are only selective when food is overly abundant. They will eat whatever is available when food is limited (Lotze and Anderson 1979).

Raccoons are also able to locate and consume new foods, and this behavior can be copied by other raccoons and passed on to later generations as a type of cultural inheritance. An example of this phenomenon would be the association of broken eggshells with terrapin nests and eggs, a source of food (Zeveloff 2002). Therefore it appears that raccoon predation of eggs is not an instinctual occurrence but rather a learned behavior. Although it is unclear how predators find terrapin nests, one study suggested that raccoons use a combination of soil disturbance patterns and scent of ocean water as indicators of nests. In another study, human scent or flags used to mark nests in scientific research did not appear to help raccoons find nests (Burke et al. 2005).

Overall, it can be inferred that terrapins and their eggs comprise only a small and unimportant portion of their predators' diet. Terrapin eggs can be labeled as more of an occasional treat than a survival necessity. Such conclusions suggest that limiting the availability of terrapin eggs would not harm the populations of either raccoons or foxes but would greatly protect the terrapin population.

Although some places have recorded a predation rate of up to 90%, the exact impact of predators on terrapin populations is unknown (Feinburg and Burke 2003). Recently, more people have begun to move to beaches and build homes there, destroying the terrapins' natural habitat. When there is less habitat available, the nesting density increases as terrapins nest closer together in the remaining accessible habitat. However, a higher nesting density also leads to higher predation rates because there are more nests in a smaller area for predators to destroy. Therefore, limited space for terrapin nests may lead to an increase in predation rate (Roosenburg 1991). One study concerning the Australian fresh water turtle (*Emydura macquarii*) suggested that foxes use both chemical detection of eggs and slight soil disturbances to locate nests (Spencer 2002). Another comprehensive experiment supported this conclusion (Burke et al. 2005). These investigators also examined the effects of humans on nest detection by predators. After recording which nests had been marked or visited by humans, the researchers observed the nests for signs of predation. They concluded that flags did not increase the likelihood for predation and the presence of human scent actually lowered the predation rate.

Other studies suggest a link between human development and an increase in the number of predators in an area. For instance, Hoffmann and Gottschang (1977) concluded that as areas become more developed, the density of predators in anthropological areas increases. Another study found that construction of roads and bridges makes accessing otherwise-secluded beaches easier. Therefore, humans facilitate the increased predation of terrapins by essentially drawing animals such as raccoons to those areas which were once unknown to the predators (Roosenberg 1991). Finally, one study concluded that eggs are susceptible to predation because with the increase in human population comes an abundance of associated nest predators such as raccoons, skunks, dogs, and cats (Chambers 2000).

The connection between developed areas and predator populations may be attributed to an increase in food and habitat availability for these predators. Raccoons and foxes in more developed areas are recognized as subsidized predators, meaning people either intentionally or accidentally provide food and other habitat requirements. By receiving such aid from people, populations of these predators can be maintained at higher than natural levels. Densities of both raccoons and foxes are typically higher in more developed areas than in more rural areas (Adams 1994; Whitaker, Jr. and Hamilton, Jr. 1998). In some areas, raccoons have become so overabundant that they could be detrimental to the continued survival of their prey (Garrott et al. 1993).

Because raccoons and foxes pose a possible threat to the status of some of their prey, many researchers are studying and developing possible predator control methods. For instance, Engeman et al. (2003) conducted long-term field research that centered on the main predators (including raccoons) of three threatened or endangered species of sea turtles. These investigators tested the impact of monitoring predators over a long period of time on the effectiveness of predation control. From their study, the researchers found that monitoring predators can successfully indicate the best times and locations for predator-removal methods. They also showed that there were low levels of predators before the nesting season and then an increase in the number of raccoons during the nesting season.

Electric Fences

Electric fences are commonly used for the exclusion of animals from vegetation, livestock, and nesting areas (LaGrange et al. 1995; Reidy et al. 2008). An electric fence consists of three major components: a hot wire fence, an energizer to supply the power to the fence, and a ground system. The ground system usually consists of a ground rod that is simply a metal rod stuck into the earth and attached to the ground side of the energizer via a wire. For current to flow through a circuit, there needs to be a complete, unbroken connection between the positive and negative ends of the battery. The positive end of the battery is attached to the energized wire while the negative end of the battery is attached to the grounding system. The fence creates an open circuit because the energized wire is not connected to the ground or the ground wire. When an animal touches the fence and the ground at the same time, it completes the circuit through the ground, and current is pulled through the animal, shocking it (Figure 11). Electric fences used on animals are also typically high-voltage, low-amperage systems.

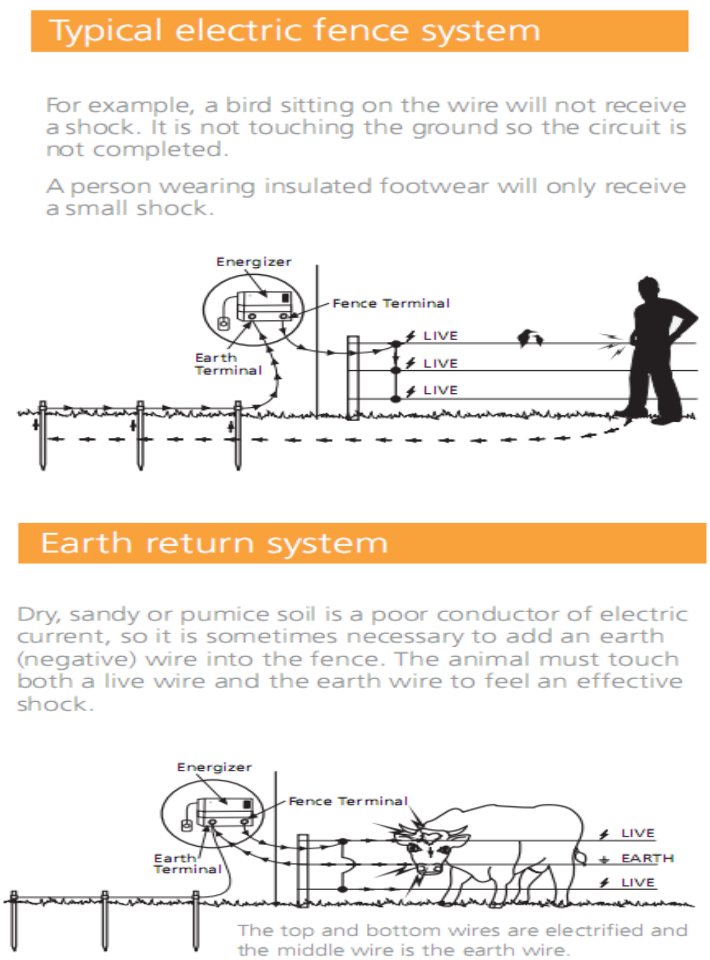

Figure 11. Diagram of our electric fence design showing double wire system and ground wire.
Image taken from Gallagher Animal Management Systems website: http://www.gallagher.co.nz/electric-fence-brochures.aspx

Typically, an energizer sends out the power in pulses. This is because when a body receives an electrical shock, the muscles tend to tense up and contract, sometimes causing an animal to grab on to the wire and not be able to let go. A pulsing signal allows time for the animal to let go of the fence. The shock does not harm the animal, but scares it and presumably makes it less likely to try to cross the fence in the future.

Predator Exclusion Through Fencing

Many studies have tested the efficacy of various types of fencing in predator exclusion, but none have been conducted specifically with diamondback terrapins. When we started the process of designing our fences, we considered two different methods of fencing: those that protected individual nests after they were laid and those that covered the beach but still allowed terrapins to move in and out. However, we were concerned with creating a fence design that was simple, easy to assemble, affordable, and maximized effectiveness. To determine the best way to do this, we consulted several studies, some that focused on fencing as a means to protect birds' nests and some that focused on fencing to keep pests out of crops.

A long-term study was conducted in Iowa between 1978 and 1990 and focused on the use of electric fences for the exclusion of striped skunks and raccoons from duck nests (LaGrange et al. 1995). After the duck eggs were laid, an electric fence exclosure was placed over the nests. The fence was constructed of wires placed at ground level and of five strands of alternating electrified and grounded wires placed at 69, 76, 86, 97, and 109 cm above the ground. A charged trip wire and 5 cm of non-electrified poultry netting were also added as additional barriers. Most importantly, the design of the fencing allowed hens and hatchlings to easily get out of the enclosures. The fences led to a 19%

increase in nest success rate and a 21% reduction in nest predation rate (LaGrange et al. 1995).

Another study, conducted in Australia, was designed to test fences for general protection of threatened species rather than for a specific species. Both electric wire fences and netting fences were tested, and feral cats, foxes, and rabbits were placed inside the fences (Moseby and Read 2006). To prevent predators from digging under the fences, the fences were extended underground, and to prevent predators from jumping over the fences, the fences were extended to an upside-down ‘U’ at the top (Moseby and Read 2006). At the beginning, wooden posts were used, but the cats easily climbed up the posts and escaped. After the posts were replaced with metal ones, the fences were more effective (Moseby and Read 2006). Overall, the electric wire fences were found to be ineffective unless combined with a physical barrier, such as a netting fence, to ensure that the predators paused long enough to receive a shock (Moseby and Read 2006).

In the United Kingdom, Poole and Mckillop (2002) studied the effectiveness of electric and non-electric fences in excluding red foxes. Wire fences with alternating electric and ground wires at various heights above the ground were used with a 6kV maximum output energizer, as well as electrified netting fences and non-electrified wire fences. Foxes that had been raised in captivity were placed inside the fences. As seen through video recordings, the foxes only ever crossed the electric fences during maintenance but frequently crossed the plain wire fences. The netted fences were crossed less frequently than the wire fences (Poole and Mckillop 2002). In a similar study conducted in the United Kingdom, researchers tried to exclude badgers using both non-electric fences and electric fences with various voltages. The non-electric fences were found to be almost wholly ineffective. The efficacy of the fences increased as the voltage increased, but the lowest voltage was significantly effective (Poole et al. 2004).

Around alkali lakes in North Dakota and Montana, Murphy et al. (2003) studied the effectiveness of predator exclusion fences to protect endangered shorebirds. A wire mesh barrier was placed over the nests, and an electric fence was placed around the whole area. Potential predators included coyotes, red foxes, raccoons, badgers, skunks, squirrels, and various birds. The electric fence, with the wire mesh barrier, was not found to be effective enough to justify its cost. In addition, these investigators determined that, although the individual nest enclosures were effective in some of the areas in which studies were set up, they were not consistently effective (Murphy et al. 2003). Therefore, while the use of enclosures around individual nests is effective in some circumstances, it is also labor-intensive, expensive, and slightly unreliable. If electric fences are effective in reducing predation on nesting beaches, then large nesting areas could be protected more easily.

Conservation Efforts

The diamondback terrapin's threatened existence received national awareness after the turtle gained its official status as the state reptile of Maryland and the University of Maryland, College Park's official mascot. After this rise in awareness, state laws began to emerge in efforts to protect the species, and more political action was taken by researchers, environmentalists, and Maryland residents to prevent a vital part of the Chesapeake Bay ecosystem from becoming a threatened species.

Currently there are a limited number of studies concerning conservation efforts for the diamondback terrapin due to a lack of general knowledge on the species and its behaviors. For decades, researchers have conducted multiple studies to obtain basic information on terrapin ecology. Ultimately, these data can be used to develop conservation strategies for the terrapin. For instance, Roosenburg et al. (1997) studied the mortality rates and declining population numbers of terrapins in the Chesapeake Bay in an effort to learn more about the species and its plight. Other researchers concentrated on collecting information regarding hatchlings and the nesting behavior of the terrapin (Burger and Montevecchi 1975; Burger 1976; Burger 1977). Overall, past research conducted on the species has pinpointed a decline in population and has identified several factors, many of them related to human behavior, affecting this population trend.

After researchers noted a decline in the diamondback's population, individuals formed institutes and programs to educate the public about the terrapin's predicament and to, on a smaller scale, physically protect the animal. For example, the Terrapin Conservation Project at the New Jersey Wetlands Institute incubates and hatches terrapin eggs recovered from terrapins killed on roads, eventually releasing the hatchlings into the wild (Appendix D). These endeavors are major firsts in addressing the population decline.

For the past several years, the diamondback terrapins' decreasing numbers have captured the interest of the public and governmental administrations. In 2006, the Maryland General Assembly passed legislation regarding commercial harvesting of terrapins in the state (Appendix E), and the Maryland Department of Natural Resources developed regulations to implement the law (Maryland Department of Natural Resources 2006). These new regulations affected the commercial harvesting season, the selection of terrapins, and the legal process associated with the harvest of terrapins. Firstly, fishermen and trappers now could only commercially harvest terrapins from the beginning of August through the end of October, six months shorter than the previous nine-month terrapin harvesting season. This protected terrapins in the winter when they are known to hibernate together in areas known as hibernacula. Secondly, only terrapins between 10.2 and 17.8 cm could be caught, protecting reproducing female terrapins and hatchlings and small juveniles. Lastly, those who want to harvest the diamondback terrapin were now required to obtain permits in advance and provide information to the Department of Natural Resources about their catch. Overall, these new regulations were a first step in addressing the population decline in the terrapin.

Most recently in Maryland, the diamondback terrapin made the news when Maryland Governor Martin O'Malley in April 2007 signed into effect a ban on commercial harvesting of terrapins (Wagner 2007). Under the Natural Resources – Diamondback Terrapin – Take and Possession Act (Appendix B), a person cannot catch a terrapin for commercial purposes (Dyson 2007). This act had great implications for the conservation of the diamondback terrapin; terrapins could no longer easily be caught to meet demand in China and American Chinese restaurants, where they are considered a delicacy. Other legislation has also recently been brought to the attention of the Maryland government; these acts will protect numerous species including the diamondback terrapin. More specifically, in spring of 2008, the Maryland Senate passed the Living Shoreline Protection Act of 2008 (Appendix F) to address habitat destruction by shoreline development. Under this act, shorefront lot owners would be required, whenever possible, to use nonstructural shoreline stabilization methods to prevent erosion and marsh destruction. Among the suggested methods include living shorelines in which natural elements such as plants, stone, and sand are deliberately placed along the shore to protect vegetation and habitats (Chesapeake Bay Foundation 2007) (Figure 12).

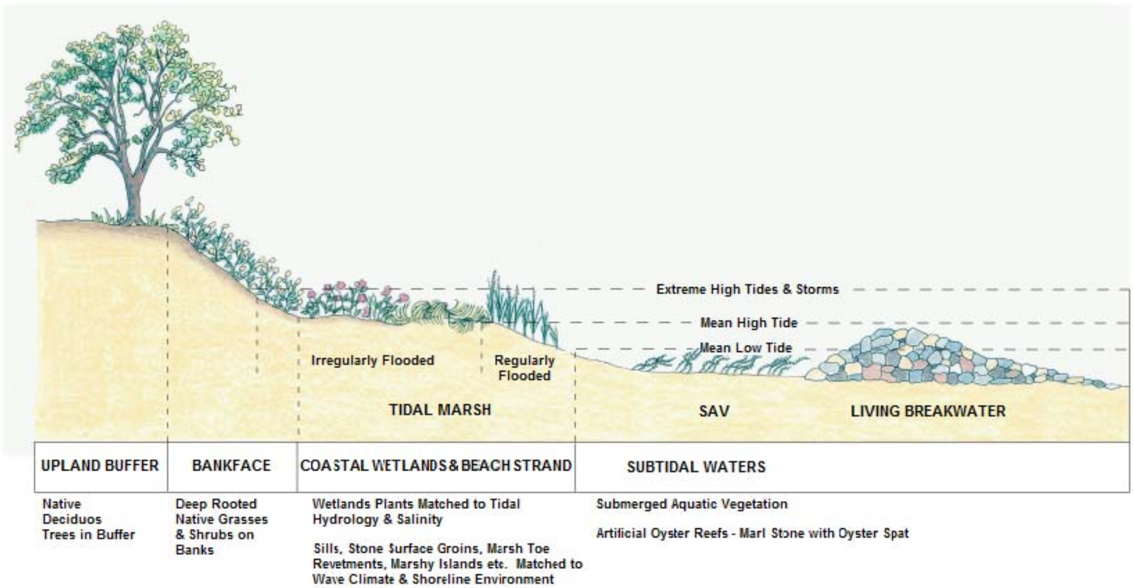

Figure 12. Living shorelines.
Image taken from Jefferson Patterson Park and Museum website:
http://www.jefpat.org/Living%20Shorelines/lsmainpage.htm

This living shorelines approach has the potential to protect the terrapin's natural habitat and offset some of the damage done by shoreline development, and several states including North Carolina and Virginia have already begun to implement the method (Welcome to Maryland…[date unknown]). While the diamondback terrapin may hold a special significance to the state of Maryland, other states in which the reptile can be found are also, like Maryland, using political means to protect the species.

Field Trips

Diamondback Terrapin Working Group Workshop

On March 2, 2007, several team members and our mentor attended the Mid-Atlantic Region's Diamondback Terrapin Working Group Annual Meeting, where we met biologists, herpetologists, and researchers from Maryland, Virginia, Delaware, Pennsylvania, New Jersey, and Ohio and several members of the state governments of Maryland, Virginia, and Delaware. One of the main areas of discussion was regulatory legislation, including the proposed moratorium on terrapin harvesting that Maryland was considering at the time. We learned a great deal about current, or not-yet-published, research in the field including habitat creation projects, tagging, and the creation of a DNA database to track terrapin populations. We also looked at several studies aimed at eliminating or lessening crab pot bycatch, specifically in Texas and New Jersey. We discussed research needs concerning terrapins with experts in the field, including Dr. Paula Henry of Patuxent Wildlife Research Center, Dr. Willem Roosenburg of Ohio University, and Dr. Roger Wood of Richard Stockton College. We learned that predation by foxes and raccoons on terrapin nests was a significant mortality factor of concern to researchers and conservationists.

Patuxent Wildlife Research Center

On March 9, 2007, we visited Patuxent Wildlife Research Center in Laurel, Maryland, and met with researchers to discuss the use of electric fences to deter mammalian predators. The Center maintains many experimental animals in pens and cages and uses electric fences to deter both avian and mammalian predators.

After we presented our initial fence design concept to these experts, we were able to thoroughly discuss with them the feasibility and quality of our experiment. The first issue that arose concerned the number of strands of wire included in the design; initially, the team had focused on a one-strand fence, but we were made aware of the heights and jumping capabilities of the various predators, so we broadened our design concept to include at least three strands of wire at different heights. The researchers also suggested baiting the wires or using an attractant (lure) to ensure that the predators would touch their noses to the fence and receive that initial shock; this had the potential to quickly and effectively deter predators away from the nests and contribute to the success of the fence as a conservation effort. While we eventually decided to bait the fences, the Center's staff raised the question of whether or not we wanted to aggressively attract predators to the nests, a question we would debate months later.

After discussing our interest in using fences to deter mammalian predators from diamondback terrapin nesting beaches, the Patuxent researchers invited us to visit a research site to see how the Center was using large electric cages to protect American kestrels, *Falco sparverius*, a small falcon. Our trip to the Center helped to further develop our experimental design.

Cremona Farms

On May 23, 2007, we visited potential study sites along the Patuxent River near Mechanicsville, Maryland. The lower Patuxent River offered several potential advantages for our study. Dr. Willem Roosenburg, of Ohio University, had studied terrapins in the area for close to 30 years and maintained a field research station at Cremona Farms with housing accommodations. In addition, Dr. Roosenburg had agreed to collaborate with us as a co-faculty advisor. Lastly, it was known that terrapins used beaches along the river for nesting.

Several of us and our mentor returned to Mechanicsville to examine two beaches: one at Trent Hall Farm and another at Burton's Beach. Both were viable nesting beaches, and the beach at Trent Hall was specifically restored to create more terrapin nesting habitat as restitution for a nearby oil spill that occurred in April 2000 (Holliday et al. 2008). Trent Hall Beach, an area estimated to be about 230 m^2, had varying levels of habitat, from loosely packed sand and sparse vegetation to dense vegetation and rocky soil. Burton's Beach was a smaller beach located off of Washington Creek. It was long and very narrow, with loose sand and dense vegetation, including small trees and poison ivy patches.

After visiting both sites with our two faculty advisors, we decided to work only at the Trent Hall Farm beach during the summer of 2007. Because our project design required multiple treatment and control plots of at least 5 m x 5 m each, Burton's Beach would not have provided sufficient area due to the very narrow nature of the beach.

Jefferson Patterson Park

In 2007, we also visited several other possible nest sites, one of which was Jefferson Patterson Park and Museum (JPP), along the Patuxent River. At JPP we observed a very high terrapin nest density and also saw high predator activity. An informal survey of the beach on one day revealed at least ten depredated nests. We felt this would be an ideal location for further testing of our fence design and ultimately received permission to use the beach at JPP for the spring of 2008. The park was very accommodating and supportive of our research and requested that we construct our fences as far away as possible from areas with heavy public traffic.

Current Study

The current study was conceived and designed following review of the scientific literature concerning diamondback terrapin populations and the field trips outlined above. We focused our efforts on excluding mammalian predators from diamondback terrapin nesting beaches with an electric fence. We developed three questions we hoped to answer with our research: (1) What effect, if any, does electric fencing have on predation of terrapin nests? (2) Do terrapins discriminate based on presence of fences when choosing nesting sites? (3) Are electric fences viable (in terms of cost, durability, environmental protection, etc.) as a widespread conservation technique? In Chapter 3, we present the study sites we selected to conduct our research.

Chapter 3: Study Areas

This study was conducted on diamondback terrapin nesting beaches at Trent Hall Farm and Jefferson Patterson Park and Museum along the lower Patuxent River, north of Solomons, Maryland, and at Patuxent Research Refuge in Laurel, Maryland. Trent Hall Farm and Jefferson Patterson Park and Museum had similar terrain and were known to provide quality nesting areas for terrapins (Figure 13).

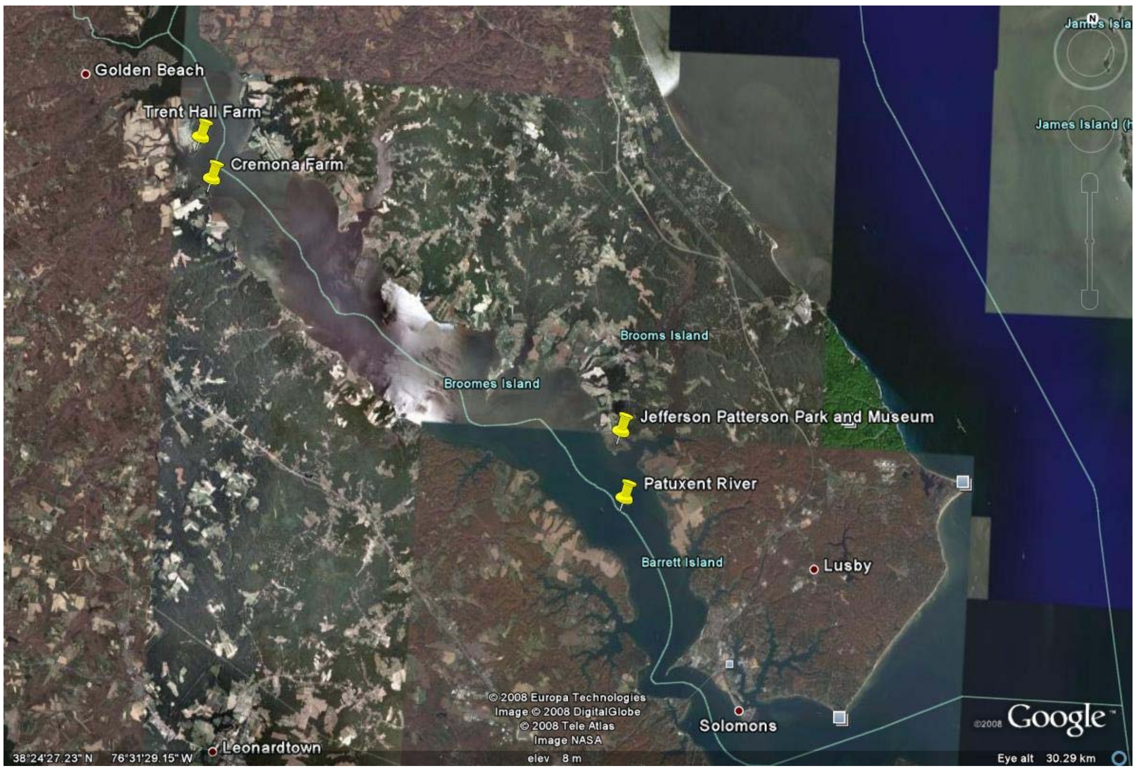

Figure 13. Location of study areas on the lower Patuxent River, Maryland.
Satellite image from Google Earth.

The Patuxent River

The Patuxent River watershed drains from seven counties in Maryland. It is one of the major river basins in the state that empty into the Chesapeake Bay, the largest estuary in the nation. The Patuxent runs along from the Maryland Piedmont in between Frederick, Carroll, Montgomery, and Howard counties, emptying out into the Chesapeake Bay at Solomons, Maryland. It is 177 km long and covers a geographical area of 2290 km^2, making it the largest river entirely bounded by the state of Maryland (Breitburg et al. 2003). It lies between the major population centers of Washington, D.C. and Baltimore, Maryland, and traverses rural-agricultural and urban-suburban land uses. This makes the Patuxent River an ideal modeling system for the effects of urban, rural, and agricultural activity on various aspects of the watershed. The river's topography is also extremely variable, ranging in depth from 3.1 to 39.6 m at its deepest and never becoming wider than 3.7 km. The estuarine portion of the river consists of brackish wetlands and marshes (USACE 1996). Most likely, the majority of terrapins can be found in these areas of the Patuxent River. This non-homogenous landscape presents a unique opportunity to study multifaceted approaches to management of the leading causes of decline to the overall health of the river and the bay (Breitburg et al. 2003).

Since colonial days, the Patuxent has served as an anthropological base for many European settlers. Quotes from the early 1800s depict the Patuxent as a clear and thriving ecosystem with a healthy seafood market (Breitburg et al. 2003). However, the arrival of agriculture and development of human settlements along the banks and surrounding fields of the Patuxent have severely altered its ecosystem and food web ecology (Bockstael 1996). In 1994, roughly 50% of the shoreline was natural vegetation while 30% was invested in agriculture and 15% in residential use. About 5% of the river was in industrial use. The intensive use of agriculture, in companion with the clearing of over 85% of the forests surrounding the Patuxent River Basin, increased the amount of nitrogen and sediment runoff to nearly 5 times pre-European settlement levels, while phosphorus increased 20 times pre-European settlement conditions (Breitburg et al. 2003). Dissolved oxygen has also reached catastrophically low levels, making it very difficult for fish and invertebrates to survive during the summer months (Breitburg et al. 2003). However, due to the concern of local citizens, the Patuxent is the focus of a major water quality and habitat restoration effort aimed at reducing the impact of fertilizers and sediment runoff (Bockstael 1996).

The industrial impact on the Chesapeake Bay came into sharp focus on April 7, 2000, when almost 530,000 liters of crude and fuel oil leaked into the River at Swanson's Creek from the Chalk Point power plant and contaminated 27.4 km of shoreline. About 64.4 km of shoreline and creeks were affected; the oil caused substantial damage to wetlands, beach shorelines, and wildlife. A comprehensive study attempted to assess the total number of terrapin-years lost in the oil spill. The estimate was based on the 122 adult and juvenile terrapins killed directly by the oil spill, the successive loss in the next generation due to these deaths, and an estimate of the loss of hatchlings made by experts working in the field. The researchers estimated that 5,244.6 terrapin-years were lost during the 2000 oil spill (Byrd et al. 2002). Another study was conducted to determine if the spill caused the uptake of polycyclic aromatic hydrocarbons (PAH) in the eggs of diamondback terrapins. After careful chemical analysis of eggs collected at different sites, it was determined that nest site itself did not present a direct correlation between degree of oil contamination and the levels of PAH in the eggs. Researchers concluded that it was more likely maternal transfer that accounted for varying levels in the eggs. It is convenient to study the localized effects on certain populations because of the abundance of terrapins in the Patuxent River area and their tendency to return to the same nesting sites (Holliday et al. 2008).

Cremona Farms and Trent Hall Farm

Cremona was a 394.2-ha historic farm in St. Mary’s County, Maryland, along the Patuxent River. A conservation easement was established in 2001 for Cremona Farms to protect forests, wetlands, farmland, historic buildings, and wildlife habitat, including that of the bald eagle and the diamondback terrapin (Maryland Environmental Trust 2001). Our field research station was located on Cremona Farms, providing us easy access to study sites along the lower Patuxent River. Trent Hall was a farm similar to Cremona that was located a few kilometers north and also bordering the Patuxent River (Figure 14).

Figure 14. Location of study areas, Cremona and Trent Hall Farms.
Satellite image from Google Earth.

Both farms were located a few kilometers downstream from PEPCO’s (now Mirant Corporation) Chalk Point Power Plant. In response to the oil spill of April 2000, restoration plans were developed for Washington Creek, a tributary of the Patuxent located just south of Chalk Point. Restoration and enhancement of beach shoreline was the primary method implemented to help increase terrapin nesting habitat. The shoreline was restored with increased beach sand and a gradual slope was developed from the shoreline to “high beach” areas to make it easier for terrapins to find nest sites. Beach grasses were planted to help stabilize the area from erosion. Our study site was located on one such enhanced shoreline located adjacent to Washington Creek (Figure 15).

Figure 15. Restored shoreline at Trent Hall Farm beach with breakwater addition providing more openings for terrapins to reach the beach and nest.
(Team Saving Testudo Research Collection)

Jefferson Patterson Park and Museum

Jefferson Patterson Park and Museum was a large, 226.6-ha tract of land along the Patuxent River and St. Leonard Creek in Calvert County, Maryland. Mary Patterson, the wife of Jefferson Patterson, donated the property to the state of Maryland in 1983, and it was then quickly turned into a park. Today, Jefferson Patterson Park and Museum offers various special programs throughout the season including heritage celebrations, children's activities, tours, concerts, dances, lectures, and educational programs (Jefferson Patterson -History…[date unknown]).

Jefferson Patterson Park houses a museum that studies the changing cultures and environment of the Chesapeake Bay region over the past 12,000 years. It also has an archeology research laboratory that has curated over 4.5 million artifacts from all over the state of Maryland, dealing with such topics as Native American life, archaeology, history, agriculture, historic agriculture, historic architecture, and the identification and conservation of artifacts. Along with the museums, Jefferson Patterson Park also has a mission to preserve and study the environment. This has led to the park's introduction of various educational opportunities for children to learn about the Chesapeake Bay ecosystem (Jefferson Patterson -Visitor…[date unknown]).

Currently, the park emphasizes the issue of erosion control. Some techniques, like groins and bulkheads, often have unintended negative consequences for shorelines. More recent developments such as "living shorelines" are better for the environment, intended to create or restore coastal wetlands and beach strand habitats (Living Shorelines…[date unknown]). These efforts have made Jefferson Patterson Park a safer area for diamondback terrapins to nest. The abundance of diamondback terrapins, along with the park's pursuit of knowledge, made it an ideal place to test the effects of electric fencing on excluding mammalian predators.

Patuxent Wildlife Research Center

The Patuxent Wildlife Research Center was originally known as the Patuxent Research Refuge and its inception was due mainly to the efforts of President Franklin D. Roosevelt. On December 16, 1936, Roosevelt signed an executive order which gave the Department of Agriculture 1080.5 ha of land located in both Anne Arundel County and Prince George's County in Maryland. This land was designated as a wildlife experiment and research refuge, and it eventually became known as the Patuxent Research Refuge. The area was ultimately renamed the Patuxent Wildlife Research Center in 1956 (Perry 2004). Since then the size of the Patuxent Wildlife Research Center has grown substantially, providing more land for wilderness area and for the construction of state-of-the-art research facilities.

Through tenures of various directors, the research center has remained focused on its goal of using wildlife research to gain a better understanding of wildlife. Over the years, scientists have studied many species, including bald eagles, box turtles, black rat snakes, red-shouldered hawks, several species of ducks, and most notably, the whooping crane (Perry 2004). Some of the research dates back to the 1930s and continues today. The center, located near the University of Maryland, provided us an excellent opportunity to conduct our research on electric fence design.

Patuxent Wildlife Research Center's long history of wildlife research was one of the many factors that interested us and persuaded us to pursue the possibility of conducting our own research at this facility. We spoke with many officials from the Patuxent Wildlife Research Center, and they provided us with valuable information regarding the best way to conduct our research. Additionally, in the spring of 2008, we conducted a small experiment at this location to test possible fence modifications. Because there were no terrapins there, we used cod liver oil to attract the same predators that were present at our beach study sites.

Chapter 4: Methodology

This study focused on the exclusion of mammalian predators from diamondback terrapin nesting beaches through the use of electric fences. We collected data on the effectiveness of electric fences in deterring mammalian predators from terrapin nests and determined whether electric fences have the potential to be used as a viable conservation technique to increase diamondback terrapin populations.

The basic concept of our study focused on surrounding small sample plots of beach with electric fencing. We observed whether terrapins nested inside the fenced plots and then compared nest depredation rates inside the fences to rates for random control plots of unprotected beach.

Summer 2007

For the first summer of experimentation, we limited our study to one beach on Trent Hall Farm.

Experimental Design

At Trent Hall Farm, we randomly established six control and six treatment plots. Each plot measured 25 m^2 (5 m x 5 m) (Figure 16). Each treatment plot was surrounded by an electric fence, whereas control plots were marked with plain wooden stakes at each corner. We determined the locations of treatment and control plots by using stratified random sampling. After gridding off the entire beach into 25 m^2 plots, we divided the beach into five sections based on distance from the water. The sections corresponded to different rows in our grid. To ensure that differences in the conditions and locations of the various beach sections did not affect our results, we established an equal number of treatment and control plots in each section. Due to the shape of the available nesting habitat, some sections were able to accommodate only one control and treatment pairing while other sections could fit two pairings.

To assign treatment and control plots within the grid, we numbered each 5-m x 5-m square and then used a computer program to randomly select which plots would be used as control and treatment areas. We then flipped a coin to determine whether the selected plot would be a treatment or control plot. As we assigned plots, we disqualified those that were touching the selected plot and reworked the random number generator so that it only selected from the remaining squares. As a result, we had the same number of control and treatment plots at various distances from the water, the control and treatment conditions were randomly assigned within each of these stratifications, and no treatment or control plot was ever within 5 m of other treatment or control plots (Figure 16).

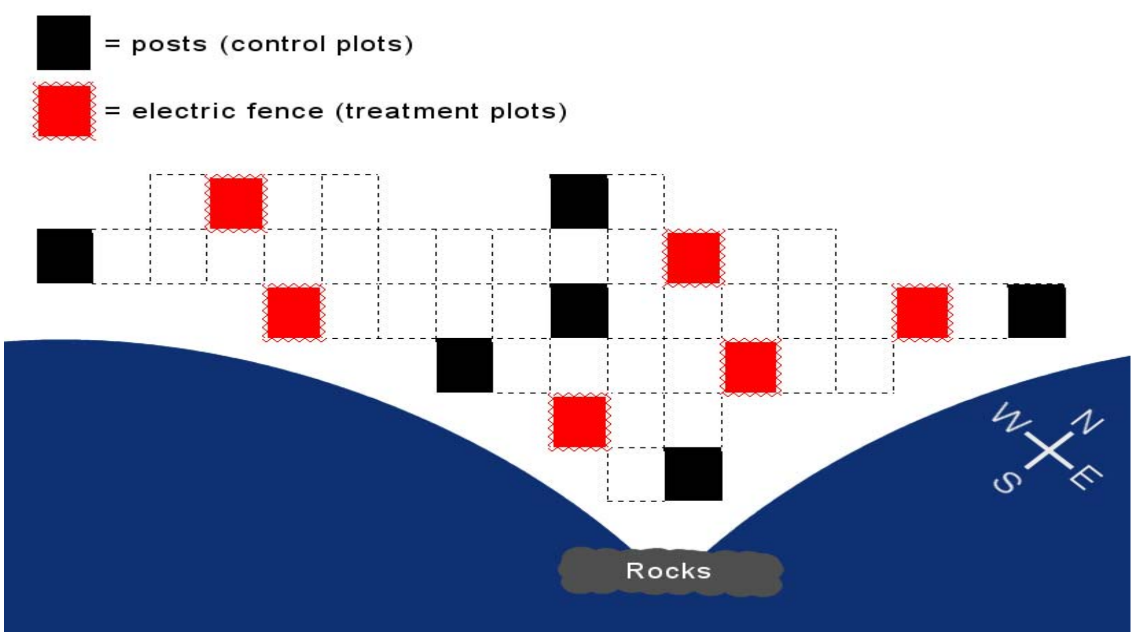

Figure 16. Trent Hall Farm beach schematic map of control and treatment plots, 2007. (Team Saving Testudo Research Collection)

Electric Fence Design

Our electric fence design was based on recommendations in the literature (Boggess 1994; Phillips and Schmidt 1994; Hadidian et al. 1997). Boggess (1994) recommended a 1-wire (15.2 cm from the ground) or 2-wire (15.2 cm and 30.5 cm from the ground) fence for deterring raccoons. Phillips and Schmidt (1994) stated that a 3-wire fence (15.2 cm, 30.5 cm, and 45.7 cm from the ground) "can repel foxes," and Hadidian et al. (1997) recommended an electric fence for exclusion of foxes and raccoons from unwanted areas. Our basic design consisted of six single wires placed in pairs at three heights. The sets of wires were 15.2, 30.5, and 45.7 cm above the ground. For each pair of wires, there was one wire which was electrified and another wire that served as a ground wire. These wires were only 2.54 cm apart. A ground wire was necessary with each "hot" wire because dry sand does not conduct electricity well (see Electric Fences section in the Literature Review). In the pairs of wires at 15.2 and 30.5 cm off the ground, we electrified the lower wire in each pair, but in the highest pair, we electrified the top wire. This arrangement may have maximized the chances of a fox or raccoon touching the electrified wire. Fence posts were necessary at each corner and in the center of each side of the plots to hold the wires taut and separate.

The following fence equipment was purchased from Premier Sheep Supplies Ltd. in Washington, Iowa.[1] The fence posts (fiberglass rods) were 0.9 m long and had a diameter of 1 cm. Insulators were plastic snap-on units, and the electric wire was MaxiShock. The insulated wire we used was MaxiShock Double Insulated Cable. Additionally, we used a lightning diverter to protect the energizer, which was a Kube

[1]Reference to company names and products does not imply endorsement of those companies or products.

Argus 250. The fence was powered by an EzePower 160-165 amp 9 volt battery. Our ground rod was galvanized, 0.9 m long, and 1.3 cm in diameter. We baited the wire by applying peanut butter directly onto the 15.2 cm hot wire (Figure 17). We wound a bit of extra electric wire to the fence to give the wire more width and then put the peanut butter on the fence and wrapped tinfoil loosely around it. When all of the fences were connected, the energizer delivered about 4,000 volts of electricity to each fence.

Figure 17. Fence baited with peanut butter.
(Team Saving Testudo Research Collection)

We found the fiberglass rods were too flexible to allow the wires enough tension to stay separated without significant reinforcement. To reinforce the rods, we secured them with a combination of plastic tent stakes and rebar stakes that were 1.2 m long and 1 cm in diameter. The rebar stakes were necessary in areas where the ground was too soft for the tent stakes to hold. The fence posts were tied to the stakes or rebar with about 0.9 m of generic twine. The control plots were marked by 0.9-m wooden stakes that were hammered into the ground about 0.3 m deep.

For set-up, we needed the following tools. First, a large sledge hammer was used to pound in the fence posts, stakes, and rebar. We used regular hammers and an electric screwdriver to attach the lightning diverter and perform various smaller jobs. Small wire cutters were used to cut and strip the wires. We cut back the vegetation with hand-held grass clippers. Lastly, the entire fence tightening was done by hand (Figure 18).

Figure 18. Fence design at Trent Hall Farm beach, 2007.
(Team Saving Testudo Research Collection)

Experimental Procedures

Starting on May 28, 2007 we checked the beach daily and recorded nest and fence conditions. We generally collected data in the evening after the daily peak terrapin nesting time was over, searching the beach for new nests and noting conditions of old nests. New nests and newly depredated nests were recorded in our data notebook. We kept a record of all nests laid on the beach, but only included nests within treatment and control plots in our data analysis. The locations of nests were recorded using a hand-held GPS unit.

To locate terrapin nests, we used a technique recommended by Roosenburg (Ohio University, personal communication). Roosenburg trained us to locate nests by following the females' tracks from the water (Appendix G). We walked along the edge of the water and when we found terrapin tracks, we followed them back to the nest. Slight disturbances in the sand, loose soil, or a typical terrapin "sand angel" pattern made when the female used her plastron to tamp down the reburied sand indicated the existence of an intact nest. Depredated nests were easier to find, marked by predator tracks, a dug-out hole, and broken eggshells (Figure 19). We recorded both nest location and conditions in a small journal and kept a daily log of other pertinent observations such as weather conditions and maintenance issues with the fences.

Figure 19. A depredated terrapin nest.
(Team Saving Testudo Research Collection)

We monitored fence conditions carefully, checking the fence voltage with a small voltage meter (Horizont Six Light Tester) to ensure that voltage remained above 4,000 volts. We immediately repaired any shortages or breaks in the fence and replaced the bait on fences every few weeks. We also used hand-held grass clippers to keep the beach grass and other vegetation away from the fences. To make it easier to find nests and follow tracks, we smoothed out the sand inside and around our treatment and control plots with a garden rake.

Spring 2008

During the spring of 2008, we conducted research at the Patuxent Research Refuge and focused on improving the design of our electric fences and studying effectiveness of the improved design in deterring raccoons and foxes. Two sites were selected for the Patuxent study based on their close proximity to water and to edge habitat, which we believed would have a greater concentration of predators within the research site. We randomly selected one site for the treatment plot and another for the control plot.

At the control site, we measured a 5-m x 5-m plot and marked the corners with wooden stakes. In the center of the plot we constructed a scent station in accordance with Travaini et al. (1996) and Lowell Adams (University of Maryland, personal communication). The station consisted of a circle of sifted soil 1 m in diameter; in the center, we placed a scent attractant (a cotton ball saturated with cod liver oil) on a wooden stake. To prepare the station, grass and other vegetation were removed from the site and the soil was sifted through a 3.2 mm mesh screen to prepare it for track impressions. Some sand was mixed with the soil and the station was covered with about 6.4 mm of the sifted earth. On the day before a survey, stations were groomed and the attractant was added. Stations were checked early the following morning and data recorded included site number, the presence of tracks (and the species leaving tracks), and any notes. This process was repeated the following night. A light boot imprint was placed at the circle boundary to indicate whether or not the station was operative or inoperative the previous night. If the boot imprint remained visible, it was assumed that the station was operative; a washed-out boot imprint resulted in an inoperative night. If the station was inoperative, the soil in the circle was raked, the attractant was replaced (if necessary), and another boot imprint was placed at the station boundary. Tracks of a single species at a station on any day were recorded as one visit, regardless of the number and size of tracks of that species, and only tracks located inside the circle were recorded. After data were recorded for a particular day, any tracks present were removed by lightly raking or brushing the dirt within the circle with a whisk broom.

At the treatment site, we set up one 5-m x 5-m electric fence plot. The electric fence design was similar to the design from the summer of 2007. However, instead of using the original fiberglass rods as our corner posts, we used steel corner posts (Figure 20) to increase the strength and durability of the fence.

Figure 20. Fence design with steel corner T-posts, 2008.
(Team Saving Testudo Research Collection)

The set-up of the scent station was similar to the set-up detailed in the previous paragraph.

We collected data on weekends from April 18 to May 18. On Fridays, we turned on the fence in preparation for gathering data over the weekend. On Saturdays and Sundays, we traveled to the research site to check for footprints in either of the plots. It is also important to note that we checked to see if the scent stations were in good operating conditions, consistently raked the sand to ensure that any footprints would still be distinguishable, and replaced the cod liver oil to ensure that our attractant remained strong. At the end of the weekend, we removed the attractant and turned off the electric fence in order to conserve the battery.

Summer 2008

During the summer of 2008, we conducted research on two beaches: Trent Hall Farm and Jefferson Patterson Park and Museum.

Experimental Design

At Trent Hall Farm, we set up our experiment in the same manner as we did in 2007: there were six treatment and six control plots distributed randomly within stratified sections of the beach. At Jefferson Patterson Park, we divided the experimental beach in half and had one large treatment plot and one large control plot.

The treatment plot at Jefferson Patterson Park was our largest plot (Figure 21).

Figure 21. Schematic design used at Jefferson Patterson Park. The treatment plot is indicated in red, and the control plot is indicated in white.
Image created with Google Maps.

To create a coordinate grid to record the locations of nests, we used the fence line farthest from the water (the back line) as the x-axis and then measured the y-axis straight down from the back line. We designated the origin of the system as the upper left-hand corner of the fence (when facing away from the water). After we constructed the electric fence to fit to the shape of the beach, we measured the perimeter and estimated the area. From that information we created a control plot on the other side of the beach with the same area as the treatment plot. We used the same coordinate grid for the control plot. Because this coordinate grid measured over a much longer length than at Trent Hall, we recorded the distances in meters instead of centimeters.

Electric Fence Design

The basic fence design remained the same for our second year of data collection except for the replacement of fiberglass rods with steel posts at fence corners. This design change resulted from our research during Spring 2008 at Patuxent Wildlife Research Center. At Trent Hall Farm, we used one fiberglass rod between the steel corner posts to keep the wires from sagging and touching each other, and at Jefferson Patterson Park, we placed fiberglass rods 3 m to 3.5 m between steel corner posts. At the landowner's request, we used larger electric fence warning signs in 2008 than in 2007. Other electric fence materials were the same as used in 2007.

In mid-June, we added about 0.6 m of non-electrified chicken wire (a light galvanized wire netting of hexagonal mesh) to the top of the fence at Jefferson Patterson Park in an effort to reduce fox penetration of the fence (Figure 22).

Figure 22. Addition of chicken wire mesh to fence design at Jefferson Patterson Park and Museum, 2008.
(Team Saving Testudo Research Collection)

There was enough height left on the steel posts above the original electric wires to allow us to attach the chicken wire directly to these posts. Because the steel posts were spaced too far apart to hold up the chicken wire, we also had to make wooden stakes, which were 1.4 m tall, to add support between the steel posts. The chicken wire was attached to the steel posts and the wooden stakes with zip ties. We used 15.2 cm of chicken wire at the top of the fence to build an overhang by curling the chicken wire back over the outside of the fence. The chicken wire addition was positioned 2.5 to 3.8 cm above the top wire of the electric fence.

Experimental Procedures

The procedures to check the beaches for nests and to check the condition of fences were the same for both study sites and were the same as used in 2007, with three exceptions. One, we did not use a GPS unit to mark the locations of nests; instead we relied exclusively on the coordinate systems of our grids. Two, we checked the plots at Jefferson Patterson Park every other day rather than daily because it was located too far from our field headquarters on Cremona Farm to check daily. Three, because Jefferson Patterson Park was a public park, there were a few days when the park required us to turn off the fence when special events, with large crowds of people, were held.

Statistical Analysis

We used two different one-tailed statistical tests to analyze our data. Firstly, because of small sample sizes, we used Fisher's Exact Test to analyze the differences in terrapin nest depredation between control and treatment plots. Additionally, the Chi Square Goodness of Fit Test procedure (Johnson and Kuby 2005) was used to analyze the differences in terrapin nesting between control and treatment plots.

Assumptions

To complete the experiment, we made several necessary assumptions. First, we assumed that terrapins were nesting at the selected locations and that nesting occurred at the same time at the two locations. Second, we assumed that predators existed on the beaches and attempted to destroy terrapin nests (Burger 1977; Spencer 2002; Feinberg and Burke 2003; Butler et al. 2004; Draud et al. 2004; Burke et al. 2005). Third, we assumed that mammalian predators such as the fox and raccoon contributed to the predation rate. Fourth, we assumed that terrapin nesting behavior was not affected by the electrical fence enclosures because the fences were placed high enough off the ground so that the turtles could fit underneath and continue with their normal nesting behavior. Fifth, we assumed that the fence shocked the predators enough to deter them from further efforts at accessing the nests in treatment plots. Lastly, we assumed that the predators did not dig under the fence. We considered these assumptions while designing the fence, recording data, and interpreting results.

Extraneous/Confounding Variables

In order to ensure accuracy of our results, we addressed several extraneous and confounding variables that could affect the successful completion of our project. A substantial amount of information concerning the actions and behaviors of terrapins and predators was unknown. Additionally, the fence was not designed to protect terrapins from all predators. For example, if the terrapin nests were preyed upon by birds or other air-borne predators, our electric fences would not be able to protect the nests.

The behavior of the terrapins could have greatly affected the research. Terrapins will most likely have different reactions to different predators, affecting how and where they nest. For example, it may be easier for terrapins to notice a fox than a bird, making them more likely to nest in different locations when each animal is present. In addition, terrapins may not fear some predators as much as they fear other predators. Also, the presence of other animals that are not necessarily predators could affect where terrapins nest on beaches. It is also possible that terrapins might display different types of behavior at the two sites. Terrapins from different beaches may have different nesting tendencies and their reaction to human presence on the beaches and nesting sites may differ. For example, if they are habituated to human presence, they may be more or less likely to nest than if they were not habituated to humans.

There were also variables that could affect where females lay their eggs including soil type, sun and/or shade, moisture, and the depth of sand on the beach where they were nesting. The types of soil and soil temperatures, as well as simple geographical differences, could also be responsible for the terrapins making their nests in different locations. These environmental differences may account for variance in nesting locations.

Lastly, there was the possibility of equipment failure and human error. With regards to the electric fences, sources of error included periodic fence shortages due to tangled wires or overgrown vegetation and battery depletion. Additionally, sources of human error include misreading the volt meter or failure to record or observe a recently laid nest. More specifically, there were instances in which we suspected a nest had been laid but were unable to locate it; if there had been nests, these oversights could have affected our overall data.

Institutional Animal Care and Use Committees

This project was conducted under the auspices and approval of the University of Maryland Institutional Animal Care and Use Committee permit number R-07-24 and the United States Geological Survey's Patuxent Wildlife Research Center Animal Care and Use Committee.

Chapter 5: Results

Effect of Electric Fences on Predators

No significant differences were noted in mammalian predation rates of terrapin nests between treatment and control plots for Trent Hall Farm (Fisher's Exact Test, P=0.55) or Jefferson Patterson Park (Fisher's Exact Test, P=0.25) (Tables 1-2). Sample sizes were small, especially in the treatment plots at both study sites.

Although no significant differences were noted in predation rates between treatment and control plots, a pattern of lower predation rates in the treatment plots for both study sites seems to suggest that electric fences may have influenced predation rates (Figure 23).

Table 1. Effectiveness of electric fences in reducing diamondback terrapin nest predation by raccoons and foxes, Trent Hall Farm, lower Patuxent River, Maryland, 2007-2008.

	Study Plots	
Terrapin Nests	Treatment (fenced)	Control (unfenced)
Not Depredated	4 nests	6 nests
Depredated	1 nest	3 nests
Total Nests	5 nests	9 nests
Percent Depredated	20%	33.3%

Table 2. Effectiveness of electric fences in reducing diamondback terrapin nest predation by raccoons and foxes, Jefferson Patterson Park and Museum, lower Patuxent River, Maryland, 2008.

	Study Plots	
Terrapin Nests	Treatment (fenced)	Control (unfenced)
Not Depredated	2 nests	3 nests
Depredated	3 nests	17 nests
Total Nests	5 nests	20 nests
Percent Depredated	60%	85%

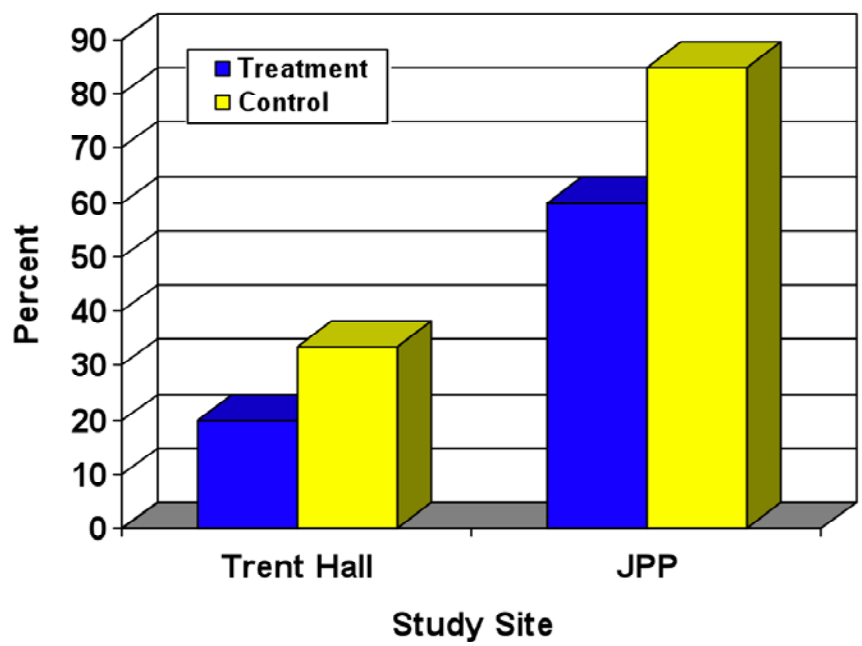

Figure 23. Diamondback terrapin nest depredation (in percent) by mammalian predators in treatment and control plots, lower Patuxent River, Maryland, 2007-2008.

Effect of Electric Fences on Terrapins

A significant difference was noted in the number of nests within treatment and control plots at Jefferson Patterson Park ($\chi^2 = 9.0$, df = 1, $P < 0.01$) (Table 3, Figure 24). No difference was found between the number of nests within treatment and control plots at Trent Hall Farm ($\chi^2 = 1.14$, df = 1, P $0.25 < P < 0.50$) (Table 3, Figure 24) although the trend was the same as for Jefferson Patterson Park (Figure 24).

Table 3. Diamondback terrapin nest location at all study sites, lower Patuxent River, Maryland, 2007-2008.

	Terrapin Nesting in Study Plots (Nest Location)	
Study site	Treatment (fenced)	Control (unfenced)
Trent Hall	35.7 % (5 nests)	64.3 % (9 nests)
Jefferson Patterson Park	20 % (5 nests)	80 % (20 nests)

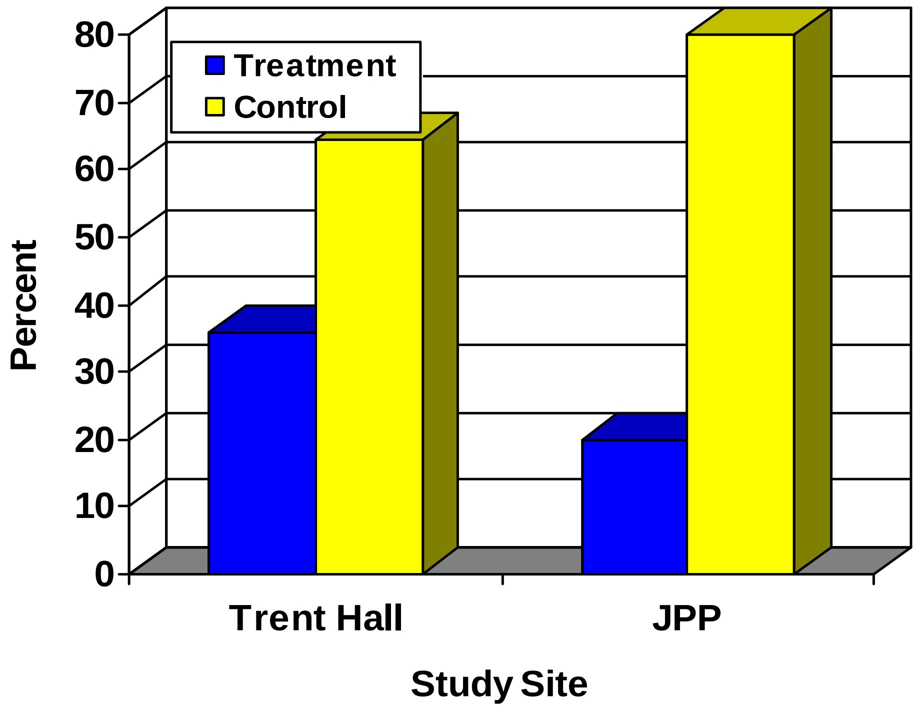

Figure 24. Diamondback terrapin nest location (in percent) between treatment and control plots, lower Patuxent River, Maryland, 2007-2008.

Fence Design Modification and Scent Stations

The modified fence design tested during spring 2008 (i.e., replacement of fiberglass rod corner posts with steel corner posts) was more stable than the original fence design used during summer 2007. The modified design was used during summer 2008.

The scent stations at Patuxent Wildlife Research Center were operable four nights and raccoon tracks were present one night at the control site for a visitation rate of 25 percent. No tracks were present at the treatment site.

Chapter 6: Discussion

Effect of Electric Fences on Predators

The data collected at Trent Hall Farm and Jefferson Patterson Park indicated that electric fences may have contributed to lower predation rates by foxes and raccoons. However, our sample sizes were small and any differences in predation rates between treatment and control plots were not large enough to be determined statistically significant. Effect of sample size can be seen in the separate data sets, where probability levels were lowered from P= 0.55 for Trent Hall Farm to P= 0.25 for Jefferson Patterson Park. A larger sample size would be needed to make a conclusive statement about the effect of electric fences on predators.

Trent Hall Farm

Combining data from the two summers, the predation rate in control areas was 33.3%, and the predation rate in treatment areas was 20%. Although these results were encouraging because they seem to show that the fence may be contributing to lowering the predation rate, our sample sizes were small and any differences in the predation rates were not large enough to be determined statistically significant.

If the data from each summer are considered separately, a large difference can be seen. There was a decrease in nesting activity on Trent Hall between the summer of 2007 and the summer of 2008. In the summer of 2007, 47 nests were recorded on the entire beach, including areas outside of our experiment. There was no depredation of nests inside the electric fences, but 60% of nests in the control areas were depredated. These data looked very promising, but the sample size was not large enough to give significant results. If similar nesting activity and results had been obtained in the second summer, our sample size would have been large enough to make results significant (Appendix H). However, in 2008, the experiment did not yield a doubling of the data as we had hoped. Instead, there was a dramatic decrease in nesting activity on Trent Hall. Only 15 nests were found on the beach over the course of the entire summer, and only five occurred within our experiment. Because of this, we did not double our sample size as we had hoped. One of the difficulties of doing field studies is the unpredictable environmental conditions from year to year.

Previous studies on active terrapin beaches have reported predation rates close to 90% (Feinburg and Burke 2003). However, at Trent Hall, between both years of study, the predation rate in control areas was only 33.3%. There are several possible explanations for this low predation rate. First of all, Trent Hall Farm is surrounded by farm land, and there were several reports during the summer of 2007 that farmers were shooting nest predators such as foxes and raccoons (Dr. Bud Virts, Trent Hall Farm, personal communication). In addition, we observed several large dogs living near and visiting the beach with their owners throughout the summer, and they may have been running loose at night. It is possible that these domestic animals reduced nest predator activity on this particular beach. During the summer of 2008, the low nesting activity on Trent Hall could have discouraged foxes and raccoons from hunting on the beach. Studies suggest that predators may locate nests with the aid of physical cues such as scent and signs of digging (Spencer 2002). With so few nests, there may not have been enough physical cues to attract predators.

There is also the possibility that the experimental design on Trent Hall was not entirely independent, meaning that the location of some electrified fences around the outer edges of the experimental area may have hindered depredation in control plots more centrally located within the experimental area. In other words, a raccoon or fox may have encountered a fence at the edge of the experimental area and then simply moved out of the area. Our experimental design layout allotted at least 5 m between control and treatment plots to prevent interactions of this kind, but it could be that this distance was not sufficient for complete independence.

Lastly, low nesting rates in the second summer at Trent Hall Beach could be attributed to a newly constructed pound net that was put into the water in close proximity to the nesting beach. A pound net is designed to capture fish and hold them live (Figure 25).

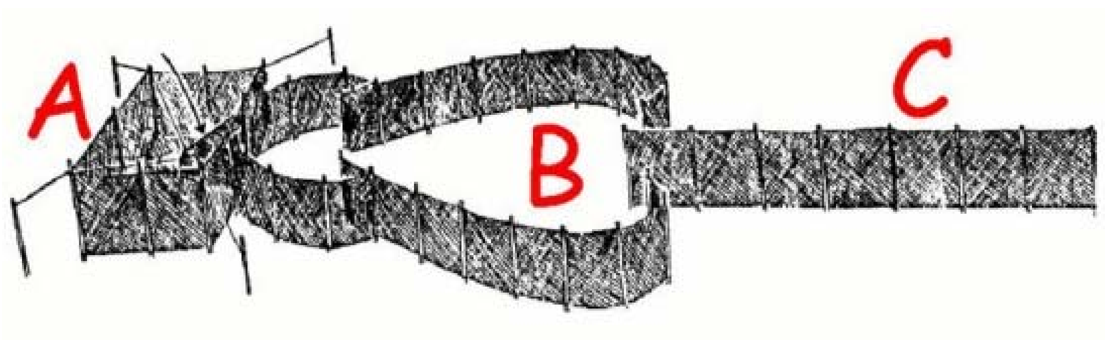

Figure 25. Diagram of a typical pound net.
Image taken from Department of Natural Resources website:
http://www.dnr.state.md.us/fisheries/commercial/poundnet.html

Terrapins are often caught in pound nets where they may spend months trying to escape before they are released. Although terrapins rarely drown in pound nets, researchers have often observed scarring and other damage to terrapins from fighting against nets while trapped (Roosenburg, personal communication). Hundreds of terrapins were found caught in the pound net near Trent Hall Farm during the summer of 2008. Roosenburg, continuing his long-term population study, observed strikingly low numbers during the summer of 2008, catching only 409 terrapins, about 600 less than he had in the previous year. Therefore, the pound nets may have prevented the terrapins from nesting. This could have had significant effects on nesting in our experiment, particularly the difference between the number of nests in the two summers.

Jefferson Patterson Park and Museum

While the raw data suggested that the fences had some role in preventing predation of terrapin nests, statistical analysis indicated that the difference between the number of depredated nests in the control and treatment areas was too close to be statistically significant for our sample size.

Jefferson Patterson Park was a well-established nesting beach. During the summer of 2008, we observed higher nesting at Jefferson Patterson Park than at Trent Hall. There also appeared to be a higher predator population. There were substantial numbers of predator footprints on the beach, along with signs of digging. Additionally, although they are normally nocturnal, predators were observed during the day. Such observations led us to believe that predators at Jefferson Patterson Park were more accustomed to preying upon terrapin nests than at Trent Hall Farm. These observations may explain the high predation both in the treatment and control plots of our experiment.

Summary of Study Sites

Overall, our data from Trent Hall during the summers of 2007 and 2008 and our data from Jefferson Patterson Park during the summer of 2008 suggest that electric fences may affect the predation of terrapin nests, but we cannot make definitive conclusions about the efficacy of the fence. However, despite this, we believe the data are promising enough to warrant further investigation and research in regards to the use of electric fences in preventing predation of terrapin nests. Our data show a reduction in predation of 13% and 25% for Trent Hall and Jefferson Patterson Park, respectively. This compares favorably with the 21% reduction in predation by striped skunks and raccoons on duck nests using a similar fence design reported by LaGrange et al. (1995). These data indicate that the fences may have an effect in reducing predation and that this effect may be better exemplified through a larger sample size (Please see Appendix I for the raw data collected in our study).

Our scent station data from Patuxent Wildlife Research Center lend some support to this pattern. No fox or raccoon tracks were present at the scent station enclosed by an electric fence, but a 25% visitation rate was recorded for raccoons at the control site.

Fence Design Modifications

Because there was ample evidence of predation within the experimental plots, we decided we needed to address the issue and attempt to improve the fence design to prevent further predation. We have several theories as to how mammalian predators were able to enter the experimental plots. Although we do not have solid evidence on how they got past the fences, we can surmise that they either jumped over the fence, or went through the wires. Another possibility is that the fence shorted due to an overgrowth of vegetation thus allowing the predators to gain access through our fence without being shocked. There was no evidence of predators digging under the fences or climbing.

Initially, we created our fence with the wires placed at three different heights to prevent foxes or raccoons from getting over the top of the fence. However, halfway through the summer of 2008, we tried to increase the efficacy of our design by adding 0.6 m of chicken wire to the top of the fence at Jefferson Patterson Park. Unfortunately, some predators continued to get through the fence and depredate the nests even after our fence modification. They most likely slipped in between the wires.

Regardless of how predators got through, it is evident that they were not sufficiently deterred by the fence. Based on the tracks, it appears that they went through without pausing. It is possible, then, that the foxes never encountered a significant shock from the fence. We tried to ensure a direct shock to the predators by baiting the fences with peanut butter wrapped in foil. We hoped that predators would be led to smell the bait with their wet noses, the most likely part of their body to feel a shock. However, the tracks indicated that the predators rarely approached the bait, suggesting that the bait did not lure the predators to touch the fence directly. Because the wires did not pose enough of a physical barrier, foxes could have penetrated the fence without receiving a deterring shock. Given the characteristics of our fence, predators may not feel a shock through their fur.

Based on our experiences, we have suggestions for other fence modifications and designs that could be tested in the future. These will be discussed in more detail in Recommendations for Future Research.

Effect of Electric Fences on Terrapins

Combined data from both beaches showed there was almost a 3:1 ratio of nesting in control plots to treatment plots ($P < 0.01$) (Table 3). We believe the significantly lower nesting activity in treatment plots compared to control plots was due to factors other than the electric fence. We believe the most likely factor was placement of our treatment plot and control plot at Jefferson Patterson Park. When the data from the two locations were analyzed separately, the terrapins showed nesting preference at Jefferson Patterson Park, but there was no significant difference in nesting preference at Trent Hall Farm. At both beaches, we observed and recorded terrapin tracks going beneath the electric fences with no apparent trouble. No tracks of terrapins being deterred by the fences were observed. Therefore, we speculate that our fences did not have an impact on where the terrapins laid nests as our combined data indicate.

Our 2008 experimental site at Jefferson Patterson Park greatly contrasted with our 2007 Trent Hall Farm site, which greatly affected the combined data results. At Jefferson Patterson Park, there was a 4:1 ratio of nesting in control plots to treatment plots. We believe this effect, however, was not the result of terrapins actually being deterred by the fence but rather due to a difference in nesting conditions between the treatment and control areas. When designing the experimental site, we were constrained in where we were allowed to place our treatment plot. The owners of the land required that, because we were testing on a public park, we keep our electric fences as far as possible from the heaviest foot-traffic. This led us to set up our treatment plot on an area of beach that was adjacent on the shoreline and on a small but steep decline between the sand and the water, which was not present in our control plot (Figure 26).

Figure 26. Photo of treatment plot at Jefferson Patterson Park and Museum, 2008. (Team Saving Testudo Research Collection)

The treatment plot also contained more vegetation than the control plot, leaving less open sandy beach for nesting. This increased vegetation may have also made it very difficult for us to find terrapin nests. Additionally, because our fence was so close to the water on the hill side, at high tide, the water from the river would reach past the fence, building the sand up under the fence throughout the summer. This meant that at times the lowest wire of the fence was less than 15.2 cm above the ground, most likely making the area within the treatment plot inaccessible to terrapins at some locations along the fence bordering the beach. We believe the control site presented the best nesting locations, and, had treatment and control plots been reversed, we would have noticed greater nesting activity in the treatment plot. We also believe that if we had utilized an experimental set-up similar to the one from Trent Hall Farm, a more ideal experimental design, that we could have obtained different results.

We do not dismiss the potential for electric fences to affect terrapin nesting activity. First, the actual presence of a fence may be visually unappealing or frightening to terrapins, causing them to find nesting areas that appear to be safer or less foreboding. Additionally, the presence of an electric current may be an influencing factor in whether the females nest within a fenced area. It is unknown whether or not terrapins can sense electricity. Lastly, placement of the first electric wire 15.2 cm from the ground may be too low, deterring some terrapins from fenced areas. These factors may have affected whether or not female terrapins nested in the treatment plots.

We are lacking information concerning where terrapins usually nest and in what numbers; therefore it is not possible for us to definitively conclude whether the fences did or did not significantly affect female terrapin nesting behavior on the beaches. We need more information in order to conclusively state whether or not the fences had an impact on nesting behavior.

Cost Analysis

Set-up costs at Trent Hall Beach were almost identical for the summer of 2008 and the previous 2007 summer (Table 4). Each 5 m x 5 m fence set-up at Trent Hall Farm cost $104.13; this cost includes only the minimum amount of materials needed to construct this fence – materials used to fix the fences throughout the summer was not included. Therefore, each perimeter meter of fence material with this design costs $5.21, no matter the interior area. The most costly aspect of this experiment was the materials needed to initially set up the beach for use: an energizer, battery, lightening diverter, and other equipment to make the electric fences safer. All totaled, it cost our team $233.15 to purchase the materials needed to prepare the beach for our experiment. It should also be noted that the costs detailed in Table 4 do not include any other expenses the team paid throughout our research such as gas, fence maintenance, or data collection material. The final, complete cost of set up on Trent Hall Farm was $857.93, which includes the initial beach set-up (energizer, battery, etc.) as well as the cost for six 5 m x 5 m fences.

Table 4. Cost breakdown of fence setup at Trent Hall Beach

Trent Hall Beach, 2008

Material	Cost Per Item	Amount we needed	Total cost
- **Each Fence:**	- -	- -	- -
wire	$140/2640 feet	120 m (393.7 feet)	$20.88
3/8" grey posts	$1.35 each	8	$10.80
steel T-posts	$11.25 each	4	$45.00
steel insulator clips	$0.16 each	24	$3.84
grey insulator clips	$0.19 each	48	$9.12
insulator cable	$70/330 feet ($0.69/1m)	~21 meters	$14.49
			$104.13
Each Beach:			
energizer	$176 each	1	$176
battery	$44 each	1	$44
ground rod	$3.75 each	1	$3.75
ground clamp	$1.40 each	1	$1.40
lightening diverter	$8 each	1	$8
			$233.15

Each fence: $104.13 x six fences = $624.78
Beach setup:
$233.15
Entire beach: $624.78 + $233.15 = **$857.93**

Set-up costs at Trent Hall Beach 2008 were very similar to the costs associated with Jefferson Patterson Park (Table 5). The set-up cost for Trent Hall Beach 2007 was slightly cheaper because we did not use the steel t-posts during the first summer; all other materials remained the same.

Table 5. Cost breakdown of fence setup at Jefferson Patterson Park.

Jefferson Patterson Park, 2008

Material	Cost Per Item	Amount we needed	Total cost
- **Each Fence:**	- -	- -	- -
wire	$140/2640 feet ($1.39/1m)	142 m (465.88 feet)	$197.38
3/8" grey posts	$1.35 each	38	$51.30
steel T-posts	$11.25 each	17	$191.25
steel insulator clips	$0.16 each	102	$16.32
grey insulator clips	$0.19 each	228	$43.32
insulator cable	$70/330 feet ($0.69/1m)	~6 meters	$4.14
			$503.71
Each Beach:			
energizer	$176 each	1	$176
battery	$44 each	1	$44
ground rod	$3.75 each	1	$3.75
ground clamp	$1.40 each	1	$1.40
lightening diverter	$8 each	1	$8
			$233.15

Each fence: $503.71
Beach setup: $233.15
Entire beach: $503.71 + $233.15 = **$736.86**

Conservation and Management Implications

Electric fences have long been studied as an effective wildlife management technique. Various fence designs have proven effective at excluding coyotes, white-tailed deer, black bears, elk, badgers, bison, feral pigs, feral cats, and foxes (Reidy et al. 2008). Electric fences have many benefits that are lacking in other management techniques. Traditional fences that depend on a physical barrier to exclude animals are generally more expensive than electric fencing (Reidy et al. 2008); electric fences require less physical material and probably have a lower impact on the environment. Electric fencing is also relatively easy to assemble and disassemble. Most of the equipment used in our study can be reused multiple times; therefore fences can be temporarily constructed and maintained for the summer terrapin nesting season and then stored for the rest of the year, further lowering the impact of the fences on the environment. Lastly, electric fencing is a non-lethal management technique that may be more acceptable to the general public than the hunting or trapping of predators.

Although electric fences are a promising solution for protecting terrapin nests on beaches, the efficacy of the fences is dependent on many different factors. Thus, the findings of any one study on electric fencing cannot necessarily be generalized to different environments or situations. For example, electric fencing may not be viable for terrapin nesting beaches that have heavy vegetation, and they may be less effective in habitats where terrapins nest more diffusely in poorly defined areas. Despite the unique challenges that the beach environment presents, we strongly believe that electric fencing is a useful conservation technique for protecting terrapin nests. We believe further research on fence design will lead to greater effectiveness of this technique and strongly urge others to continue such work.

Recommendations for Future Research

Over the course of the two summers, we assessed our fence design and determined several modifications that might enhance fence effectiveness.

First, the poles we originally used to support the fence proved to be too flimsy to be effective as corner posts. During the first summer of research (2007), we used thin fiberglass fence posts because of their affordability and easiness to transport and construct. However, their flexibility made it difficult for us to maintain the correct tension on the wires, and throughout the summer, the wires would sag and touch, causing shorts. Because of this, we were forced to re-tighten the fences several times throughout the nesting season. To solve this problem, during spring 2008, we tested a modified design and found it to be more effective. Thus, for the second summer (2008), we used 1.75 m metal T-bar fence posts at the corners and at various intervals throughout the fence. Consequently, we did not have to re-tighten the fences, and there were no problems with shorts or wire tangling. The stronger posts also prevented raccoons, foxes and other animals from pulling the wires off the posts, a problem that we had the first summer. Any fence design in the future should use strong metal posts to anchor the corners because using solely fiberglass materials requires too much maintenance and continual upkeep.

Additionally, during our research with electric fencing, we encountered obstacles concerning the location of the fences on beaches and the conductivity of sand. Electrical fences depend on the ground being able to efficiently conduct electricity in order to complete the circuit. In the case of this study, the electric fences needed to be used on the dry, sandy environment of a nesting beach. Sand does not conduct electricity well enough to create a large enough shock when an animal only touches an electrified wire and the sand. Through our own qualitative experimentation, we found that touching an electrified wire alone did not give a substantial shock, but touching an electrified wire with a ground wire was effective. It was therefore necessary to incorporate a ground wire into our fence design, and we altered the design of the fence to include it. Instead of depending on the ground to conduct electricity, ground wires were placed close to the hot, or electrified, wires. This design eliminates the need to have a conductive surface under the fence, but it also requires the use of twice as much wire. In addition, it made the fences more difficult to maintain because the fence shorts if any of the wires sag and touch each other. Therefore the fences had to be kept very tight. With this design, an animal had to touch both wires to complete the circuit and feel a shock. We tried to encourage this by placing the wires as close together as possible and baiting the fence between the two wires.

To more effectively ensure foxes and raccoons could touch both wires, a different fence design could be researched and used. An inner fence of mesh or of closely spaced electrified wires could be constructed along with an outer fence that just consists of ground wires (Figure 27). With that design, a fox would be forced to push through both fences and touch both a ground and hot wire at the same time, ensuring that it would be shocked. Our fence design and the theory behind it required the fences to be baited to ensure an effective shock. If the fence has a more physical barrier, such as chicken wire, the bait may not be necessary. If bait is used in the future, we recommend using commercially purchased scents and changing them at regular intervals to ensure freshness and strength of odor.

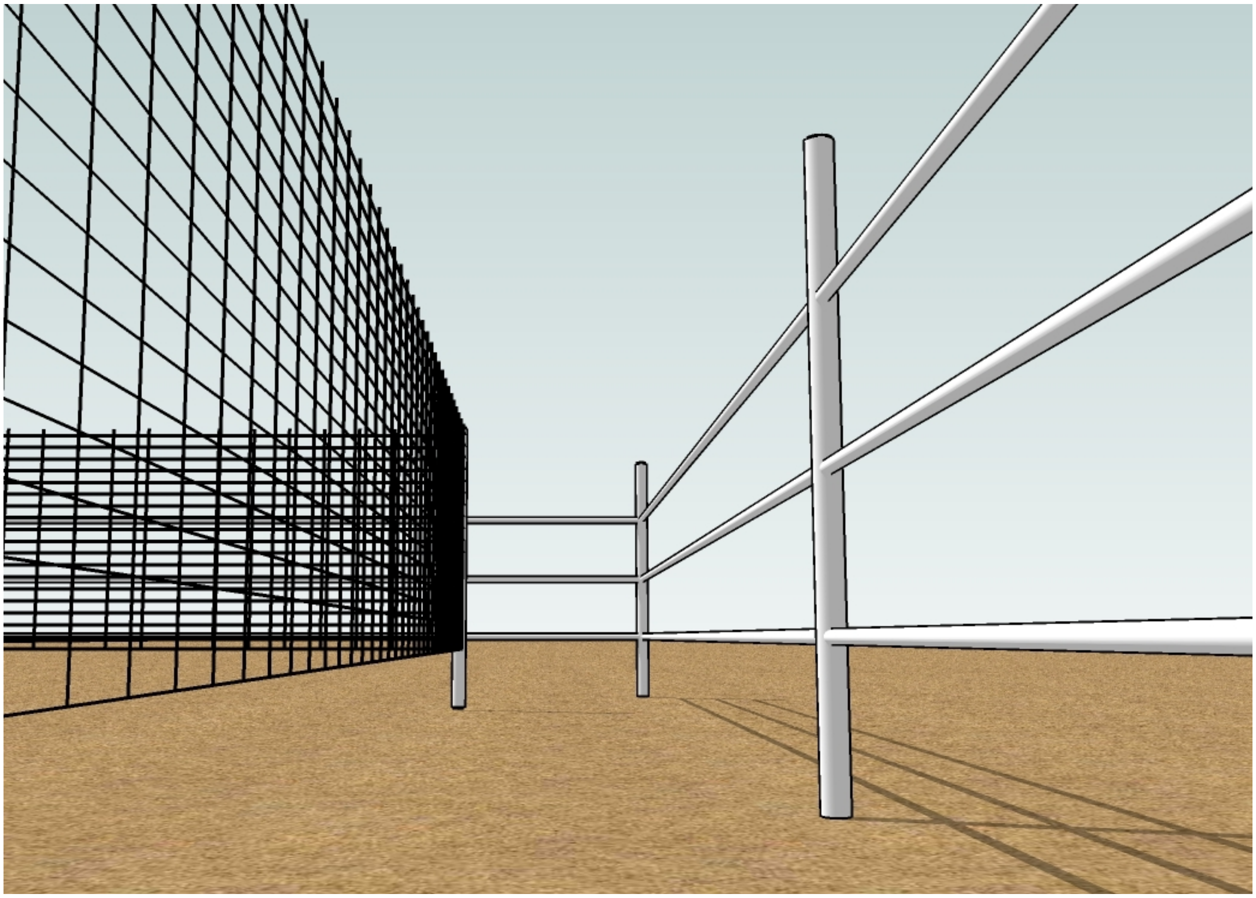

Figure 27. Diagram of a recommended fence design for testing, with inner mesh along with outer fencing.
(Team Saving Testudo Research Collection)

Another weakness with our fence design was its height. In the literature we reviewed, we found suggestions to use a fence of 45.7 cm to deter red foxes, but there is a good chance foxes could easily jump this height since they are known to jump fences up to 51 cm (West et al. 2007). To address this problem, we added a non-electrified chicken wire addition to the top of our fence. This was relatively cheap and easy to construct, and there was no indication that foxes or raccoons were able to climb over this barrier. We recommend that the top of any fence construction have an overhang to prevent animals from climbing over the fence, especially if the top of the fence is not electrified. Another option would be to simply increase the number of electrified and ground wires to expand the height of the fence.

The fence design, particularly in regards to the fences that are designed to cover very large areas of beach, and its security are particularly important because, when hunting terrapin nests, foxes and raccoons can destroy many nests in one foray. If a fox was able to get through the fence, it could potentially destroy all the nests being protected. A way to try to prevent this may be to run some wires inside the fences to divide up the beach. These wires would keep the foxes from destroying the entire area of the beach encompassed by the fence. For future testing, we recommend that these wires be placed in a cross-hatched or 'X' formation within the larger fence (Figure 28).

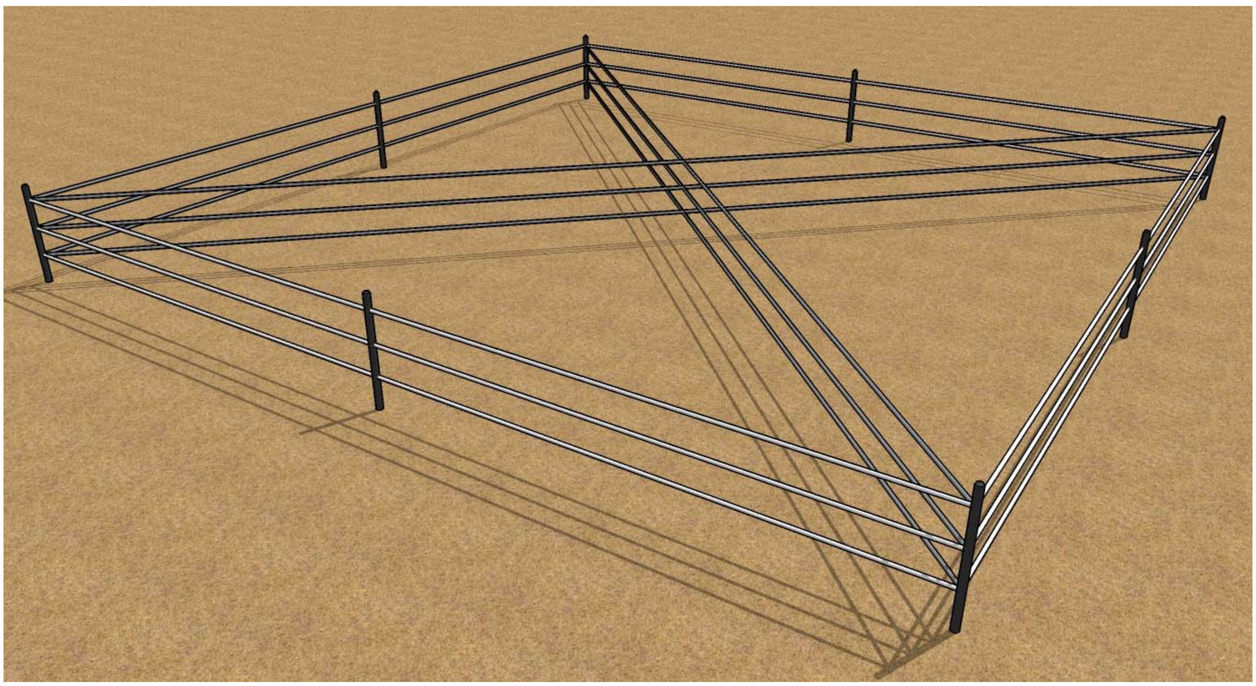

Figure 28. Diagram of a recommended fence design for testing, with interior wires. (Team Saving Testudo Research Collection)

There were times when wind or surf either deposited or eroded sand around the fence, potentially leading to too much space or too little space under the fence. When this occurs, either foxes are let in or terrapins are blocked from the beaches. To prevent terrapins from being blocked from nesting in the treatment plots, we recommend that the fence not be built too close to surf lines. Terrapins do not nest below the high-tide line (Brennessel 2006); therefore, it is a good idea to build fences well above the waterline to prevent this change in fence level relative to the ground. As for wind and other effects, future researchers may be required to level the beach ground below the fences occasionally to make sure there are 15.2 cm of space for the terrapins.

Additionally, there are different options for power sources. We used a 9 volt battery, but we had to change batteries once at each fence site. These two batteries lasted us almost three months, which is the length of a nesting season. It may be more cost effective, therefore, to invest in a solar-powered battery that recharges. This would allow the fence to stay active longer into the incubation period of the nests and even into the hatching season when the nests again become very vulnerable. This decision would depend on the study's length and the solar panels' durability; the longer the projected research or conservation timeline, the more sensible having a rechargeable battery would be.

Future researchers need to take into account the maintenance and manpower needed to construct and preserve the fences. Setting up our fence design was not difficult; no experience was necessary. Different designs may take more time, but the basic materials to construct any electric fence are easy to use and simple to put together. There are numerous suppliers that offer the necessary materials.

The recommendations outlined above may make the design, construction, and implementation of electric fences easier and may lead to better protection of terrapin nests. It is important to note that electric fence designs are site specific meaning that the conditions of the surrounding environment will dictate the electric fence design that should be used and will hopefully be the most effective. Based on our research, the low cost of our fence design, and the success of past electric fence studies with other animals, we recommend that further research be conducted with electric fence designs to further document their effectiveness in excluding mammalian predators from terrapin nesting beaches.

Chapter 7: Summary and Conclusions

Diamondback terrapins have always been an integral part of Maryland culture and the Chesapeake Bay watershed. Currently, the species' populations are in decline, which could impact the well-being of the environment. To address this issue, numerous conservation efforts have been put into effect. However, very little research has been done on specific threats to the terrapins. Development on beaches is a major contributing factor to the species' decreasing presence. Urbanization attracts mammalian predators such as foxes and raccoons that prey on terrapin nests. A popular method of excluding predators from unwanted areas includes the use of fences. We tested whether electric fences could be used to deter mammalian predators from terrapin nesting beaches.

Our project focused on "The Effect of Electric Fences on Excluding Mammalian Predators from Diamondback Terrapin Nesting Beaches." We addressed the effect of fences on nest predation, the effect of fences on terrapin nesting habits, and the viability of fences from a financial perspective.

With regard to the effect of electric fences on predators, our results showed a consistent pattern of lower predation within fenced areas than within unfenced control plots that compared favorably with published literature focused on other species. Despite this promising trend, we are unable to make definitive statements about the effectiveness of our fences. We believe that, had we been able to obtain larger sample sizes, results would have been statistically significant.

Additionally, we examined the effect of the fences on terrapins. At Trent Hall Farm, which was a randomized experimental set-up, there was no significant difference between control and treatment plots. At Jefferson Patterson Park, there was a significant difference, with more nests in the control area. We believe that the difference in number of nests between the single treatment and control plots at Jefferson Patterson was due to extraneous variables such as vegetation and location that biased the results. Overall, we saw no evidence from tracks that fences affected the terrapins and their nesting choices. We believe that the electric fences did not deter terrapins from nesting on these beaches.

Lastly, we determined the viability, in terms of cost and durability, of using electric fences to protect terrapin nests. The effectiveness of the fences is site-specific and depends on the landscape of the location. The fences were relatively cheap by the meter (perimeter) and square-meter (area). We believe that, with the same design or further design modifications, electric fencing can be an effective conservation technique for diamondback terrapin nests on beaches with minimal vegetation.

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Appendices:

Appendix A

Maryland Diamondback Terrapin Task Force Findings & Recommendations

Final Report to the Secretary of the Maryland Department of Natural Resources
September 20, 2001

EXECUTIVE ORDER 01.01.2001.05

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Summary

The consensus of the Maryland Diamondback Task Force is that the current population status and general health of the Maryland diamondback terrapin is unknown. Further, lacking a general stock assessment of Maryland terrapins their status will remain undetermined. However, the Task Force charged with recommending interim management strategies to the State of Maryland and relying on: (1) State terrapin records from 1878 to the present, (2) expert testimony, (3) regional, national and international trends, and (4) specific long-term research work conducted in the Patuxent River, concludes that the Maryland diamondback terrapin is an historically notable species in decline and in need of increased State protection.

Background

Turtles in general have survived a number of catastrophes over the past 200 million years to include several ice ages, the breakup and collision of continents, and a huge prehistoric global event that eradicated most life forms to include the dinosaurs. Today, however, scientists from around the world have sounded the alarm that as a categorical family, turtles and by extension terrapins, may not survive their most dangerous threat to date – humans.

At a recent national conference, 60 convening experts concluded that half the 270 turtle species in the world today face extinction, most of which will probably disappear in our lifetime. International wildlife experts and representatives of 14 Asian nations at a recent

United Nations conference on the "worldwide turtle crisis", confirmed these same findings. The Diamondback terrapin, the elusive icon of the Chesapeake and traditional Maryland symbol, is among those turtle species in decline and is listed as either declining, threatened, and / or endangered in many states along the Atlantic Seaboard.

As an important part of tidewater and American history diamondbacks: fed our impoverished minutemen during the hard times of the Revolutionary War, were a staple among 18th and 19th Century African-American slaves, and in the first half of the 20th Century a delicacy among the privileged members of society. The Maryland diamondback terrapin is one of Maryland's original commercial fisheries and is present at each significant phase of our country's history.

Nearly harvested to extinction in this past century, terrapins had been thought to be making a slow recovery. However, today their numbers once again may be declining through the cumulative impact of: (1) declining nesting habitat forever lost to waterfront development and misguided erosion control practices, (2) remaining fragmented nesting habitat that has become increasingly vulnerable to increasing numbers of traditional predators, (3) by-catch drowning deaths of terrapins in crab pots situated in the shallow water areas of nearly every tributary of the Chesapeake Bay, and (4) a potential emergent commercial market with an ability to pay for all species of turtles. Taken together, the long-term viability of terrapin populations in Maryland waters is of great concern.

Findings

Terrapin Life History & Ecology

Diamondback terrapins are the only truly estuarine turtle in North America. Diamondbacks are non-migratory and spend their entire lives in local creeks, salt marshes, and coves.

Terrapins differ dramatically in their life history traits from most fisheries species in the Chesapeake Bay. Most fishery species have high reproductive potential, i.e. they mature at an early age and produce a tremendous number of offspring when they reproduce. For example, oysters and crabs mature in 2-3 years and can produce millions of eggs when they reach maturity. Terrapins on the other hand produce only about 40 eggs per year and do not reach maturity until a minimum of 8 years of age. The low reproductive potential of terrapins indicates that females must reproduce for many years in order for the population to grow or remain stable.

Experts point out that turtles have a high biomass among vertebrates present in aquatic systems, and thus contribute to the feeding dynamic, nutrient and energy flow and the balance within ecosystems. As such, they play a critical role in their immediate environment and constitute a meaningful strand in the Chesapeake's tapestry of biodiversity.

Terrapins exhibit considerable variation throughout their range in body size, age at maturity, growth rate, egg size, clutch size and the number of clutches produced per year. For example, female terrapins in Florida mature in 4-5 years, nest up to 5 times per season, lay large eggs with 6-8 eggs per clutch. In Massachusetts terrapins mature in 12 - 15 years and lay up to 2 clutches per year of 15 -18 smaller eggs. In the Chesapeake Bay, female terrapins mature between 8 and 13 years, produce an average of 13 eggs per clutch and can nest up to 3 times per year. The best data on longevity in this species suggests that they can live beyond 50 years.

It is estimated that only two percent of terrapin eggs hatch, owing largely to predation by foxes, skunks, and raccoons, which dig into the nests and consume the eggs and baby terrapins. Survivors emerging from the nest are often eaten by gulls and crows or by herons and predatory fish after entering the water. Traditional intelligent predators increasingly target limited and fragmented nesting areas.

Throughout their range terrapins have been divided into seven sub-species based primarily on differences in life history traits. Recent studies investigating sub-species distinctions using molecular techniques in terrapins have suggested that only two sub-species exist.

Disappearing Habitat

Although the terrapin is considered an aquatic organism, it depends heavily on the near shore and shoreline habitat to complete its life cycle. Female terrapins must lay their eggs in terrestrial open sandy areas to successfully reproduce. These are among the few times that terrapins must exit the water.

Juvenile and smaller male terrapins also rely on the near shore area where they forage on readily available prey such as clams, crabs, and small crustaceans. These individuals live on the edge of the marsh following the shoreline searching for food and at high tide entering into grassy, salt marsh areas.

Much of the natural shoreline in the Chesapeake Bay is excellent terrapin habitat because of the alternating areas of sandy beaches used for nesting and salt or fringe marsh necessary for juvenile feeding and growth. Areas where these two habitats are not found together usually do not support large populations of terrapins.

In the Chesapeake Bay terrapins nest on low lying beaches. Due to the low lying nature of these beaches most terrapin nesting occurs in areas that are marginally above the high tide line.

Competition for essential terrapin habitat is steadily increasing. Impacts include: loss of nesting habitat, poor recruitment due to increased nest and hatchling predation, beach disturbance, shoreline modifications that eliminate beach strand habitat essential for terrapin breeding, injuries and morality due to boating and vehicle impacts during both active and inactive periods in their life cycles.

Many shoreline erosion control practices within Maryland today constitute a primary threat to diamondback terrapins. Current erosion control practices, principally stone revetment and bulkheads, destroy the narrow strip that has suitable sandy material required for nesting. Stone revetment and bulkheads, additionally block access to high beach elevations necessary for the successful development of terrapin eggs. As a consequence, terrapins attempt to nest in areas that are not sufficiently above high tide and the developing embryos drown, or females lay then-eggs in higher grassy areas where eggs and hatchlings become entrapped or killed by grasses.

Traditional nesting areas have been severely and permanently altered by waterfront development.

Habitat loss is a significant threat to the continued existence of the Maryland diamondback terrapin in the Chesapeake Bay. Beach strand nesting areas are universally and permanently being altered through rip-rapping, bulkheading, and other shoreline stabilizing practices.

Beach habitat is critical to the continued existence of terrapins. Research in the Patuxent River indicates that more than 95% of breeding females return to a particular area to nest year after year.

Commercial Fishing Gear & Terrapin By-Catch Mortality

Perhaps the single largest factor affecting terrapin populations in the Chesapeake Bay today and through their range is their interaction with commercial fishing gear. Crab pots have been identified to be a large source of mortality for terrapins. Crab pots have been observed with as many as 49 drowned turtles in them.

Each spring and summer Maryland's Department of Natural Resources (DNR) receives reports of turtles trapped and drowned in crab pots. These turtles are usually the diamondback terrapin which, under normal circumstances, may live for 50 years. Terrapins enter these crab pots and, like other air-breathing animals, drown when kept from taking a breath at the water's surface. A crab pot in the Patuxent River was once discovered with the remains of 49 drowned terrapins inside.

Crab pots set in previously unfished areas can have terrapin catch rates of 1 terrapin per 5 days. Although this does not seem like a high number, multiplied by thousands of pots that are fished both recreationally and commercially, this leads to a substantial impact on terrapin populations. It is estimated that terrapin populations can be decimated in 3-5 years in areas where there is
heavy crab pot usage.

Terrapin mortality in crab and eel pots can be avoided by the inexpensive installation of By-catch reduction devices (BRDs). Terrapin deaths in fyke nets can be easily avoided by inserting a float in the cod end of the net that maintains a permanent air space. Neither technique reduces the catch of the intended species.

Maryland is one of the more forward states in that it has a regulation requiring the use of a by-catch reduction device (BRD) in recreational crab pots. Although the recreational crab pot fishery in Maryland has a large impact on terrapin populations, in the shallow water areas such as Tangier Sound and the coastal bays it is likely that the commercial crab pot fishery has a substantial impact on terrapin populations.

There is a lack of compliance and enforcement of the current recreational crab pot BRD requirement. Many boating and tackle stores clearly targeting recreational crabbers sell crab pots that do not have BRDs already installed, nor carry BRDs in stock.

By-catch moralities in commercial fishing gear used by waterfront property owners are a leading cause of mortality (drowning) among terrapins.

Terrapins may encounter other types of fishing equipment that can kill them. Similar to crab pots, eel pots also pose a threat to terrapin populations. In a recent example, 21 terrapins were recovered from 4 eel pots fished in Washington Creek within a three-week period. This is similar to the catch rates of 1 terrapin per 5 pot days identified for crab pots. Fyke nets that are set with a submerged cod end during the warmer months, April - November, will kill turtles.

Commercial Harvest of Turtles & Terrapin

Millions of turtles are exported from the United States every year as food or pets. Turtle exports from the United States in recent years have soared. In 1995, the United States exported more than 84,000 map turtles, 23,000 snapping turtles and 38,000 soft-shell turtles. A five-fold increase from the previous year and a forty-fold increase since 1990. The vast majority of these increases are attributed to Asia's increased ability to purchase commodities from abroad. Given a lack of federal trade limits biologists have become increasingly concerned that turtle populations in the United States cannot sustain such harvests. As traditional turtle supplies dwindle it is anticipated that an Asian market will emerge for the consumption of the Maryland diamondback terrapin.

The number of watermen legally harvesting and reporting terrapin in Maryland is small. At last report one waterman reported a harvest worth approximately $500. Unreported commercial harvests of wild terrapin, however, may exceed reproductive rates of the small remnant population of Maryland's first fishery.

Except for a detailed study in the Patuxent River, little is known about the terrapin in Maryland today. While the Maryland Diamondback terrapin has not been designated as threatened or endangered at this point, data does exist to refute the current viability of Maryland terrapins as a commercial fishery. Particularly, that a moderate trapping effort on or near a nesting beach can destroy 95% of a nesting population within one or two years.

Terrapin Management Practices

Of the 55 species of turtles in the United States, 21 are protected by law or under consideration for protection. Freshwater turtles have fared better than sea turtles. Scientists agree that many freshwater turtles, especially large river-based turtles, may not survive unless their habitats are better protected.

States along the Eastern Seaboard list terrapins in various protection categories from endangered to threatened to species of special concern. In Maryland, the terrapin is commercially harvested with the state's acknowledgment that the species is "declining in population".

The Nongame and Endangered Species Conservation Act protects most reptiles and amphibians in Maryland. A case in point is all native snakes. Any Maryland snake, unlike any Maryland terrapin, cannot lawfully be killed, possessed, bred or sold without a regulatory permit. New Maryland regulations have been recently adopted further restricting the possession, breeding, and sale of native reptiles and amphibians in Maryland. The specific citation with regard to snakes reads in part, "...snakes are part of our natural world and should be left there unharmed... worthy of our respect and admiration."

Maryland legislators passed the first terrapin protection act in 1878. Laws that govern the protection of terrapin today include:

1. No terrapin may be taken from May 1 to July 31.

2. Terrapin taken during the open season must measure at least 6 inches on the bottom of the shell (plastron length).

3. It is illegal to take, destroy, or tamper with terrapin eggs.

4. A license is required for the commercial harvest of terrapin. There is no limit to the number that may be harvested.

5. Regulations regarding possession and size do not apply to persons owning not more than three terrapins, which are being kept as pets.

Reptile populations have insufficient recruitment to allow for meaningful management of optimal or maximum sustainable yields. Maryland resource management of reptiles as a fishery, such as terrapin, has never accounted for "acceptable levels of biological removal", nor accounted for reptilian life histories that do not allow for sustainable yields.

The Chesapeake Bay Agreement, Chesapeake 2000, provides the policy guidance and hope for the continuance of the Maryland diamondback terrapin as a viable Bay species. These policies are specifically articulated in the agreement's preamble, "We must manage for the future. We must have a vision for our desired destiny and put programs into place that will secure it." This vision is, specifically delineated in many of the agreements goals to include: " (1) Restore, enhance and protect the finfish, shellfish and other living resources, their habitats and ecological relationships to sustain all fisheries and provide for a balanced ecosystem. (2) Preserve, protect and restore those habitats and natural areas that are vital to the survival and diversity of the living resources of the Bay and its rivers. (3) Develop, promote and achieve sound land use practices which protect and restore watershed resources and water quality, maintain reduced pollutant loadings for the Bay and its tributaries, and restore and preserve aquatic living resources."

Interim Recommendations and Comments

1. **Establish an immediate moratorium on the commercial harvest of Maryland diamondback terrapins in Maryland.** In the absence of a general definitive stock assessment of the Maryland diamondback terrapin, coupled with: expert opinion, low reproductive potential, current low economic value, few commercial participants, and a significant by-catch adult mortality rate, a conservative and cautious resource protection posture is warranted.

2. **Fund a general stock assessment of the Diamondback Terrapin.**

3. **If a terrapin harvest is to continue, it is deemed appropriate to enact a legal slot size limit (harvesting within this range) between 4 to 7 inches in plastron length.** Maryland should protect reproducing female terrapins. Slot limit standards serve to protect half of the reproductive females from harvest and all of the best reproducing females thus helping to maintain breeding stocks in the Chesapeake Bay and Coastal Bay areas. The Diamondback's susceptibility to over-harvesting is validated by its decline earlier this century. As with most reptiles, terrapin populations are very vulnerable to low levels of removal (less than 5%) of the local adult population.

4. **If a terrapin harvest is to continue, establish a limited entry fishery to only those currently commercially reporting terrapin harvests.**

5. **If a terrapin harvest is to continue, restore the original time period (1878 — 1974) of April 1 through November 1, when terrapin may not be taken and establish harvest limits of less than 1-2% of the bay-wide projected adult population.**

6. **6. Ban recreational use of all commercial crab pots in tributaries of the Chesapeake Bay and Coastal Bays of Maryland.** The entrapment of **diamondback** terrapins in crab pots frequently results in the drowning deaths of trapped terrapins. Male and juvenile female terrapins are most vulnerable to

shallow water and infrequently checked recreational crab pots. Banning the use of commercial fishing gear by recreational crabbers in all tributaries would: (1) eliminate frequent terrapin drowning incidents, (2) be consistent with the commercial ban of crab pots within tributaries, and (3) be viably enforceable as it would bar all applications of commercial crab pots from tributaries.

7. **Establish a research agenda that evaluates the impact of the commercial crab and eel pot fishery on terrapin populations, including developing and testing BRDs that will be cost effective.**

8. **In the absence of a commercial crab pot ban within tributaries of the Chesapeake Bay and Maryland Coastal Bays, mandate and enforce the usage of safe crab pots by requiring turtle excluder devices (By-Catch Reduction Devices, BRDs) on crab pot entrance funnels.** Keeping terrapins out of crab pots would eliminate drowning deaths. Inexpensive wire excluders that can be snapped into crab pot entrance funnels have been field tested and deemed categorically successful. Conscientious use of BRDs would eliminate a significant portion of **terrapin** mortality. The enforcement of Maryland law should not be viewed as an option. Enforcement of the current BRD requirement is deemed most appropriate at recreational retail outlets and should be enforced at point of use.

9. **Institute and apply regulatory enforcement practices that motivate meaningful obedience to Maryland law.**

10. **List the terrapin as, "In Need of Conservation", in accordance with Title 08.02, Chapter 12.01.C within the Department of Natural Resources (Fisheries) and as a "Species of Special State Concern".**

11. **Establish criteria for the regulatory identification of terrapin habitat through the use of descriptive attributes serving to promote beach conservation, protection, and restoration.** The State of Maryland in developing these guidelines would better enable State permitting officials to protect the vanishing natural shorelines of the Chesapeake, its tributaries, and Coastal Bays of Maryland.

12. **12. Identify and protect terrapin nesting beaches throughout the tidewater regions of Maryland.** Terrapins require unrestricted access to nesting and over-wintering habitats. In Maryland, waterfront bulkheads and stone revetments prevent terrapins from reaching their traditional nesting beaches. The permanent loss of nesting habitat through the alteration of estuarine areas poses an imminent threat to many terrapin populations today. Smaller local populations resulting from fragmented habitat ultimately leads to the high potential for localized extinction.

13. **Enact enabling legislation and administrative policy that specifies beach strand preservation mitigation requirements in all future shoreline erosion control projects.** Model mitigation requirements using current Critical Area language, e.g. minimum necessary to provide relief, 3:1 habitat impact replacement, and mitigation requirements for tidal and nontidal wetland losses. Preservation of natural beaches with an emphasis on protecting a wide variety of nesting environments would ensure survivorship among terrapins.

14. **Enact enabling legislation that encourages the preservation of terrapin beach strand habitat through the use of shoreline environmental easements and sensitive habitat acquisition funding.** Use proposed shoreline mitigation impact fees as a future funding source, as well as the DNR's preliminary proposal for acquiring beach strand habitat using existing state revenues. Build on the contributions made by private property owners in recent years through the DNR's Terrapin Nesting Sanctuary Program.

15. **Enact shoreline management policies that take into consideration critical habitat for terrapin nesting.** Shoreline stabilization should favor stabilization techniques that create terrapin nesting habitat in lieu of destroying it. State of Maryland funds should favor only shoreline stabilization techniques that are compatible with species restoration and the 2001 Chesapeake Bay Agreement.

16. **Continue and expand the DNR's "Head Start - Repatriation" program to educate the public about terrapin conservation and to augment wild stocks.**

17. **Permanently establish Diamondback Terrapin Day as May 13th.** Mid-May is when terrapins start to nest and are visible when surveying beaches. Additionally, this creature has a remarkable educational potential for the general public, particularly among non-traditional constituencies. Understanding and appreciation of this species by the public will offer significant advances to stewardship, habitat restoration, and resource protection.

18. **Enact humane treatment regulations in the handling and shipment of terrapins**.

Maryland Diamondback Terrapin Task Force

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EXECUTIVE ORDER
01.01.2001.05

Maryland Diamondback Terrapin Task Force

WHEREAS, The perpetuation of Maryland's beloved icon and official State reptile, the Maryland Diamondback Terrapin *(Malaclemys terrapin)* depends on concerted conservation efforts;

WHEREAS, Accurate biological data are needed to establish population estimates and institute management strategies which will help ensure continued progress in the protection and repatriation of the Maryland Diamondback Terrapin species in Maryland; and

WHEREAS, Coincident with the data collection effort, interim management strategies may be required to minimize further risk to Maryland's Diamondback Terrapin population.

NOW, THEREFORE, I, PARRIS N. GLENDENING, GOVERNOR OF THE STATE OF MARYLAND, BY VIRTUE OF THE AUTHORITY VESTED IN ME BY THE CONSTITUTION AND THE LAWS OF MARYLAND, HEREBY PROCLAIM THE FOLLOWING EXECUTIVE ORDER, EFFECTIVE IMMEDIATELY:

A. Established. A Maryland Diamondback Terrapin Task Force is hereby established to evaluate current population data and management practices for Maryland Diamondback Terrapins and recommend interim strategies to protect and preserve the species prior to the completion of a more comprehensive population study and management plan.

B. Membership and Procedures.

(1) The Task Force shall consist of up to nine members, including:

(a) A member of the Maryland State Senate appointed by the President of the Senate;

(b) A member of the Maryland House of Delegates appointed by the Speaker of the House of Delegates; and

(c) Up to seven members appointed by the Governor, who have interest or expertise in animal welfare and/or Terrapin conservation, including a student and educator involved in the "Terrapin Station" initiative sponsored by the Department of Natural Resources.

(2) The Governor shall designate a Chairperson from among the members of the Task Force.

(3) A member may not receive compensation for serving on the Task Force, but may be reimbursed for expenses incurred in the conduct of duties under this Executive Order, in accordance with the Standard State Travel Regulations and as provided for in the State budget.

C. Scope. The Task Force shall have the following responsibilities:

(1) Analyze and interpret data concerning current and future population trends of the Maryland Diamondback Terrapin.

(2) Assess current management practices and, based on the results of the population data analysis, make recommendations for more effective, long-term strategies for conservation and repatriation of the Maryland Diamondback Terrapin.

(3) Propose and assist the Department of Natural Resources in implementing interim measures to minimize further risk to the Maryland Diamondback Terrapin population while the comprehensive population study is in progress.

D. Report. On or before October 1, 2001, the Task Force shall complete its work and submit a final report of its findings and recommendations to the Secretary of the Department of Natural Resources.

E. The Department of Natural Resources shall provide staff support to the Task Force.

Appendix B

Maryland's 2007 Law Banning Commercial Harvest of Diamondback Terrapins

MARTIN O'MALLEY, Governor Ch. 117

CHAPTER 117
(Senate Bill 532)

AN ACT concerning

Natural Resources – Diamondback Terrapin – Take and Possession

FOR the purpose of repealing the requirement that the Department of Natural Resources prepare a fishery management plan for the diamondback terrapin; prohibiting the take or possession of diamondback terrapin for commercial purposes; prohibiting the possession of a certain number of diamondback terrapin for noncommercial purposes; *providing for certain exceptions to the prohibition on taking or possessing diamondback terrapin; requiring the Department, in consultation with the Maryland Aquaculture Coordinating Council, to adopt certain regulations before issuing certain permits;* repealing the requirement that the Department adopt certain regulations for the catching of terrapin; requiring the Department to adopt certain regulations for the conservation of diamondback terrapin; repealing certain exemptions from certain excise and use taxes relating to the catching of terrapin for commercial purposes; and generally relating to the catch, take, or possession of diamondback terrapin.

BY repealing and reenacting, with amendments,
Article – Natural Resources
Section 4–215(b), 4–902, and 4–903
Annotated Code of Maryland
(2005 Replacement Volume and 2006 Supplement)

BY repealing and reenacting, without amendments,
Article – Natural Resources
Section 8–716(c)
Annotated Code of Maryland
(2000 Replacement Volume and 2006 Supplement)

BY repealing and reenacting, with amendments,
Article – Natural Resources
Section 8–716(e) and (g) and 8–716.1(k)
Annotated Code of Maryland
(2000 Replacement Volume and 2006 Supplement)

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, that the Laws of Maryland read as follows:

Article – Natural Resources

4–215.

(b) The Department shall prepare fishery management plans for the following species:

(1) Striped bass or rockfish;

(2) White perch;

(3) Yellow perch;

(4) American shad;

(5) Hickory shad;

(6) Oysters;

(7) Blue crabs;

(8) Bluefish;

(9) Herring;

(10) Weakfish;

(11) Croaker;

(12) Spot;

(13) Summer flounder;

(14) American eel;

(15) Red drum;

(16) Black drum;

(17) Spotted sea trout;

(18) Horseshoe crabs;

(19) Menhaden;

(20) Tautog;

(21) Black sea bass;

(22) Scup;

(23) Hard shell clams; **AND**

(24) Catfish**[**; and

(25) Diamondback terrapin**]**.

4–902.

[A person may not catch terrapin for commercial purposes unless he first obtains a license from the Department.**]**

(A) EXCEPT AS PROVIDED IN SUBSECTION (B) OF THIS SECTION:

(1) A PERSON MAY NOT TAKE OR POSSESS DIAMONDBACK TERRAPIN FOR COMMERCIAL PURPOSES; AND

(2) A PERSON MAY NOT POSSESS MORE THAN THREE DIAMONDBACK TERRAPIN FOR NONCOMMERCIAL PURPOSES.

(B) THIS SECTION DOES NOT PROHIBIT:

(1) THE INCIDENTAL CATCH OF DIAMONDBACK TERRAPIN, PROVIDED THE DIAMONDBACK TERRAPIN ARE RETURNED IMMEDIATELY TO THE WATER; OR

(2) THE COLLECTION OR POSSESSION OF DIAMONDBACK TERRAPIN IN ACCORDANCE WITH THE TERMS OF A SCIENTIFIC OR EDUCATIONAL CERTIFICATE OR PERMIT ISSUED IN ACCORDANCE WITH § 4–212 OF THIS TITLE OR § 10–909 OF THIS ARTICLE*; OR*

(3) THE POSSESSION AND BREEDING OF DIAMONDBACK TERRAPIN BY A PERSON WHO HOLDS A VALID PERMIT ISSUED BY THE DEPARTMENT FOR:

(I) AQUACULTURE ACTIVITIES UNDER SUBTITLE 11A OF THIS TITLE; OR

(II) CAPTIVE WILDLIFE BREEDING UNDER TITLE 10, SUBTITLE 9 OF THIS ARTICLE.

(C) (1) THE DEPARTMENT, IN CONSULTATION WITH THE MARYLAND AQUACULTURE COORDINATING COUNCIL, SHALL ADOPT REGULATIONS FOR DIAMONDBACK TERRAPIN AQUACULTURE AND CAPTIVE BREEDING BEFORE ISSUING ANY ADDITIONAL PERMITS RELATING TO DIAMONDBACK TERRAPIN UNDER SUBTITLE 11A OF THIS TITLE OR TITLE 10, SUBTITLE 9 OF THIS ARTICLE.

(2) THE REGULATIONS ADOPTED IN ACCORDANCE WITH PARAGRAPH (1) OF THIS SUBSECTION SHALL INCLUDE:

(I) VERIFIABLE SAFEGUARDS TO IDENTIFY LEGALLY OBTAINED DIAMONDBACK TERRAPIN;

(II) STANDARDS FOR DIAMONDBACK TERRAPIN HUSBANDRY; AND

(III) STANDARDS FOR SHIPPING DIAMONDBACK TERRAPIN.

4–903.

[(a)**]** The Department shall adopt regulations governing**[**:
(1) The catching of terrapin; and
(2) Terrapin resources**] THE CONSERVATION OF DIAMONDBACK TERRAPIN**.
[(b) The regulations adopted under this section shall be consistent with the recommendations of the Maryland Diamondback Terrapin Task Force issued in 2001.**]**

8–716.

(c) (1) Except as provided in § 8–715(d) of this subtitle and in subsections (e) and (f) of this section, and in addition to the fees prescribed in subsection (b) of this section, an excise tax is levied at the rate of 5% of the fair market value of the vessel on:

(i) The issuance of every original certificate of title required for a vessel under this subtitle;

(ii) The issuance of every subsequent certificate of title for the sale, resale, or transfer of the vessel;

(iii) The sale within the State of every other vessel; and

(iv) The possession within the State of a vessel used or to be used principally in the State.

(2) Notwithstanding the provisions of this subsection, no tax is paid on issuance of any certificate of title if the owner of the vessel for which a certificate of title is sought was the owner of the vessel prior to June 1, 1965, or paid Maryland sales and use tax on the vessel as required by law at the time of acquisition. The Department may require the applicant for titling to submit satisfactory proof that the applicant owned the vessel prior to June 1, 1965.

(e) A person is not required to pay the tax provided for in subsection (c) of this section resulting from:

(1) A transfer between members of the immediate family as determined by Department regulations;

(2) A transfer between members of the immediate family as determined by Department regulations of a documented vessel for which the transferor applied for and was issued a valid use sticker under § 8–712.1 of this subtitle;

(3) A transfer to a licensed dealer of a vessel for resale, rental, or leasing purposes;

(4) The holding of a vessel that is titled or numbered in another state or is federally documented, provided:

(i) The vessel is held for resale or listed for resale by a licensed dealer; and

(ii) The vessel owner signs an affidavit that there will be no use of the vessel on the waters of the State other than for a sea trial;

(5) Purchase of a vessel by the State or any political subdivision;

(6) Purchase of a vessel by an eleemosynary organization which the Secretary has approved;

(7) The purchase within the State of a vessel if the owner paid or incurred a liability for the Maryland sales and use tax on the vessel prior to July 1, 1986;

(8) The possession within the State of a vessel which was purchased outside the State if the owner paid or incurred a liability for the Maryland use tax on the vessel prior to July 1, 1986;

(9) The possession of a vessel in the State that is not used or to be used principally on the waters of the State and for which the issuance of a title is not sought or required under this subtitle, except that:

(i) A vessel is not deemed used on the waters of the State if the vessel is used for 90 days or less of a calendar year; and

(ii) If a vessel is used for more days than 90 days in a calendar year, the period of 90 days shall be counted in the determination of principal use under this subtitle;

(10) The possession within the State of a vessel if the current owner, before July 1, 1986:

(i) 1. Was licensed by the Department to catch, for commercial purposes, finfish, eels, crabs, conch, **[**terrapin,**]** soft–shell clams, hard–shell clams, oysters, or any other fish; and

2. Used the vessel for any of the commercial fishing purposes described in item 1 of this item;

(ii) 1. Was licensed as a commercial fishing guide under the provisions of § 4–210 of this article; and

2. Used the vessel as a charter boat with a license as provided in § 4–745(d)(2) of this article;

(11) The possession within the State of a vessel that:

(i) Is owned by a nonprofit organization that:

1. Is qualified as tax exempt under § 501(c)(4) of the Internal Revenue Code; and

2. Is engaged in providing a program to render its best efforts to contain, clean up, and otherwise mitigate spills of oil or other substances occurring in United States coastal and tidal waters; and

(ii) Is used for the purposes of the organization;

(12) The possession within the State of a vessel for a period of not more than one year if the current owner is a member of the armed services and is serving on active duty in this State; or

(13) The sale of a vessel within the State if:

(i) The vessel is purchased from a licensed dealer;

(ii) The issuance of a title is not sought or required;

(iii) The vessel is not used or to be used principally on the waters of this State;

(iv) The vessel is duly registered in another jurisdiction within 30 days of the date of purchase; and

(v) The dealer and the purchaser execute an agreement certifying the state of principal use for the vessel which is filed with the Department within 30 days of the date of purchase.

(g) (1) A person may claim a credit against any tax imposed under subsection (c) of this section on a vessel for sales tax the person has paid to the State, to another state, or to the District of Columbia on materials and equipment that are incorporated into the vessel, if:

(i) 1. The person is licensed by the Department to catch, for commercial purposes, finfish, eels, crabs, conch, **[**terrapin,**]** soft–shell clams, hard–shell clams, oysters, or any other fish; and

2. The vessel is to be used for any of the commercial fishing purposes described in item 1 of this item; or

(ii) 1. Was licensed as a commercial fishing guide under the provisions of § 4–210 of this article; and

2. Used the vessel as a charter boat with a license as provided in § 4–745(d)(2) of this article.

(2) The Department may require a person claiming the credit allowed under this subsection to submit satisfactory proof of payment of the sales tax and that the materials or equipment have been incorporated into the vessel.

8–716.1.

(k) Notwithstanding any other provision of law, the Department may not collect or enforce any liability for the Maryland use tax that was incurred before July

1, 1986 on a vessel owned by a person who at the time the liability was incurred:

(1) (i) Was licensed by the Department to catch, for commercial purposes, finfish, eels, crabs, conch, **[**terrapin,**]** soft–shell clams, hard–shell clams, oysters, or any other fish; and

(ii) Used the vessel for any of the commercial fishing purposes described in item (1)(i) of this paragraph; or

(2) (i) Was licensed as a commercial fishing guide under the provisions of § 4–210 of this article; and

(ii) Used the vessel as a charter boat with a license as provided in § 4–745(d)(2) of this article.

SECTION 2. AND BE IT FURTHER ENACTED, That this Act shall take effect October *July* 1, 2007.

Approved by the Governor, April 24, 2007.

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Appendix D

Terrapin Conservation Programs of the Wetlands Institute

“**The Terrapin Conservation Project**

The serious declines in southern New Jersey’s terrapin population, due to increased mortality from roadkills and drowning in crab traps, prompted the launching of the Terrapin Recovery/Conservation Project in 1989. Under the direction of Dr. Roger Wood, the program has developed techniques to incubate and hatch eggs recovered from road-killed terrapins, after which the hatchlings are head started and released. In addition, the program’s ongoing studies have proven the effectiveness of terrapin excluder devices to prevent drowning in crab traps.”

“**Hands-on Conservation — Recovering Eggs from Roadkills**

Research interns will work closely with Dr. Wood and the Wetlands staff to receive a practical laboratory and field course in hands-on conservation. This will include round-the-clock road patrols during the terrapin nesting season in June and July, to minimize the number of roadkills of nesting females, as well as the removal of potentially viable eggs from the carcasses of roadkills. Eggs are incubated and, after hatching, head-started at the Richard Stockton College “turtle farm.” Head-started turtles (hatched from the previous season) are weighed, measured, marked (with a microchip PIT tag injected just beneath the skin in front of the rear leg), and released into the salt marsh. For more information see Terrapins and Tires.”

“**Barrier Fencing Project**

Increased motor vehicle traffic on the causeways between the mainland and the barrier islands of coastal southern New Jersey is a growing threat to diamondback terrapins. Development on the barrier islands has destroyed most of the sand dunes that originally served as the primary nesting site for terrapins. With the disappearance of sand dunes, females have had to find alternative nesting grounds, primarily the shoulders of roads crossing and adjacent to their native salt marshes. Embankments of causeways have proved to be a dangerous substitute for sand dunes, resulting in hundreds of terrapin roadkills annually.

Barrier fencing installed along Stone Harbor Boulevard has decreased terrapin mortality by 84% over the past four summers.

In 2004 researchers from the Wetlands Institute began to install temporary barrier fencing along the coastal causeways, in an attempt to reduce road mortality of nesting terrapins in areas known to be major "kill zones." For the past three summers, the fencing along Stone Harbor Boulevard has reduced terrapin mortality, on average, approximately 84 percent.

In 2006, in an attempt to improve the fencing project, a 1,000-foot section of a new fencing material, "Tenax" (a thick, mesh material), was installed to determine its durability in the harsh coastal conditions over the course of a year. The Tenax proved to be durable, so in 2007 the Wetlands Institute installed the year-round Tenax fence along the entire section of Stone Harbor Boulevard. In addition, the fencing project was expanded to include a mile and a half section of Avalon Boulevard (combination of both Tenax and silt fence material), which, because the fence was installed in a continuous line with no openings, resulted in a 100 percent reduction of terrapin roadkills. (The fencing along Stone Harbor Boulevard had necessary openings for building entrances and exits.) In 2008, the entire fence was reinstalled along the mile and a half section of Avalon Boulevard with the permanent fence material "Tenax." Once again, the fence project expanded because Lisa Doherty, a concerned local Margate citizen who worked closely with Wetlands Institute scientists, initiated a terrapin fence project along a mile long section of Margate Causeway. She received funding for the fence materials from the City of Margate and contacted a Boy Scout troop to install the fence. The Margate terrapin fence project is an excellent example of how important citizen involvement can be in conservation biology."

"**Predator Exclosures**

Two predator exclosures constructed around terrapin nests

From the end of May to late July, female terrapins emerge from the marsh to nest on high ground, digging a 6–8 inch hole and laying approximately 8–12 eggs. Numerous terrapin nests are preyed upon each summer, particularly along the Wetlands Institute's nature trail. To help reduce this loss, we construct predator exclosures (black mesh cages) over the nests to protect the eggs from various predators such as raccoons, skunks, and foxes. In 2008 we constructed 50 predator exclosures along the nature trail. To locate terrapin nests, student researchers regularly walk the vicinity of the Wetland Institute and the nature trail, searching for nesting terrapins. When they come across a terrapin, they wait patiently until the nest is completed. A predator exclosure is then constructed over the nest, and the turtle is retrieved to be microchipped for future identification. In 50–90 days terrapin hatchlings emerge from the nests. In the fall and in the spring (as some hatchlings overwinter in the nest), Wetlands Institute staff monitor the predator exclosures several times a day to remove emerged hatchlings and record measurement data. We release the hatchlings at night so they don't become instant gull food!"

"**Diamondback Terrapin Sonic Telemetry**

In 2005, the Wetlands Institute's began conducting a sonic telemetry study, attaching small coded transmitters to adult diamondback terrapins. The transmitter sends a unique signal through the water to a receiver that is attached to a buoy located in the marsh. Each time a terrapin swims by an underwater acoustic receiver, information is recorded. We then use the information collected by the receiver to determine where a terrapin is, how far it moves, and how long it takes to move from one location to another. This information is extremely valuable because little is known about terrapin movements (particularly because females leave the water only during the nesting season and males barely ever leave the water other than to bask in the sun).

Currently, we have 9 receivers strategically placed throughout the marsh, specifically near the mouths of creek openings. Over the past three years, 47 terrapins have been fitted with mobile transmitters (Vemco V9-2L-R04K coded pingers), attached to the margins of their shell and then released back into the salt marsh. Results so far show that there is considerable individual variation in the movements of different terrapins."

Adopt A Terrapin

What is a terrapin?

Diamondback terrapins are relatively small, harmless turtles that live in salt marshes (like the ones at the Wetlands Institute!) along the Atlantic and Gulf coasts of the United States. Diamondback terrapins are closely related to freshwater turtles such as map turtles and red-eared sliders, but terrapins are the only turtles that live exclusively in brackish water.

Why do the terrapins need help?

Diamondback terrapins face a variety of problems attributable to human activities both historically and currently. In the late 1800s and early 1900s terrapins were hunted intensively because their meat was considered to be a gourmet delicacy. Consequently, terrapin populations were drastically reduced throughout their range. More recently, terrapins have lost most of their natural nesting habitat (sand dunes or barrier beach islands) due to development of coastal resort communities. Nowadays the only nesting habitat available to female terrapins along the Atlantic coast of New Jersey is the embankments of roads crossing and adjacent to coastal salt marshes. Locally, many hundreds of adult female terrapins are maimed or die each year during the nesting season (normally late May through mid July) while attempting to cross roads in search of suitable nesting habitat. Sadly, these problems are not the biggest threat to terrapin populations at present. Throughout their range, thousands of terrapins die each year by drowning in commercial crab traps.

How is the Wetlands Institute helping?

Every year researchers at the Wetlands Institute help thousands of diamondback terrapins. Researchers engage in a variety of terrapin conservation projects including road patrols, "head-starting" hatchlings, rehabilitating injured adults, study of wild populations, and public education. Moreover, Terrapin Excluder Devices, invented and extensively tested at the Wetlands Institute, are required modifications for some of the commercial-type traps used in New Jersey, Maryland, and Delaware.

What will your contribution be used for?

Your gift will be used to help defray expenses connected with a variety of terrapin projects at the Wetlands Institute including:

- Documentation of data vital for research and conservation activities

- Road patrols to remove female terrapins from roads before they get hit by vehicles, rescue injured terrapins, and save potentially viable eggs retrieved from road-killed female terrapins
- Hatching, “head-starting,” and releasing baby terrapins
- Rehabilitating adult females struck by motor vehicles
- Publicizing the plight of terrapins in local to international locations

How Can You Help?

Please choose an adoption level:
□ **$10 — Adopt a hatchling**

Receive an adoption certificate, terrapin conservation brochures, and a photograph of a terrapin!

□ **$30 — Adopt a head starter**

Receive an adoption certificate, terrapin conservation brochures, a photograph of a terrapin plus *Terrapin Times* (the fall and spring terrapin newsletter) and a “Terrapin Crossing” pin!

□ **$50 — Adopt a head starter *Special Privilege***

Receive an adoption certificate, terrapin conservation brochures, a photograph of a terrapin, *Terrapin Times* newsletter, **plus** an “I Brake for Terrapins” sign and help release a head starter at a special terrapin release event during the summer!

□ **$100 — Adopt a Dozen Eggs!**

Can't stop with just one egg? Adopt a dozen! Receive an adoption certificate, terrapin conservation brochures, a photograph of a group of basking terrapins, “Terrapin Times” newsletter, plus a “Terrapin Crossing” T-shirt and help release a head starter at a special terrapin release event during the summer!

□ **$500 — Adopt a Transmitting Terrapin**

Support advanced technological research by adopting a diamondback terrapin with a small transmitter attached to its carapace (shell). The transmitter sends a unique signal through the water to a receiver that is attached to a buoy located in the marsh. Each time a terrapin swims by an underwater acoustic receiver, information is recorded. The information collected by the receiver is used to determine where a terrapin is, the duration a terrapin stays in an area, how far it moves, and how long it takes to move from one location to another. This information is extremely valuable because little is known about terrapin movements.

Receive an adoption certificate, a report on the terrapin movements (especially your adopted terrapin!), terrapin conservation brochures, a photograph of a terrapin with a transmitter, "Terrapin Times" newsletter, plus "Terrapin Crossing" goodies (sign, magnet and two turtle X-ing T-shirts), and help release a head starter at a special terrapin release event during the summer! In addition, research scientists will take you and a guest on a boating excursion through the wetlands to view the telemetry equipment and to learn first-hand how it works.

Download Donation Form

Download and print the Donation Form in **MS Word** or in **Portable Document Format (PDF)**.
Complete the form and return it with your donation to:

The Wetlands Institute
1075 Stone Harbor Boulevard
Stone Harbor, NJ 08247

Phone: 609-368-1211
Fax: 609-368-3871

Innovative Use of Dredged Materials and Disposal Sites to Reduce Diamondback Terrapin Mortality & Enchance Nesting Habitats

The Wetlands Institute, in partnership with the Richard Stockton College Coastal Research Center and Ocean Coastal Consultants Inc., has developed a research project in support of the New Jersey Department of Transportation's Office of Maritime Resources (NJDOT/OMR) comprehensive long-term management strategy for dredging projects and dredged material placement. The project will identify locations that are suitable for restoration of terrapin nesting habitats with an emphasis on beneficial use of dredged material. Priority areas for terrapin habitat restoration and mortality reduction will be identified using spatial analysis techniques (GIS and remote-sensing) and field visits. Subsequent habitat restoration projects will be identified. An ad hoc program will also be established that offers design and permitting assistance to marinas interested in incorporating the goals of this project. The intent of this project is to provide an opportunity to enhance terrapin habitat, reduce turtle mortality, expand beneficial uses of dredged material in the State, and improve boating through increased dredged material capacity and forging new partnerships between public, nonprofit and government entities.

Appendix E

Maryland Department of Natural Resources Terrapin Regulations in the Code of Maryland Regulations (COMAR)

Title 08 DEPARTMENT OF NATURAL RESOURCES

Subtitle 03 WILDLIFE

Chapter 11 Reptile and Amphibian Possession and Permits

Authority: Natural Resources Article, §§4-602, 4-902, 4-903, 10-205, and 10-901—10-903, Annotated Code of Maryland

.01 Scope.

A. This chapter does not apply to reptiles and amphibians that are held in accordance with:

(1) A Scientific Collection Permit described in Natural Resources Article, §10-909 and §4-212, Annotated Code of Maryland;

(2) An Endangered Species Permit described in Natural Resources Article, §10-2A-05, Annotated Code of Maryland; or

(3) Aquaculture activities regulated under COMAR 08.02.14.

B. This chapter regulates the possession, breeding, sale, offer to sell, trade, or barter of certain native reptiles and amphibians. It is intended to protect and conserve native reptiles and amphibians while maintaining many of the educational and economic benefits derived from them.

.02 Definitions.

A. In this chapter, the following terms have the meanings indicated.

B. Terms Defined.

(1) "Amphibian" means salamanders, frogs, and toads, or any part, egg, tadpole, offspring, or dead body of any of them.

(2) "Captively produced" means produced as a result of breeding in captivity.

(3) "Captivity" means intentionally holding a reptile or amphibian under any condition of restraint or control imposed by humans.

(4) "Educational facility" means State wildlife agencies, public game farms or parks, public museums, public zoological parks, accredited members of the American Association of Zoological Parks and Aquariums, and public scientific or educational institutions.

(5) "Native reptiles and amphibians" means those species of reptiles and amphibians that naturally occur or historically occurred within Maryland not as a result of any action by humans.

(6) "Permittee" means any person holding a permit issued under the authority of this chapter to perform certain activities.

(7) "Public" means open to the general public and established, maintained, and operated as a governmental service, or privately established and operated on a nonprofit basis for tax purposes.

(8) "Reptile" means turtles, lizards, and snakes, or any part, egg, offspring, or any dead body of any of them.

(9) "The wild" means any land or water in the State, either natural or altered, upon which any native reptile or amphibian can exist in a condition which is not constrained or controlled by humans.

.03 List of Native Species.

A. The following species or subspecies are considered native to Maryland and may be lawfully possessed, bred, or commercially traded only as provided in Regulations .04—.09 of this chapter:

(1) Salamanders:

(a) Red-spotted newt (Notophthalmus viridescens),

(b) Spotted salamander (Ambystoma maculatum),

(c) Marbled salamander (Ambystoma opacum),

(d) Northern dusky salamander (Desmognathus fuscus),

(e) Seal salamander (Desmognathus monticola),

(f) Mountain dusky salamander (Desmognathus ochrophaeus),

(g) Northern two-lined salamander (Eurycea bislineata),

(h) Long-tailed salamander (Eurycea longicauda),

(i) Northern spring salamander (Gyrinophilus porphyriticus),

(j) Four-toed salamander (Hemidactylium scutatum),

(k) Eastern red-backed salamander (Plethodon cinereus),

(l) Northern slimy salamander (Plethodon glutinosus),

(m) Valley and ridge salamander (Plethodon hoffmani),

(n) Northern red salamander (Pseudotriton ruber);

(2) Frogs and toads:

(a) Eastern spadefoot (Scaphiopus holbrooki),

(b) American toad (Bufo americanus),

(c) Fowler's toad (Bufo fowleri),

(d) Northern cricket frog (Acris crepitans),

(e) Cope's gray treefrog (Hyla chrysoscelis),

(f) Gray treefrog (Hyla versicolor),

(g) Green treefrog (Hyla cinerea),

(h) Northern spring peeper (Pseudacris crucifer),

(i) Southeastern chorus frog (Pseudacris feriarum),

(j) Pickerel frog (Rana palustris),

(k) Southern leopard frog (Rana spenocephala),

(l) Wood frog (Rana sylvatica);

(m) Green frog (Rana clamitans),

(n) American bullfrog (Rana catesbeiana);

(3) Lizards:

(a) Eastern fence lizard (Sceloporus undulates),

(b) Common five-lined skink (Eumeces fasciatus),

(c) Little brown skink (Scincella lateralis),

(4) Snakes:

(a) Eastern wormsnake (Carphophis amoenus),

(b) Northern black racer (Coluber constrictor),

(c) Ring-necked snake (Diadophis punctatus),

(d) Cornsnake (Elaphe guttata guttata),

(e) Black ratsnake (Elaphe obsoleta obsoleta),

(f) Mole kingsnake (Lampropeltis calligaster rhombomaculata),

(g) Eastern milksnake (Lampropeltis triangulum triangulum),

(h) Coastal plain milksnake (Lampropeltis triangulum elapsoides x triangulum),

(i) Eastern kingsnake (Lampropeltis getula getula),

(j) Red-bellied watersnake (Nerodia erythrogaster),

(k) Northern watersnake (Nerodia sipedon),

(l) Rough greensnake (Opheodrys aestivus),

(m) Smooth greensnake (Opheodrys vernalis),

(n) Dekay's brownsnake (Storeria dekayi),

(o) Red-bellied snake (Storeria occipitomaculata),

(p) Eastern gartersnake (Thamnophis sirtalis sirtalis).

B. The following species or subspecies are considered native to Maryland and may be lawfully possessed only as provided in Regulations .04C and .05A of this chapter, or bred or commercially traded only as provided in Regulations .05—.09 of this chapter:

(1) Lizards:

(a) Broad-headed skink (Eumeces laticeps),

(b) Eastern six-lined racerunner (Cnemidophorus sexlineatus);

(2) Snakes:

(a) Eastern hog-nosed snake (Heterodon platirhinos),

(b) Queen snake (Regina septemvittata),

(c) Common ribbonsnake (Thamnophis sauritus sauritus);

(3) Turtles:

(a) Wood turtle (Glyptemys insculpta),

(b) Spotted turtle (Clemmys guttata),

(c) Eastern box turtle (Terrapene carolina carolina),

(d) Eastern painted turtle (Chrysemys picta picta),

(e) Midland painted turtle (Chrysemys picta marginata),

(f) Eastern mud turtle (Kinosternon subrubrum),

(g) Northern red-bellied cooter (Pseudemys rubriventris),

(h) Stinkpot (Sternothorus odoratus),

(i) Diamond-backed terrapin (Malaclemys terrapin).

C. Except under the authority of the permits described in Regulation .01A of this chapter, the following species or subspecies are considered native to Maryland and may not be possessed, bred, or commercially traded:

(1) Salamanders:

(a) Eastern tiger salamander (Ambystoma tigrinum),

(b) Green salamander (Aneides aeneus),

(c) Jefferson salamander (Ambystoma jeffersonianum),

(d) Wehrle's salamander (Plethodon wehrlei),

(e) Eastern hellbender (Cryptobranchus alleganiensis),

(f) Mudpuppy (Necturus maculosus),

(g) Eastern mud salamander (Pseudotriton montanus),

(2) Frogs and Toads:

(a) Eastern narrow-mouthed toad (Gastrophryne carolinensis),

(b) Carpenter frog (Rana virgatipes),

(c) Mountain chorus frog (Pseudacris brachyphona),

(d) Barking treefrog (Hyla gratiosa);

(3) Turtles:

(a) Northern map turtle (Graptemys geographica),

(b) Leatherback seaturtle (Dermochelys coriacea),

(c) Loggerhead seaturtle (Caretta caretta),

(d) Green seaturtle (Chelonia mydas),

(e) Atlantic hawksbill seaturtle (Eretmochelys imbricata),

(f) Kemp's ridley seaturtle (Lepidochelys kempii),

(g) Bog turtle (Glyptemys muhlenbergii),

(h) Spiny softshell (Apalone spinifera).

(4) Lizards: Northern coal skink (Eumeces anthracinus);

(5) Snakes:

(a) Rainbow snake (Farancia erytrogramma),

(b) Smooth earthsnake (Virginia valeriae),

(c) Northern scarletsnake (Cemophora coccinea),

(d) Timber rattlesnake (Crotalus horridus),

(e) Copperhead (Agkistrodon contortrix).

D. Unless otherwise stated, when both the scientific and common names are listed, the scientific name takes precedence over the common name.

.04 Possession Without Permits.

A. Except as provided in §§D—F of this regulation, a person without a reptile and amphibian permit may not possess more than four of each individual reptile or salamander, live or dead, listed in Regulation .03A of this chapter. The individual reptiles or salamanders may have been:

(1) Obtained from the wild;

(2) Captively produced; or

(3) Legally obtained outside of Maryland.

B. Except as provided in §§D—F of this regulation, a person without a reptile and amphibian permit may not possess more than four adults and 25 eggs or tadpoles of each individual frog or toad, live or dead, listed in Regulation .03A of this chapter. The frog or toad may have been:

(1) Obtained from the wild;

(2) Captively produced; or

(3) Legally obtained outside of Maryland.

C. A person without a reptile and amphibian permit may possess only one of each individual reptile or amphibian, live or dead, listed in Regulation 03B of this chapter. A person may not take wood turtles, spotted turtles, or diamond-backed terrapins from the wild. A certificate of origin, bill of sale, or other documentation proving captive origin of these wood turtles, spotted turtles, or diamond-backed terrapins shall be retained. All turtles shall have a carapace length of at least 4 inches.

D. An educational facility without a reptile and amphibian permit may possess an unlimited number of individual frogs and toads listed in Regulation .03A of this chapter if they are obtained:

(1) From a permittee; or

(2) Legally from outside of Maryland.

E. A person without a reptile and amphibian permit may possess an unlimited number of albino, or other color mutations, resulting from captive breeding, of any species or subspecies listed in Regulation .03A of this chapter. The burden of proving that the mutant is a legitimate color mutant lies with the owner. However, commercial trade in these individuals is regulated as described in Regulations .05—.07 of this chapter.

F. American Bullfrogs.

(1) A person without a reptile and amphibian permit may:

(a) Take from the wild not more than ten American bullfrogs, or parts of them, per day, for personal use as food or possess more than 20 American bullfrogs, or parts of them; and

(b) Possess or sell, for use as food, an unlimited number of American bullfrogs, or parts of them, if the animals were legally obtained from outside of Maryland.

(2) American bullfrogs under §F(1)(a) of this regulation may not be sold or commercially traded.

G. Possession of a hybrid applies to the possession limit for each species or subspecies in its lineage.

.05 Permits.

A. Except as provided in Regulation .04D—F of this chapter, a person shall obtain a reptile and amphibian permit from the Department in order to:

(1) Possess more than four individuals, live or dead, of each reptile or salamander listed in Regulation .03A of this chapter, of which only four of each reptile or salamander may have been taken from the wild;

(2) Possess more than four adults and 25 eggs or tadpoles, live or dead, of each frog or toad listed in Regulation .03A of this chapter, of which only four adults and 25 eggs or tadpoles of each frog or toad may have been taken from the wild;

(3) Possess more than one individual, live or dead, of any species or subspecies listed in Regulation .03B of this chapter, of which:

(a) No wood turtles, spotted turtles, or diamond-backed terrapins may have been taken from the wild; and

(b) Only one eastern box turtle, eastern painted turtle, midland painted turtle, eastern mud turtle, northern red-bellied cooter, stinkpot, broad-headed skink, eastern six-lined racerunner, eastern hog-nosed snake, queen snake, or common ribbonsnake may have been taken from the wild; or

(4) Breed, attempt to breed, sell, offer for sale, trade, or barter any reptile or amphibian as allowed by Regulations .06 and .07 of this chapter.

B. A permittee may possess an unlimited number of any reptiles or amphibians listed in Regulation .03A and B of this chapter that are:

(1) Captively produced and documented as described in Regulation .11B of this chapter;

(2) Legally obtained from outside of Maryland and documented as described in Regulation .11B of this chapter; or

(3) Obtained from a licensed reptile and amphibian rescue service, veterinarian, or wildlife rehabilitator if documentation accompanies the reptiles or amphibians.

C. Issuance of Permit.

(1) The Director may issue a reptile and amphibian permit to possess, breed, sell, offer for sale, trade, or barter reptiles or amphibians only after the Director is satisfied that the issuance of a permit will not be detrimental to the protection and conservation of native reptiles or amphibians.

(2) The Department may issue a reptile and amphibian permit for activities authorized in this chapter to a person who has submitted a completed application on a form provided by the Department, and a fee of $25. The permit is valid from the date of issuance until the following December 31.

.06 Breeding.

A. A permittee may collect from the wild for breeding purposes not more than the number of individual reptiles or amphibians allowed in Regulation .05A of this chapter.

B. A permittee may breed turtles.

.07 Commercial Trade.

A. A permittee may sell, offer for sale, trade, or barter individuals of each species or subspecies of reptiles or amphibians listed in Regulation .03A and B of this chapter if they are:

(1) Captively produced and documented as described in Regulation .11B of this chapter; or

(2) Legally obtained from outside of Maryland and documented as described in Regulation .11B of this chapter.

B. Reptiles or amphibians listed in Regulation .03A and B of this chapter may be obtained:

(1) From another permittee and documented as described in Regulation .11B of this chapter; or

(2) Legally from outside of Maryland and documented as described in Regulation .11B of this chapter.

C. A permittee may not sell, offer for sale, trade, or barter turtles with a carapace length less than 4 inches to any person in Maryland. A permittee may not display live turtles, sell, offer for sale, trade, or barter turtles with a carapace length less than 4 inches at a facility open to the general public. A permittee may sell, offer for sale, trade, or barter turtles with a carapace length less than 4 inches outside of Maryland if it is legal to do so in the state where the commercial trade occurs.

D. Reptiles or amphibians regulated under this chapter may not be taken from the wild in Maryland and sold, offered for sale, traded, or bartered.

.08 Sanitary Housing and Shipping Requirements.

A. Reptiles and amphibians held in captivity under the authority of this chapter shall be housed under conditions which are humane, safe, and healthy.

B. Housing conditions shall meet all of the following requirements:

(1) Enclosures shall be designed to:

(a) Provide appropriate lighting, temperatures, humidity, and clean water to meet the physical requirements of the reptile or amphibian,

(b) Keep the reptile or amphibian in complete and continuous captivity,

(c) Restrict the entry of unauthorized persons or predatory animals,

(d) Provide sufficient fresh food and clean water to fulfill the reptile or amphibian's dietary requirements and present the food and water in a manner compatible with the reptile or amphibian's particular eating habits, and

(e) Minimize any potential danger to humans;

(2) Enclosures shall be maintained in a sanitary condition and good repair;

(3) Equipment shall be available for proper storage and disposal of waste material to control vermin, insects, and obnoxious odors;

(4) Effective measures shall be provided to prevent and control infection and infestation of disease, parasites, or vermin;

(5) Adequate shelter shall be provided for the comfort of the animal and, when necessary, for the isolation of diseased reptiles or amphibians; and

(6) Reptiles or amphibians that are housed together shall be maintained in compatible groups without overcrowding.

C. Standards for Shipping and Transportation of Live Reptiles and Amphibians.

(1) Container Design and Maintenance.

(a) Containers used for the transport of live animals shall be designed, constructed, and fitted as appropriate to the species, size, and weight of the animals to be transported. Special attention shall be paid to the avoidance of injury to animals through the use of secure smooth fittings or walls free from sharp protrusions.

(b) Containers shall be designed with the structures necessary to provide protection from adverse weather conditions and to minimize the opportunity for animals to escape.

(c) In order to minimize the likelihood of the spread of infectious disease during transport, containers shall be designed to permit thorough cleaning and disinfection. The cleaning and disinfection shall be completed after animals have been removed from the container.

(d) Containers shall be maintained in good mechanical and structural condition.

(e) Containers shall have adequate ventilation to meet variations in climate and the thermo-regulatory needs of the species to be transported.

(f) For salamanders, frogs, toads, and juvenile turtles, sufficient moisture shall be available and applied to prevent desiccation of the animal. Turtles may not be transported in water.

(2) Provisions for Transport.

(a) Containers shall be adequately designed and positioned during transport so that the containers are securely fastened within the vehicle.

(b) Vehicles shall have adequate ventilation to meet variations in climate and the thermo-regulatory needs of the species being transported.

(c) For salamanders, frogs, toads, and juvenile turtles, sufficient moisture shall be available and applied to prevent desiccation of the animal.

(3) Space allowance considerations shall:

(a) Limit the number of animals that may be transported in a container to only one animal per compartment;

(b) Ensure that each animal is able to assume its natural position during transport, including during loading and unloading, without coming into contact with the roof or upper deck of the container; and

(c) Provide sufficient headroom to allow for adequate airflow over the animals.

(4) Animals may not be stacked upon one another in a container.

.09 Unlawful Methods for Taking from the Wild.

A. A person may not take any reptile or amphibian regulated by this chapter by:

(1) Lethal methods;

(2) The use of a hook and line, trot line, bow and arrow, spear, gig or gig iron, or any other device capable of piercing any part of the reptile or amphibian;

(3) Use of traps, pit falls, snares, seines, or nets other than dip nets; or

(4) Use of chemicals, including gasoline.

B. A person may not destroy or alter dens, burrows, basking sites, or other refugia of reptiles or amphibians while in the act of taking.

.**10 Conditions for Release.**

A. Except as provided in §B(2) of this regulation, a reptile or amphibian that has been captively produced or that is not native to Maryland may not be released into the wild.

B. A person may release an individual of any species or subspecies of reptiles or amphibians taken from the wild back to the wild if:

(1) It was not held in captivity with any other reptile or amphibian and it was not held in captivity for more than 30 days; or

(2) The person has obtained prior written authorization from the Department.

C. Release of an individual reptile or amphibian under §B of this regulation shall occur at or near the point of capture.

.11 Record-Keeping Requirements.

A. A permittee shall maintain accurate, current, and complete records on forms provided by the Department. A copy of these records shall be submitted to the Department:

(1) At the time of application for permit renewal; or

(2) By January 31, following expiration of the permit, if the permit is not renewed.

B. To prove that any reptile or amphibian held under a reptile and amphibian permit did not come from the wild in Maryland, a permittee shall retain as part of the permittee's records for each individual reptile or amphibian:

(1) One of the following:

(a) A certificate of origin issued at the time an individual of any species or subspecies of reptiles or amphibians listed in Regulation .03A and B of this chapter is obtained; or

(b) A bill of sale or other documentation to prove that the individuals of any species or subspecies of reptiles or amphibians listed in Regulation .03A and B of this chapter were legally obtained; and

(2) Breeding records for young produced in captivity by a permittee, including number of young produced by each female of each species.

C. A certificate of origin, bill of sale, or other documentation shall include:

(1) Common name;

(2) Scientific name;

(3) Number of individuals by species;

(4) Date of transaction;

(5) Name and address of seller, including Maryland permit number when applicable.

D. The records referred to in §B of this regulation shall be maintained for each individual reptile or amphibian possessed by the permittee for as long as the reptile or amphibian is possessed by the permittee, or for 3 years following the disposition of each individual reptile or amphibian, whichever is longer.

E. A certificate of origin, a bill of sale, or other documentation shall be retained for the individuals of any species or subspecies of reptiles or amphibians that are similar in appearance to those species or subspecies regulated under this chapter.

.12 Inspection.

A permittee shall allow the Department to:

A. Enter and inspect at any reasonable hour the premises where operations under this chapter occur; and

B. Inspect the records described in Regulation .11 of this chapter.

.13 Revocation.

A. The Director may revoke a reptile and amphibian permit for a violation of:

(1) Natural Resources Article, Title 10, Annotated Code of Maryland;

(2) This chapter; or

(3) The terms of the permit.

B. At the sole discretion of the Director, a reptile and amphibian permit revocation may result in confiscation of an individual of any species or subspecies of reptiles or amphibians listed in Regulation .03A—C of this chapter which only may be possessed, bred, or sold with a permit issued under the authority of this chapter. The disposition of confiscated individuals of any species or subspecies of reptiles or amphibians is at the discretion of the Director.

.14 Penalties.

Violation of these regulations is a misdemeanor punishable under Natural Resources Article, §§10-205 and 10-1101—10-1107, Annotated Code of Maryland.

.15 Grandfather Clause.

A. A person shall have until March 31, 2008, to declare in writing to the Director possession of each individual:

(1) Eastern painted turtle, midland painted turtle, eastern mud turtle, northern red-bellied cooter, and stinkpot possessed prior to the effective date of this regulation, if the person possesses more than one individual, live or dead;

(2) Diamond-backed terrapin possessed prior to the effective date of these regulations, if the person possesses any individuals taken from the wild;

(3) Copperhead possessed prior to May 31, 2006;

(4) Broad-headed skink, eastern six-lined racerunner, eastern hog-nosed snake, queen snake, or common ribbonsnake possessed prior to the effective date of this regulation, if the person possesses more than one individual, live or dead; or

(5) Eastern mud salamander possessed prior to the effective date of this regulation, live or dead.

B. For each individual reptile or amphibian possessed, the declaration shall include:

(1) Species name;

(2) Number of individuals of each species;

(3) Date acquired;

(4) Sex, if known;

(5) Estimated age;

(6) Length;

(7) Origin; and

(8) Other identifying characteristics or specific markings such as tattoos, registration numbers, PIT tag numbers, coloration, missing limbs, or notched shells.

C. The Department shall acknowledge each declaration in writing. This acknowledgement shall serve as a permit for possession only and is not transferable.

D. The holder of a grandfather permit shall be subject to inspection as described in Regulation .12A of this chapter.

Appendix F

Maryland’s 2008 Living Shoreline Protection Act

Chapter 304
H.B. No. 973

ENVIRONMENT--WATER MANAGEMENT ADMINISTRATION--LIVING SHORELINE PROTECTION ACT

AN ACT concerning

Water Management Administration--Living Shoreline Protection Act of 2008

FOR the purpose of requiring certain erosion protection projects to include certain nonstructural shoreline stabilization measures, with certain exceptions; requiring the Department of the Environment, in consultation with the Department of Natural Resources, to adopt certain regulations; requiring certain regulations to include a certain waiver process; and generally relating to the regulation of shore erosion control projects.

BY repealing and reenacting, with amendments, Article--Environment Section 16-201 Annotated Code of Maryland (2007 Replacement Volume and 2007 Supplement)

Preamble

WHEREAS, The State of Maryland and its people, property, natural resources, and public investments will be significantly impacted by climate change and sea level rise; and

WHEREAS, Sea level rise contributes to the erosion of approximately 580 acres of shoreline per year along Maryland's Chesapeake Bay, Atlantic coastal bays, and Atlantic Ocean coast; and

WHEREAS, The Maryland Commission on Climate Change has recommended that the State begin to actively address the impacts on the natural environment of shore erosion induced by sea level rise; and

WHEREAS, Current shore protection practices used to control shore erosion and protect upland properties range from "hard" techniques such as bulkheads, retaining walls, and riprap, to more "soft" alternatives such as "living shorelines" that combine marsh plantings with sills, groin fields, or breakwaters; and

WHEREAS, "Living shorelines" are the preferred method of shore protection as they trap sediment, filter pollution, and provide important aquatic and terrestrial habitat; and

WHEREAS, It is the public policy of the State to protect natural habitat and that shoreline protection practices, where necessary, consist of nonstructural "living shoreline" erosion control measures wherever technologically and ecologically appropriate; now, therefore,

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, that the Laws of Maryland read as follows:

Article--Environment

<< MD ENVIR § 16-201 >>

16-201.

(a) A person who is the owner of land bounding on navigable water is entitled to any natural accretion to the person's land, to reclaim fast land lost by erosion or avulsion during the person's ownership of the land to the extent of provable existing boundaries. The person may make improvements into the water in front of the land to preserve that person's access to the navigable water or, subject to subsection (c), protect the shore of that person against erosion. After an improvement has been constructed, the improvement is the property of the owner of the land to which the improvement is attached. A right covered in this subtitle does not preclude the owner from developing any other use approved by the Board. The right to reclaim lost fast land relates only to fast land lost after January 1, 1972, and the burden of proof that the loss occurred after this date is on the owner of the land.

(b) The rights of any person, as defined in this subtitle, which existed prior to July 1, 1973 in relation to natural accretion of land are deemed to have continued to be in existence subsequent to July 1, 1973 to July 1, 1978.

(c)(1) Improvements to protect a person's property against erosion shall consist of nonstructural shoreline stabilization measures that preserve the natural environment, such as marsh creation, except:

(i) In areas designated by Department mapping as appropriate for structural shoreline stabilization measures; and

(ii) In areas where the person can demonstrate to the Department's satisfaction that such measures are not feasible, including areas of excessive erosion, areas subject to heavy tides, and areas too narrow for effective use of nonstructural shoreline stabilization measures.

(2)(i) Subject to subparagraph (ii) of this paragraph, in consultation with the Department of Natural Resources, the Department shall adopt regulations to implement the provisions of this subsection.

(ii) Regulations adopted by the Department under subparagraph (i) of this paragraph shall include a waiver process that exempts a person from the requirements of paragraph (1) of this subsection on a demonstration to the Department's satisfaction that nonstructural shoreline stabilization measures are not feasible for the person's property.

SECTION 2. AND BE IT FURTHER ENACTED, That this Act shall take effect October 1, 2008.

Approved April 24, 2008.

Appendix G

Additional Images

Figure 29. Typical size and shape of terrapin egg
(Team Saving Testudo Research Collection)

Figure 30. Terrapin tracks in “J” shapes

Image taken from Capital Gazette Newspapers website:
http://www.hometownannapolis.com/nat_terrapins.html

Appendix H

Doubling of Trent Hall Data from Summer 2007

Table 6. Effectiveness of electric fences in reducing diamondback terrapin nest predation by raccoons and foxes, Trent Hall Farm, lower Patuxent River, Maryland, 2007.

	Study Plots	
Terrapin Nests	Treatment (fenced)	Control (unfenced)
Not Depredated	4 nests	2 nests
Depredated	0 nests	3 nests

P=0.119048

Table 7. Predicted effectiveness of electric fences in reducing diamondback terrapin nest predation by raccoons and foxes, Trent Hall Farm, lower Patuxent River, Maryland, with 2 years of data equivalent to 2007.

	Study Plots	
Terrapin Nests	Treatment (fenced)	Control (unfenced)
Not Depredated	8 nests	4 nests
Depredated	0 nests	6 nests

p=0.0113122

Appendix I

Additional Nest Information from Study Sites, 2007-2008

Key:

Control = nest found inside control plot

Treatment = nest found inside treatment plot

Out = nest found outside of treatment or control plots

Whole = nest was found intact

Dep = nest was found depredated

Nest information from Trent Hall Farm Beach, lower Patuxent River, Maryland, 2007

Nest	Date Found	Date Depredated	Location	Condition
1	5/28/07		Control	Whole
2	6/6/07	6/19/07	Out	Dep
3	6/6/07	6/6/07	Out	Dep
4	6/6/07	6/6/07	Out	Dep
5	6/6/07		Out	Whole
6	6/6/07	6/21/07	Out	Dep
7	6/6/07	6/6/07	Out	Dep
8	6/6/07	6/6/07	Out	Dep
9	6/6/07		Out	Whole
10	6/6/07		Out	Whole
11	6/6/07	6/6/07	Out	Dep
12	6/6/07	6/6/07	Out	Dep
14	6/6/07		Out	Whole
15	6/7/07		Out	Whole
16	6/8/07		Out	Whole
17	6/8/07	6/25/07	Out	Dep
18	6/9/07		Out	Whole
19	6/9/07		Control	Whole
20	6/14/07	6/18/07	Out	Dep
21	6/14/07		Out	Whole
22	6/14/07		Out	Whole
23	6/17/07		Control	Whole
24	6/17/07	6/19/07	Out	Dep
25	6/18/07		Out	Whole
26	6/19/07	6/19/07	Out	Dep

27	6/19/07		Out	Whole
28	6/19/07		Out	Whole
29	6/19/07		Out	Whole
30	6/19/07	6/19/07	Out	Dep
31	6/24/07		Out	Whole
32	6/24/07		Treatment	Whole
33	6/25/07	6/25/07	Out	Dep
34	6/25/07	6/25/07	Out	Dep
35	6/30/07	6/30/07	Control	Dep
36	7/1/07	7/1/07	Out	Dep
37	7/1/07		Out	Whole
38	7/1/07		Treatment	Whole
39	7/2/07		Control	Whole
40	7/4/07		Out	Whole
41	7/5/07		Treatment	Whole
42	7/7/07		Out	Whole
43	7/7/07		Treatment	Whole
44	7/8/07	7/8/07	Out	Dep
45	7/8/07	7/8/07	Out	Dep
46	7/11/07		Out	Whole
47	7/15/07		Treatment	Whole
48	7/18/07		Out	Whole

Nest information from Trent Hall Farm Beach, lower Patuxent River, Maryland, 2008

Nest	Date Found	Date Depredated	Location	Condition
1	6/1/08		Out	Whole
2	6/2/08		Control	Whole
3	6/8/08	6/8/08	Out	Dep
4	6/10/08		Out	Whole
5	6/10/08		Control	Whole
6	6/11/08		Control	Whole
7	6/11/08		Out	Whole
8	6/23/08		Out	Whole
9	7/3/08		Out	Whole
10	7/3/08		Out	Whole
11	7/4/08		Control	Whole
12	7/8/08	7/8/08	Out	Dep
13	7/8/08		Out	Whole
14	7/8/08	7/8/08	Out	Dep
15	7/13/08	7/13/08	Treatment	Dep

Nest information from Jefferson Patterson Park and Museum, lower Patuxent River, Maryland, 2008

Nest	Date Found	Date Depredated	Location	Condition
1	6/1/08		Control	Whole
2	6/4/08		Out	Whole
3	6/8/08		Treatment	Whole
4	6/12/08		Control	Whole
5	6/12/08	6/12/08	Control	Dep
6	6/20/08	6/21/08	Control	Dep
7	6/20/08	6/20/08	Control	Dep
8	6/20/08	6/20/08	Control	Dep
9	6/20/08	6/20/08	Control	Dep
10	6/20/08		Treatment	Whole
11	6/23/08	6/23/08	Control	Dep
12	6/25/08	6/25/08	Treatment	Dep
13	6/27/08		Control	Whole
14	6/27/08	6/27/08	Control	Dep
15	6/27/08	6/27/08	Treatment	Dep
16	6/27/08	6/27/08	Treatment	Dep
17	6/30/08	7/3/08	Control	Dep
18	7/1/08		Out	Whole
19	7/1/08	7/1/08	Out	Dep
20	7/3/08	7/3/08	Control	Dep
21	7/7/08	7/7/08	Control	Dep
22	7/12/08	7/12/08	Out	Dep
23	7/12/08	7/12/08	Control	Dep
24	7/12/08	7/12/08	Control	Dep
25	7/12/08	7/12/08	Out	Dep
26	7/12/08	7/12/08	Treatment	Dep
27	7/15/08	7/15/08	Out	Dep
28	7/15/08	7/15/08	Control	Dep
29	7/15/08	7/15/08	Control	Dep
30	7/18/08	7/18/08	Control	Dep
31	7/22/08	7/22/08	Control	Dep
32	7/22/08	7/22/08	Control	Dep
33	7/23/08	7/23/08	Out	Dep
34	7/28/08	7/28/08	Out	Dep