# *The Northern Diamondback Terrapin (Malaclemys terrapin terrapin) in the Northeast United States: A Regional Conservation Strategy*


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*COVER IMAGE: Female Northern diamondback terrapin © Brian Tang*

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## EXECUTIVE SUMMARY

Northern diamondback terrapin (*Malaclemys terrapin terrapin*) (terrapin) populations have declined due to a number of factors since the early 1900's. Historic commercial fisheries, loss of habitat, drowning in commercial and recreational crab pots, increased nest failure due to predation from raccoons and other subsidized predators, and road mortality have been the primary causations for population decline (Brennessel n.d.). Illegal harvest and trade in the Asian food markets, both domestic and abroad may also be a major threat.

The terrapin has been identified as a Species of Greatest Conservation Need (SGCN) in the NE SWAPs. The terrapin is found in eight states of the Northeast /mid-Atlantic regions and is considered Threatened in MA, Endangered in RI, and Special Concern in CT. In DE's SWAP, the species is considered a Tier I species, which is most in need of conservation action in order to sustain or restore their populations. In VA's SWAP, the species is considered a Tier II Species of Greatest Conservation Need. In NY and MD, the species is identified in their respected SWAP, but with no priority ranking given. In NY and CT, the terrapin is identified as an S3 - Vulnerable species and in MD it's an S4 – Apparently Secure species. NatureServe lists the Global Status of the terrapin as T4-Apparently Secure. In NJ, the terrapin is a commercial marine species and identified in the SWAP as species of greatest conservation need [SGCN].

The species has been identified by the NE Partners in Amphibian and Reptile Conservation (NEPARC) as a species of regional conservation concern in the NE Amphibian and Reptile Species of Regional Responsibility and Conservation Concern Report as it found in ≥ 75 % of states listed in the SWAP and > 50% of NDBT distribution is within the NE Region of North America (NEPARC 2010). Therres (1999) also suggested that the terrapin merits a federal listing assessment. There is no specific federal program/policy for the terrapin and state programs rarely coordinate regional efforts in the absence of a federal mandate (Hackney 2010).

A regional Conservation Strategy is needed at this time to identify steps that can be taken regionally and by state to reduce further decline of this species and to help achieve long-term sustainability of the terrapin population in the Northeast and mid-Atlantic regions. To pursue a regional Conservation Strategy, existing data must be compiled and evaluated by state and regionally from a number of partners and organizations. This proposal represents the first major effort of the DTWG to take a comprehensive view of the status of the terrapin in the Northeast and mid-Atlantic regions. In 2008, the (mid-Atlantic) DTWG meeting identified the development of a conservation plan as a priority action item. Despite its importance, no plan has been developed to date due to limited resources. The development of a Conservation Strategy will help guide and coordinate multiple-state laws and policies to protect the terrapin and its habitat and may reduce the need for a Federal listing assessment (as was also suggested by Hackney [2010]).

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## ABBREVIATIONS AND ACRONYMS

AUC - Area under the curve
BBEP - Barnegat Bay Estuary Program
BLCT - Barrington Land Conservation Trust
BMP - Best management practices
BRD - Bycatch reduction device
CIB - Center for the Inland Bays
CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora
CJS - Cormack Jolly Seber
CT - Connecticut
CWFNJ - Conserve Wildlife Foundation of New Jersey
DCR- Department of Conservation and Recreation
DE - Delaware
DE DNREC - Delaware Department of Natural Resources and Environmental Control
DEC - Department of Environmental Conservation
DEEP - Department of Energy and Environmental Protection
DelDOT - Delaware Department of Transportation
DNR - Department of Natural Resources
DOT - Department of Transportation
DTWG - Diamondback Terrapin Working Group
ECAT - Environmental Conservation Appearance Ticket
ESI - Environmental Sensitivity Index
Forsythe NWR - Edwin B. Forsythe National Wildlife Refuge
GBWMA - Great Bay Wildlife Management Area
GIS - Geographic Informational Systems
GNRA - Gateway National Recreation Area
IUCN - International Union for Conservation of Nature and Natural Resources
JBWR - Jamaica Bay Wildlife Refuge
JCNERR – Jacques Cousteau National Estuarine Research Reserve
JFK Airport - John F. Kennedy International Airport
KIT - Kids Interact with Terrapins
LE – Law Enforcement
LEMIS - Law Enforcement Management Information System (USFWS)
LINO - Long Island Nature Organization
MA - Massachusetts
MATES - Marine Academy of Technology and Environmental Science
MCBP - Maryland Coastal Bays Program
MD - Maryland
MDTWG - Maryland Diamondback Terrapin Working Group
MU - Monmouth University
NE - Northeast
NEFWDTC - Northeast Fish and Wildlife Diversity Technical Committee
NEPARC - Northeast Partners in Amphibian and Reptile Conservation
NFWF- National Fish and Wildlife Foundation
NGO - Non-governmental organization
NJ - New Jersey
NJAC - New Jersey Administrative Code
NJBMF - New Jersey Bureau of Marine Fisheries
NJDEP - New Jersey Department of Environmental Protection
NJDFW - New Jersey Division of Fish and Wildlife
NOAA - National Oceanic and Atmospheric Administration

NPS - National Parks Service
NWR - National Wildlife Refuge
NY - New York
NYSDEC - New York State Department of Environmental Conservation
OCVTS - Ocean County Vocational Technical School
PBDEs - Polybrominated diphenyl ethers
PRC - Patuxent River Commission
PIT - passive integrated transponder tags
POPs - Persistent Organic Pollutants
RCN - Regional Needs Grant Program
ReClam – ReClam the Bay
RI - Rhode Island
RIDEM - Rhode Island Department of Environmental Management
RINHS - Rhode Island Natural History Survey
ROC - Receiver operating curve
SGCN - Species of Greatest Conservation Need
SHA - State Highway Administration
SHU - Sandy Hook Unit
Stockton - Stockton University
SWAP - State Wildlife Action Plan
TED - Turtle excluder device
TERP - Terrapin Education and Rescue Program
TRACS - Tracking and Reporting Actions for the Conservation of Species
TWI - The Wetlands Institute
URI - University of Rhode Island
USACOE - United States Army Corp of Engineers
USDA - U.S. Department of Agriculture
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
VA - Virginia
VCR - Virginia Coast Reserve
VDEQ - Virginia Department of Environmental Quality
VDGIF - Virginia Department of Game and Inland Fisheries
VDOT- Virginia Department of Transportation
VIMS - Virginia Institute of Marine Science
VMRC - Virginia Marine Resources Commission
WBWS - Wellfleet Bay Wildlife Sanctuary

## OBJECTIVES

The objectives of the Conservation Strategy were to: a) Compile and examine existing data on terrapin locations and status within the states and the region, identify data gaps, build a dataset from existing occurrence data, develop maps and show trends in distribution and habitat, and identify the most important focal areas to the species; b) Compile, characterize and rank threats within states and regionally; c) Draft the Conservation Strategy with developed strategic conservation actions from the eight Northeast and Mid-Atlantic states as described in the *DOCUMENTED TERRAPIN OCCURRENCE OF THE NORTHEAST* section.

The Conserve Wildlife Foundation of New Jersey, Inc. (CWFNJ) took the lead in coordination between the states/partners and organized meeting(s) to help foster a collaborative process and conservation strategy. The CWFNJ collected, analyzed, and interpreted region-wide data, in partnership with the DTWG, which represents all states where the species occurs in the NE, multiple NGOs, and other partners (listed in Appendix A). The CWFNJ compiled GIS maps with the data collected for occurrences and areas of important habitat. The CWFNJ with state partners and members of the DTWG, conducted a threat assessment and developed strategic conservation actions for each state and regionally. The CWFNJ also conducted a literature search to evaluate and summarize the regulatory status region wide. We also used the compiled regional data to conduct species distribution modeling and demonstrated how this information can inform decision makers, land managers, and others on the impacts of threats to this species, such as sea level rise, road mortality, and fisheries interactions. Available mark/recapture data were also compiled for some states and population analysis was conducted to determine current trends. The CWFNJ developed this Conservation Strategy with invaluable assistance from key players of the Diamondback Terrapin Working Group and RCN committee members.

## PURPOSE AND GEOGRAPHIC SCOPE OF THIS STRATEGY

This Conservation Strategy synthesizes conservation needs across the coastal NE range, MA to VA, SGCN, the Northern Diamondback Terrapin. The NE RCN Grant Program funded the development of this Conservation Strategy to enhance collaboration among recovery partners and address priority threats and conservation actions across its NE range. This Conservation Strategy provides a unified summary of the occurrence, species distribution and population modeling (where applicable), and threat assessments. It also identifies the planning, coordination, protection, and research actions needed to address priority threats to terrapins and their habitat. The Conservation Strategy is intended to serve as an integrated resource for biologists, land managers, regulators, and others seeking to conserve terrapins and to focus conservation actions within the NE. While we recognize that terrapin protection in the remainder of the range is very important, this document only provides cursory information about the NE. Terrapin conservation actions in other states are strongly encouraged, and parallel-planning documents may be warranted.

## RELATIONSHIP OF THIS STRAEGY TO STATE WILDLIFE ACTIONS PLANS

For this Conservation Strategy, the NE states partook in a Threat Assessment outlined by the Northeast Lexicon, which is a hierarchical Threat Classification System adopted by the IUCN threat classification system to classify and name threats and also the system that is being used for the 2015 revisions of the NE SWAPs. We therefore organized threats for terrapins under the broadest categories including: Residential and Commercial Development, Transportation, Biological Resource Use, Human Intrusions and Disturbance, Natural System Modifications, Pollution, Climate Change and Severe Weather, Invasive and Other Problematic Species and Genes. We added our own broad category of Predation and Disease as well. The strategic Conservation Actions developed for this Conservation Strategy, which were derived from conducting the Threat Assessment, mainly followed the format of the Northeast Lexicon as well and the format that is also being used for the 2015 revisions of the NE SWAPS. Essentially for future revisions of the NE SWAPS, this Conservation Strategy may be referenced or used directly for state proposed conservation actions.

## LIFE HISTORY AND DEMOGRAPHICS

The diamondback terrapin (*Malaclemys terrapin*) is a turtle in the family Emydidae, the group of pond or marsh turtles occurring in the Western Hemisphere. It occurs along the U.S. Atlantic coastline from Cape Cod, MA south to the Gulf of Mexico (Roosenburg 1994, Hart and Lee 2006) and is the only species of turtle in the USA that exclusively inhabits brackish water. Seven subspecies of diamondback terrapin are currently delineated; however, recent genetic analyses suggest only four subspecies exist (Hart et al. 2014). The northernmost ranging subspecies is the Northern diamondback terrapin (*Malaclemys terrapin terrapin*) (terrapin), which occurs along the NE and mid-Atlantic coast of the U.S. from Cape Cod, MA south to Cape Hatteras, North Carolina (Ernst et al., 1994).

Terrapins spend much of their lives in open bays and tidal creeks, where they breed and forage on a variety of mollusks, crustaceans, and submerged aquatic vegetation. Females emerge from the water for a brief period of time in search of nesting grounds on dry upland beaches. Terrapins nest in June and July (Roosenburg 1991, Feinberg and Burke 2003), but the nesting season extends from April to September for the southern subspecies (Seigel 1980a, Zimmerman 1992). Terrapins prefer nesting in areas with either little vegetation or very sparse vegetation, rather than areas heavily covered with it (Williamson 2011), preferably upland and sandy areas (Hart and Lee 2006). An ideal nesting habitat would include narrow strips of sand between estuarine water and a marsh (Hart and Lee 2006). Females have also been observed to prefer cleaner areas to littered ones (Scholz 2006). Terrapins exhibit nest site fidelity and typically have small home ranges within their populations (Burger 1977, Roosenburg 1991, Spivey 1993, Gibbons et al. 2001, Butler 2002, Sheridan et al. 2010); however, exceptions have been documented, including one individual terrapin returning 12.5 km to its original tagging location after being displaced by a fisherman (Spivey 1993) and two others that were caught > 8 km away from their original release locations over multiple years (Sheridan et al. 2010).

Terrapins like other turtles, grow and mature at a slow rate. Females generally reach sexual maturity around six years of age (between 13.2 and 17.6 cm) while males mature around three to four years (9 cm) (Lovich and Gibbons 1990 as cited in Szerlag 2006). However, Roosenburg (1991) noted that some terrapins mature later -- between eight and thirteen years for females (as cited in Szerlag 2006) and between four and seven years for males (Roosenburg 1996 as cited in Wnek 2014) and observed in MA (B. Brennessel, Wheaton College, pers. comm. 2016). The typical size for an egg laying female in NJ is between 13.2 cm and 18.4 cm (SPL) (Montevecchi and Burger 1975 as cited in Szerlag 2006). Terrapins lay one to a three clutches (Roosenburg 1991, Wnek 2014) of 4 to 18 eggs per season (Burger and Montevecchi 1975). Terrapins have been observed laying at least two clutches in NJ, New York (NY), and MA (Szerlag 2006, Feinberg and Burke 2003, Auger and Giovannone 1979). In one NJ study, clutch sizes averaged 9.76 and ranged from 4 to 18 eggs (Burger and Montevecchi 1975) while in another NJ study the average clutch was 12.7 eggs in situ (Wnek 2014). This is not markedly different from clutch sizes measured in nearby states: 10.9 in NY (Feinberg and Burke 2003) and 13.2 in Maryland (MD) (Roosenburg 1991).

Terrapins generally enter hibernation in November and December, buried in the mud substrate of the tidal estuary creek bottoms, in ponds, or banksides (Coker 1906, Carr 1952, Ernst and Barbour 1972, Yearicks et al. 1981, Seigel 1984 as cited Outerbridge 2013). They will remain there until February or March the following year (Yearicks et al. 1981, Seigel 1984 as cited in Outerbridge 2013). In MA, the earliest observed emergence is typically in April (B. Brennessel pers. comm. 2016). Terrapins may hibernate in large aggregations (Haramis et al. 2011), small numbers of individuals or singly (Yearicks et al. 1981). Terrapins hibernate in shallow depths, as it has been observed in NJ where terrapins were documented in the intertidal zone or the upper limit of the tides in the bankside, or at the bottom of the salt marsh creek 1.5 to 2.5 m deep at low tides (Yearicks et al. 1981 as cited in Palmer and Cordes 1988). Terrapins have been found stacked on top of each other in just a few feet of water during low tides during hibernation (Brennessel 2006). This behavioral trait makes terrapins very vulnerable to harvest as they are immobile and in large groups so many terrapins may be harvested in a relatively short period of time (Haramis et al. 2011).

Terrapin demography is characterized by very low natality and recruitment and high adult survival (Gibbons et al 2001; Tucker et al. 2001 as cited in Haramis et al. 2011). The survival rate of terrapin nests has been estimated to be 10% (Ayers 2010 - VA). Feinberg and Burke (2003 - NY) documented a 92.2% nest mortality rate (i.e., 7.8% survival) for terrapins. Limited information is available for hatchling or juvenile survival rate, but Draud et al. (2004 - NY) found a 67% predation rate from Norway rats (*Rattus norvegicus*) on hatchlings with transmitters and suggest less than 10% survivorship during the first year. An indirect estimate of juvenile survival was calculated through matrix population modeling at 56.5% (Mitro 2003 – Rhode Island [RI]). Adult survival rate was calculated for females at 94.4% to 95.9% (model averaged estimates) (Mitro 2003 - RI).

## STATUS OF THE TERRAPIN IN THE NORTHEAST

Terrapins face a suite of anthropogenic threats across the NE including, but not limited to, habitat loss, predation, fisheries issues (i.e. overharvest, mortality in abandoned crab pots and other fishing gear), road mortality, recreational boating, and sea-level rise. The available habitat for terrapins has been severely impacted by the rapid urbanization of estuaries, which has reduced marsh habitat availability and quality (Ner and Burke 2008). Coastal development, particularly the installation of hard structures for shoreline stabilization, prevents terrapins from accessing nesting habitat (Wnek 2010, Roosenburg et al. 2014) and causes individuals to travel farther distances in search of suitable locations from which to access land, potentially reducing fitness due to greater energy expenditure (Winters et al. 2015).

Automobile collisions are a significant cause of mortality. As coastal development continually expands and access to natural habitats are lost, gravid females increasingly encounter roads while accessing nesting grounds (Roosenburg 1994). Roadsides act as ecological traps, mimicking the elevated, sandy terrain of natural nesting habitat. In southern NJ, 4,020 terrapins were killed on just six roads over seven years (Wood and Herlands 1997), and a study conducted over two nesting seasons observed nearly 10% mortality of all nesting females that had ventured onto a single road (Szerlag and McRobert 2006 and Szerlag 2006). The selective loss of mature females can have significant population-level impacts on this long-lived species, which experience delayed sexual maturity and high hatchling mortality rate (Aresco 2005, Avissar 2006, Steen et al. 2006).

Abandoned commercial crab traps in bays and estuaries are also a major concern because terrapins enter the traps and cannot escape. Roosenburg et al. (1997) estimated 15 – 78% of a population in Maryland (MD) drowned in crab pots in one year, and mortality was reported to approach 100% in NJ (Wood 1997). Whereas mature females are disproportionately at risk from vehicular strikes, crab pots predominantly threaten smaller males and juvenile females that can more easily enter the traps (Bishop 1983, Wood 1997, Harden and Williard 2012).

Human-subsidized predators, such as raccoons (*Procyon lotor*), crows (*Corvus* spp.), and red foxes (*Vulpes vulpes*) prey heavily on eggs and hatchlings. Predation, particularly by raccoons, has been cited for up to 70% of nest mortality in the Patuxent River, MD (Roosenburg and Place 1994), and 92% in Jamaica Bay, NY (Feinberg 2004), with most depredations occurring within 48 hours of oviposition (Burger 1977, Butler et al. 2004). Predation rates increase with nest density (Roosenburg and Place 1994), and the loss of nesting habitat increases nest density at remaining available sites, negatively affecting nest survivorship of those populations.

Recreational watercraft in bays and waterways pose both a direct mortality threat, as well an indirect impact on habitat quality (Burger and Garber 1995, Gibbons et al. 2001). Even where morality does not occur, collisions with boat propellers cause major damage to the carapace and loss of limbs (Sornborger et al. 1994, Cecala et al. 2008, Lester et al. 2013). Larger individuals are more susceptible to injury (Cecala et al. 2008), placing an additional selective pressure on mature females.

In addition to the major threats detailed above, terrapins are also impacted by the rapid urbanization of estuaries, which has reduced marsh habitat availability and quality (Ner and Burke 2008). Coastal development, particularly the installation of hard structures for shoreline stabilization, prevents terrapins from accessing nesting habitat (Wnek 2010, Roosenburg et al. 2014) and causes individuals to travel farther distances in search of suitable locations from which to access land, and may increase risk of predation due to exposure (Winters et al. 2015). Climate change only exacerbates these threats.

Terrapins face similar threats across the NE (and their entire range), making examinations of their populations beyond the typical constraints of administrative and political boundaries necessary (Butler et al. 2006, Ner and Burke 2008). Conservation efforts and research for terrapins are typically conducted at the local scale (Burger and Montevecchi 1975, Hurd et al. 1979, Gibbons et al. 2001, Feinberg and Burke 2003, Szerlag and McRobert 2006, Crawford et al. 2014). While these actions likely are beneficial to local populations, the large distribution of terrapins and their wide dispersal capabilities require consideration of population impacts at a regional scale (Poiani et al. 2000, Spivey 1993, Sheridan et al. 2010). To offset the effect of disturbed habitat, habitat restoration or reserve creation must also be implemented at a much larger size than the disturbed patch (Poiani et al. 2000), a goal that may only be feasible at larger scales. Management across state boundaries is needed to effectively implement and regulate policies, particularly for neighboring states whose coastlines and waters are likely shared by terrapin populations.

While terrapins are not federally listed, significant observed mortality from threats summarized above combined with limited information on population dynamics have prompted conservation attention and proposals for protective regulations. Terrapins are currently listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna & Flora (CITES), following a 2013 proposal to afford the species protection from illegal harvest and trade (CITES 2013) (see *Commercial Harvest* Section). In 2011, the International Union for Conservation of Nature and Natural Resources (IUCN) recommended amending the terrapin status from near threatened to vulnerable. Terrapins are however, State-listed in MA (Threatened), RI (Endangered), and CT (Special Concern), but are considered a SGCN in all states in the NE from MA to VA (Table 1). Terrapins are also considered to be a game species in NY, NJ, and DE and still subject to harvest (Table 1). In NJ, terrapins are listed as a game species; however, there has been a moratorium on a commercial harvest during the open season of 2015 and 2016 (see *Administrative Order* - *http://www.nj.gov/dep/docs/ao2016-02.pdf*). Currently, there is a bill (A-2949) that would designate the terrapin as a nongame indigenous species subject to the same laws, rules, and regulations governing other nongame indigenous reptiles in NJ. On April 7, 2016 the bill was approved 71-0 and now awaits further consideration by the NJ Senate (see the news release for further information).

Below are the current legal status and/or conservation status of terrapins from MA to VA.

**Table 1. Terrapin status in the Northeast**

| | CURRENT LEGAL and/or CONSERVATION STATUS |
|---|---|
| **Massachusetts** | State listed as Threatened,<br>SWAP* species of greatest conservation need |
| **Rhode Island** | State listed as Endangered,<br>SWAP* species of greatest conservation need |
| **Connecticut** | State listed as species of special concern (2015),<br>SWAP* species of greatest conservation need |
| **New York** | Protected game species. SWAP*species of greatest conservation need |
| **New Jersey** | Commercial marine species. SWAP* species of greatest conservation need |
| **Delaware** | Protected game species. SWAP* species of greatest conservation need |
| **Maryland** | SWAP* species of greatest conservation need |
| **Virginia** | SWAP* species of greatest conservation need |

*SWAP= STATE WILDLIFE ACTION PLAN

## DOCUMENTED TERRAPIN OCCURRENCE IN THE NORTHEAST

The CWFNJ collaborated with 40 partners including federal and state agencies, NGOs conservation groups, researchers and academia, and other stakeholders across the NE and Mid-Atlantic U.S. to gather terrapin occurrence data (see Appendix A for a full list of contributors). An occurrence is defined as the confirmed sighting of a terrapin nesting, crossing a road, or in the water. Additional sources of occurrence data were pulled from peer-reviewed journals and other reports for a total of 60 sources that contributed to the NE regional terrapin occurrence data set and GIS layer (Appendix A). These data represent terrapins within the NE Region of MA, RI, CT, NY, NJ, DE, MD, and VA and are consistent with the known range of the Northern diamondback terrapin, spanning from Cape Cod, MA south to the VA coastline (Figure 1). It should be noted that terrapins may be present in areas outside of the documented occurrence, but are not currently studied or managed. Descriptions of terrapin occurrence are provided below for each individual state in areas where terrapins occur and are managed (varying degrees). These are likely not the only areas where terrapins occur within the NE.

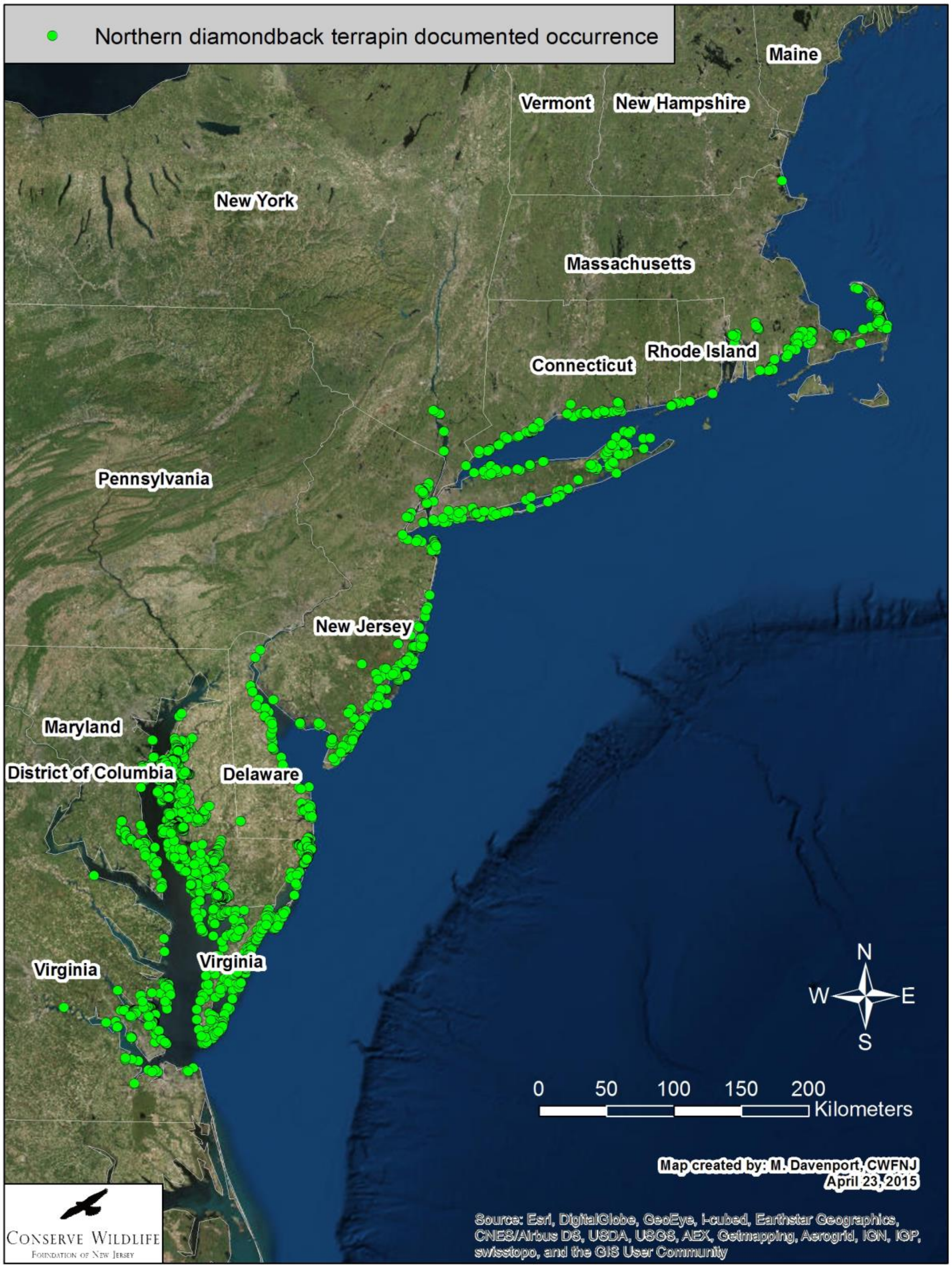



**Figure 1. Documented terrapin occurrence in the Northeast.**

## Massachusetts

Massachusetts has approximately 67,163 acres of tidal marsh habitat (The Nature Conservancy [TNC] n.d.). Terrapin occurrence has been documented in Barnstable, Plymouth and Bristol counties in MA (Figure 2) with documented concentrations in Cape Cod Bay (Wellfleet, Eastham, Orleans, Sandy Neck/Barnstable), Buzzards Bay (Wareham, Bourne, Marion, Dartmouth, Westport) and Tauton River. Comprehensive research in MA has occurred for the last 35 years on terrapin occurrence and local level threats by Don Lewis and Sue Wieber Nourse (Cape Cod Consultants). They provided much of the following information on terrapins in MA. Terrapins are managed by several organizations and researchers including the federal Cape Cod National Seashore, Massachusetts Audubon, Cape Cod Consultants, Wheaton College (B. Brennessel), Sandy Neck Beach Park, among others.

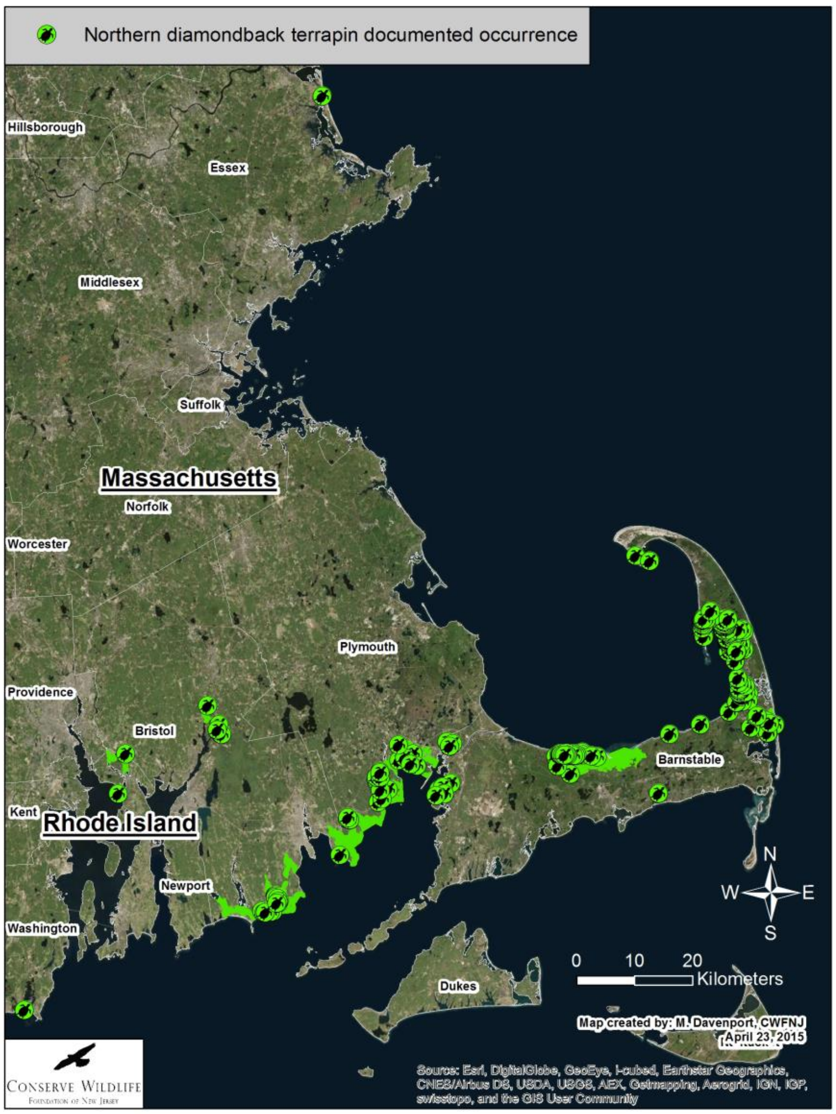



**Figure 2. Documented terrapin occurrence in Massachusetts.**

***Cape Cod Bay***

Cape Cod Bay is a large bay, measuring 604 square miles (mi) from Marsh to Provincetown, MA. It is enclosed by Cape Cod to the south and east, and Plymouth County, MA to the west and has 559 mi of coastline (MA Executive Office of Energy and Environmental Affairs 2016a). Cape Cod Bay populations (bay and oceanside) have escaped some of the heaviest human development pressures on the mainland side of the Cape Cod Canal until recent decades. The size of Cape Cod Bay female terrapins is at least 15% smaller than other populations of MA (D. Lewis pers. comm. 2015). Terrapins can be found on Cape Cod Bay in Wellfleet Bay (principally Wellfleet, North Eastham) - Wellfleet (Cape Cod National Seashore) North Eastham, Wellfleet/Eastham Border (North) Eastham, Eastham/Orleans Border, Orleans and Chatham (primarily oceanside), Orleans/Brewster Border, Brewster (bayside) within the following estuaries/sites: Barnstable Wellfleet Bay - Herring River (Griffin & Great Islands), Great Beach Marshes, Duck Creek, Chipman's Cove, Indian Neck (Fox Island Wildlife Management Area), Blackfish Creek, Lieutenant Island, Loagy Bay, Fresh Brook Run, Wellfleet Bay Wildlife Sanctuary (WBWS), Hatches Creek, Sunken Meadow; *Pleasant Bay (principally oceanside Orleans, Chatham)* - Henson's Cove, Arey's Pond, Henson's Cove, Frostfish Cove, Lucy Pond, Pochet Island, Nauset Beach, Sampson, Island, Hog Island; Cape Cod Bay Inner Elbow (Bayside Brewster-Orleans-Eastham) – First Encounter Marsh (Herring River), Boat Meadow Creek, Rock Harbor, Little Namskaket Creek, Namskaket Creek; and Barnstable Harbor (Barnstable).

Nesting occurs along the entire coastline of Wellfleet Bay. Nesting in Barnstable Harbor occurs in dunes all along the south-facing coastline of Sandy Neck, the full expanse, yet it also occurs in any sandy spot, dirt road or driveway on the south-side, north-facing coastline where no obstacles exist. The same is true throughout the Buzzards Bay estuaries (D. Lewis pers. comm. 2015).

***Buzzards Bay***

Buzzards Bay is a moderately large estuary located in southeastern MA between the western-most portion of Cape Cod and the Narragansett Bay in RI (MA Executive Office of Energy and Environmental Affairs 2016b). The coastline of Buzzards Bay (including Westport) stretch over 350 mi including the outer coast and harbor and estuary coastlines, and the bay facing coasts of the Elizabeth Islands (Buzzards Bay National Estuary Program 2016). Buzzards Bay contains 5,000 acres of salt marsh, 10,500 acres of eelgrass beds, and 5,000 acres of tidal flats (MA Executive Office of Energy and Environmental Affairs 2016b). Coastal areas, especially on the mainland side of Buzzards Bay, have been under human pressure (development) since the 17th century resulting in loss of nesting habitat (D. Lewis pers. comm. 2015). Coastal development and hardening coastlines have destroyed much of the nesting habitat and degraded most of the salt marsh nurseries. Harvesting of terrapins and crab bycatch has also contributed to depressed populations (D. Lewis pers. comm. 2015). Compared to Cape Cod Bay, mainland populations are very small and the numbers of terrapins in many estuaries are very low and these terrapins may be close to extirpation or have populations that have already been extirpated (D. Lewis pers. comm. 2015). Minimal population mixing among upper Buzzards Bay populations/estuaries has been documented (D. Lewis pers. comm. 2015). In Buzzards Bay, terrapins can be found in Onset (Wareham), Wareham, Bourne, Bourne (Cape Cod side of Buzzards Bay), Poccaset & Cataumet (Cape Cod side of Buzzards Bay), Wareham-Marion Border, Marion, Marion-Mattapoisett Border, Mattapoissett, Fairhaven, New Bedford, Dartmouth, Dartmouth/Westport Border, and Westport within the following estuaries/sites: Buttermilk Bay/Little Buttermilk Bay, Onset Bay, Coves and Broad Marsh, Bourne Cove, Indian Neck, Phinneys Harbor & Monument Beach, & Tobys Island, Pocasset Harbor, Red Brook Harbor, Megansett Harbor, Wing Island, Wareham River & Tributaries, Marks Cove, Cromeset Neck, Weweantic & Sippican Rivers, Sippican Harbor, Coves & Creeks, Aucoot Cove, Mattapoisett Harbor & River, Nasketucket Bay & West Island, Acushnet River, New Bedford Harbor, Apponagansett Bay, Slocum's River & Tributaries, Allen’s Pond and Westport River.

### *Tauton River*

The Taunton River, the first Heritage River in MA, starts in Bridgewater before ending at Mount Hope Bay, which is part of Narragansett Bay, RI (MA Executive Office of Energy and Environmental Affairs 2016c). In Tauton River there has been significantly pressure by human development and loss of nesting habitat.  This population is likely very low and may be close to extirpation (D. Lewis pers. comm. 2015). Terrapins can be found in Freetown & Berkley and Dighton within the estuaries/sites of Assonet Bay & Wescott Island.

## Rhode Island

Rhode Island has approximately 8,583 acres of tidal marsh habitat (TNC n.d.). Terrapin occurrence has been documented in Bristol, Kent and Washington counties in RI (Figure 3), with the largest concentration/population in Nockum Hill/Hundred Acre Cove at the Doug Rayner Wildlife Sanctuary in Barrington, RI, which is managed by the Barrington Land Conservation Trust (BLCT) (Sornborger 2015). The terrapin population in Barrington is considered the last stronghold population for RI (Brennessel 2006). However, with recent documented terrapin concentrations found in the Palmer River estuary (Sornborger 2015), which, like Hundred Acre Cove, empties into the Barrington River before heading to Narragansett Bay, previously unknown terrapin occurrences are being revealed. Additionally, newly identified sites in Greenwich Bay (N. Karraker, University of RI [URI], pers. comm. 2014), along with terrapin occurrences scattered along the south shore of RI, have been documented by the work of URI researchers (Schwartz 2013). Contributors of the data for RI include members of the RI Natural History Survey’s (RINHS) RI Diamondback Terrapin Project. RINHS also serves as the repository for terrapin data in the state.

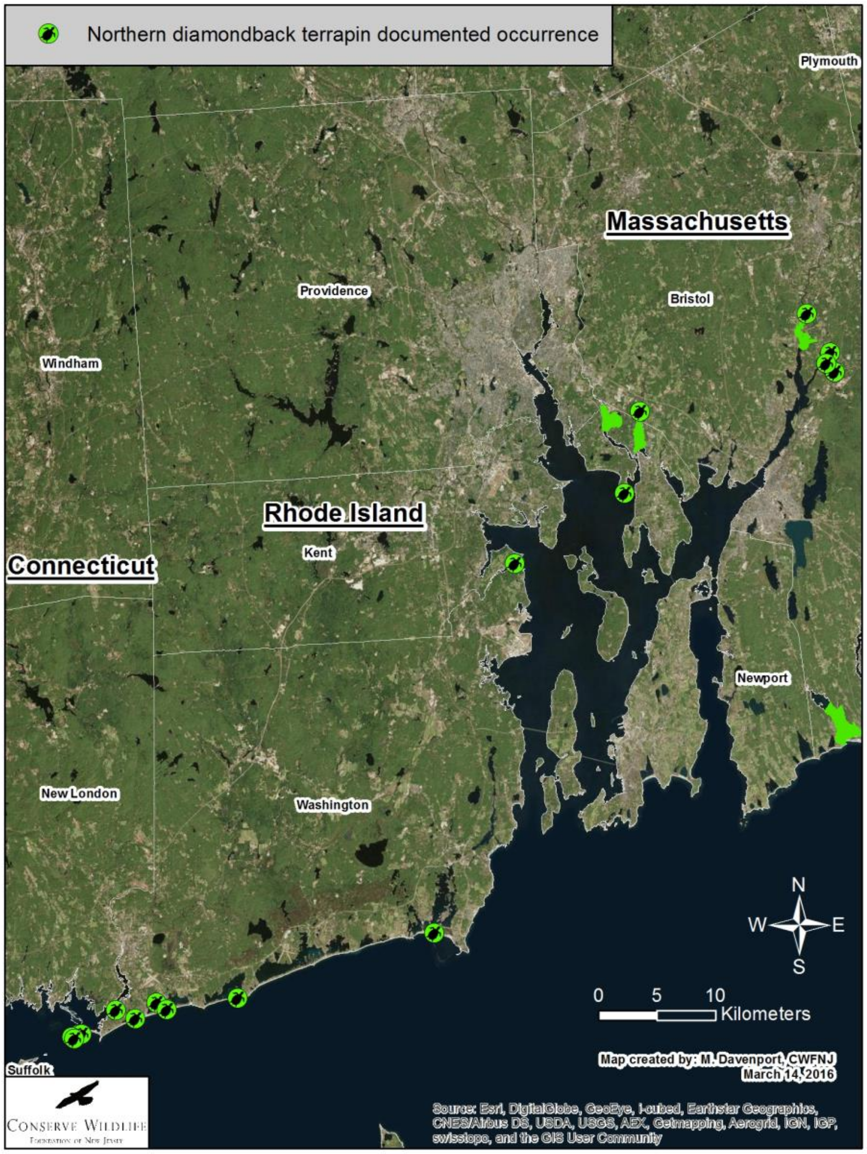



**Figure 3. Documented terrapin occurrence in Rhode Island.**

### *Doug Rayner Wildlife Sanctuary at Nockum Hill, Hundred Acre Cove*

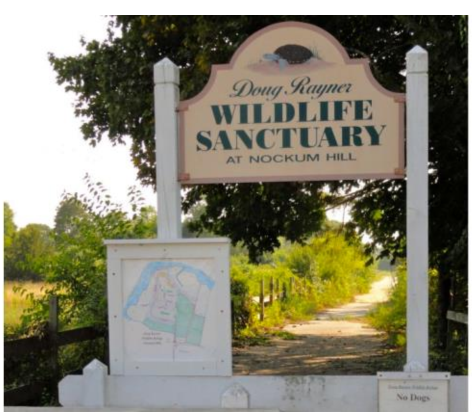



**Figure 4. Doug Rayner Wildlife Sanctuary.**

Doug Rayner Wildlife Sanctuary is a 75-acre protected area on a salt marsh/upland peninsula extending into the Barrington River and Hundred Acre Cove estuary (Sornborger et al. 1994). Terrapins have been well studied in this area since at least 1990 (Bush and Auger 1990; Sornborger et al. 1994, Sornborger 2015). Terrapins inhabit Hundred Acre Cove and nest at Nockum Hill (McClelland 2008). The majority of nesting at Nockum Hill occurs in several well-known sandy areas and/or areas with less than 50% vegetation, including sandpit one, the rear field, the point, and the meadow (Goodwin 1994; Williamson 2011). For a list of terrapin studies at Nockum Hill, see here.

### *RI South Shore*

A small number of terrapin occurrences on RI's south shore were documented by a project led by URI researchers, including: Winnapaug Pond, Napatree Point, Little Maschaug Pond, Succotash Salt Marsh at Pt. Judith Pond, and Pawcatuck River Estuary (Schwartz 2013).

### *Other Occurrences in RI*

In 2015, a second relatively significant nesting site (potentially 25-30 nests per year) was found at Rocky Hill School in Greenwich Bay — an offshoot of Narragansett Bay (N. Karraker pers. comm. 2014). Other locations of terrapin sightings throughout RI include Colt State Park (Bristol, RI, with the western border of the park open to the Narragansett Bay), Coggeshall Cove on the northwest section of Prudence Island in Narragansett Bay, and several confirmed reports of hatchling and adult terrapins sighted swimming in Greenwich Bay and Narragansett Bay proper (M. Schwartz, URI, pers. comm. 2016).

## Connecticut

Connecticut has over 85% of the tidal marshes in the Long Island Sound, approximately 18,000 acres in CT alone (Holst et al. 2003, TNC n.d.). Terrapin occurrence has been documented in Washington, New London, Middlesex, New Haven, and Fairfield Counties in CT (Figure 4). Terrapins can be found along much of CT shorelines, but greater numbers of terrapins can be found in the salt marsh habitat to the west of the Connecticut River (Connecticut Department of Energy and Environmental Protection [CT DEEP 2015]). There are few organizations actively managing terrapins in CT. The CT Department of Energy and Environmental Protection's (DEEP) Wildlife Division monitored the species at several locations in the 1990s and continues to coordinate research efforts for terrapins. SoundWaters, a non-profit educational organization for Long Island Sound, focuses on monitoring terrapins, protecting nests, and providing outreach and education. The sites they have monitored include Cove Island Park (Stamford, CT), Holly Pond (Fairfield County), and in Norwalk, CT near the NRG Energy Plant and Village Creek neighborhood (Selditch 2011). Some studies have been conducted by Connecticut Universities including: CT College (New London, CT) and the University of New Haven (West Haven, CT) (Whitelaw and Zajac 2002), and Fairfield University (Fairfield, CT) (Gauthier et al. 2000).

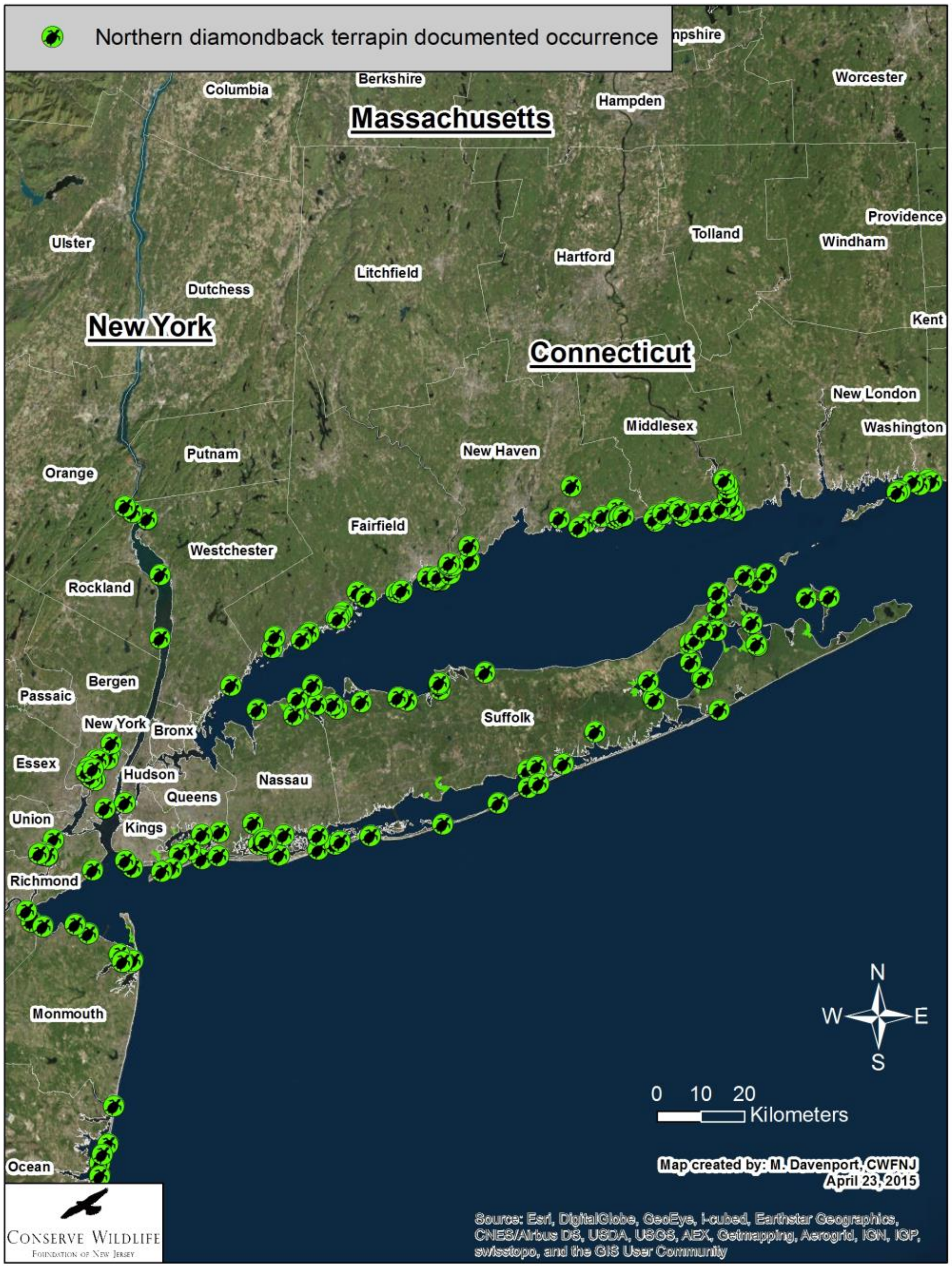



**Figure 4. Documented terrapin occurrence in Connecticut and New York.**

## New York

New York potentially has 2,181 km of terrapin habitat, more than any other state in the NE, and may encompass 36% of total terrapin habitat between Cape Cod (MA) and the Delaware River (NJ) (Browne et al. 2015). It is estimated that NY has approximately 49,268 acres of tidal marsh habitat (TNC n.d.). Terrapins only occur around Long Island, the lower Hudson River (north to

Piermont Marsh), and the Hudson River Bight (Burke 2006, NYSDEC 2014 as cited in Browne et al. 2015) (Figure 5). Terrapin occurrence has been documented in Suffolk, Nassau, Queens, Kings, Hudson, and Westchester counties (Figure 4). Terrapins are found in small numbers on Long Island in North Fork and South Fork, Oyster Bay, Mt. Sinai Harbor, South Oyster Bay near Fire Island, Peconic Bay near Riverhead, Shirley, Captree Basin, Huntington and Nesconset rivers, Cold Spring Harbor (Brennessel 2006). Terrapins occur at John F. Kennedy International Airport (JFK Airport), while very few terrapins have been observed at LaGuardia Airport (Flushing Bay, Queens, NY) as well (L. Francoeur, Port Authority of NY & NJ, pers. comm. 2014).


**Figure 5. Overview of tidal marshlands that provide potential terrapin habitat in New York. Used with permission, Browne et al. 2015. Terrapins are known to occur in Jamaica Bay, Oyster Bay, Mount Sinai Harbor, Hempstead South Oyster Bay, Peconic Bay, and the Hudson River. There are records from the 1990's of some incidental sighting on Staten Island and Moriches Bay.**

### *Jamaica Bay/Jamaica Bay Wildlife Refuge*

The Jamaica Bay Wildlife Refuge (JBWR) is over 9,000 acres of estuarine wildlife refuge located at the southwestern corner of Long Island in the boroughs of Queens and Brooklyn. The JBWR consists of one large island, Ruler's Bar Hassock (1,285 acres), several smaller islands, and much of the coastline of Jamaica Bay (Kanonik and Burke 2011). The JBWR is part of federal Gateway National Recreation Area (GNRA), managed by the National Park Service (NPS), which also includes the GNRA in NJ (Sandy Hook Unit). Hofstra University (Dr. Russell Burke) and the Jamaica Bay Terrapin Research Project have extensively managed terrapins on Ruler's Bar Hassock since 1998 as well as some aspects of the terrapin management at the JFK Airport. The Ruler's Bar population is estimated to be 1,200 nesting females, while the JFK Airport is suspected to be larger (R. Burke, Hofstra University, pers. comm. 2015). There has been a decline in the number of terrapin nests at Ruler's Bar from a high of 2,040 nests to 1,032 nests per year (1999-present) (Burke and Francoeur 2014).

The main threats to the Jamaica Bay populations are salt marsh loss and nest predation (R. Burke pers. comm. 2015). Raccoons predate about 92% of terrapin nests on Jamaica Bay (Feinberg and Burke 2003).


**Figure 6. Terrapin on a runway at the JFK Airport.**

***John F. Kennedy International Airport***

The JFK Airport is located within Jamaica Bay and is built on about 5,000 acres of former salt marsh. The airport runway ends at JoCo Marsh, the largest and healthiest salt marsh island remaining in Jamaica Bay (Burke and Francoeur 2014). Terrapins are managed by the Port Authority of NY & NJ (L. Francoeur, Port Authority of NY & NJ, pers. comm. 2014). Nesting data has been collected since 2009 although there are reports of terrapins being killed on the runways since at least the year 2000. Biologists monitor nesting activity, tag terrapins and install corrugated plastic tubing to keep terrapins off the runway (Figure 6). They have tagged 2,426 at this site to date (Burke and Francoeur 2014).

***Oyster Bay/Oyster Bay National Wildlife Refuge***

The Oyster Bay NWR, part of the federal Long Island NWR Complex, on the north shore of Long Island, is considered to have one of the largest populations of terrapins on Long Island. Terrapins are common at Oyster Bay, particularly in the Frost Creek and Mill Neck Creek sections (USFWS 2013). At Long Island University – C.W. Post, Dr. Matt Draud, formally managed terrapins in Oyster Bay (Mill Neck Creek, Centre Island Beach, Gun Club Beach) in addition others outside the NWR including West Meadow Beach, Flanders, and Mt. Sinai Harbor (Suffolk County).

Predation is an issue in some parts of Oyster Bay. There is a high mortality rate on hatchlings by the Norway rat (Draud et al. 2004).

***West Meadow Beach/West Meadows Wetlands Reserve***

West Meadow Beach/West Meadow Wetlands Reserve is a one-mile stretch of beach with 100 acres of nearby tidal salt marshes and wetlands, along West Meadow Creek on Smithtown Bay in Stonybrook, NY (Suffolk County) (GEI 2013). Friends of Flax Pond manage terrapins in this area. In the past, terrapin monitoring was conducted at both West Meadow Beach and Flax Pond (north of West Meadow Beach in Brookhaven); however, no terrapins have been observed nesting at Flax Pond since 2008 (surveyed 2009-2011 and none were observed, no surveys conducted in 2012- 2014) (N. Grant, Friends of Flax Pond, pers. comm. 2015).

### *Middle Bay/Oceanside Marine Nature Study Area*

The Oceanside Marine Nature Study Area consists of a 52-acre salt marsh bordered on the south by Middle Bay, on the west by Bedell Creek, on the east by unnamed tidal waters and on the north by residential development. The Town of Hempstead, through its Department of Conservation and Waterways, developed this Marine Nature Study Area. Terrapins are managed by the Town of Hempstead (Conservation Biologist M. Farina). Nest predation by raccoons occurs at this site (M. Farina, Town of Hempstead, pers. comm. 2014).

### *Turtle Rescue Group of the Hamptons*

Although the Turtle Rescue Group of the Hamptons (Long Island, NY) does not manage terrapins in their natural environment, they are worth noting as they receive many injured terrapins each year from a variety of threats including; an unknown mass die off in Peconic Bay, (approximately 76 terrapins in 2015), human abduction, human disturbance, dog attacks, road strikes, boat strikes, entanglement in fishing line, predator attacks, nest disturbance from dock construction (52 hatchlings in 2013 from one dock) and some unknown causes (K. Testa Turtle Rescue Group of the Hamptons, pers. comm. 2015).

## New Jersey

New Jersey has approximately 228,298 acres of tidal marsh habitat (TNC n.d.). Terrapins occur in all coastal counties with estuarine habitat in NJ (Figure 5), from Delaware Bay, the Atlantic Coast, the tidal marshes of Raritan Bay, Newark Bay north to the lower Hackensack River, Bergen County (Figure 7); however, the degree to which these areas are populated is largely unknown, with the exception of some long-term study sites in New Jersey such as in southern Cape May County by The Wetlands Institute (TWI) and North Sedge Island in Barnegat Bay by The Marine Academy of Technology and Environmental Science (MATES) (Wnek 2014).

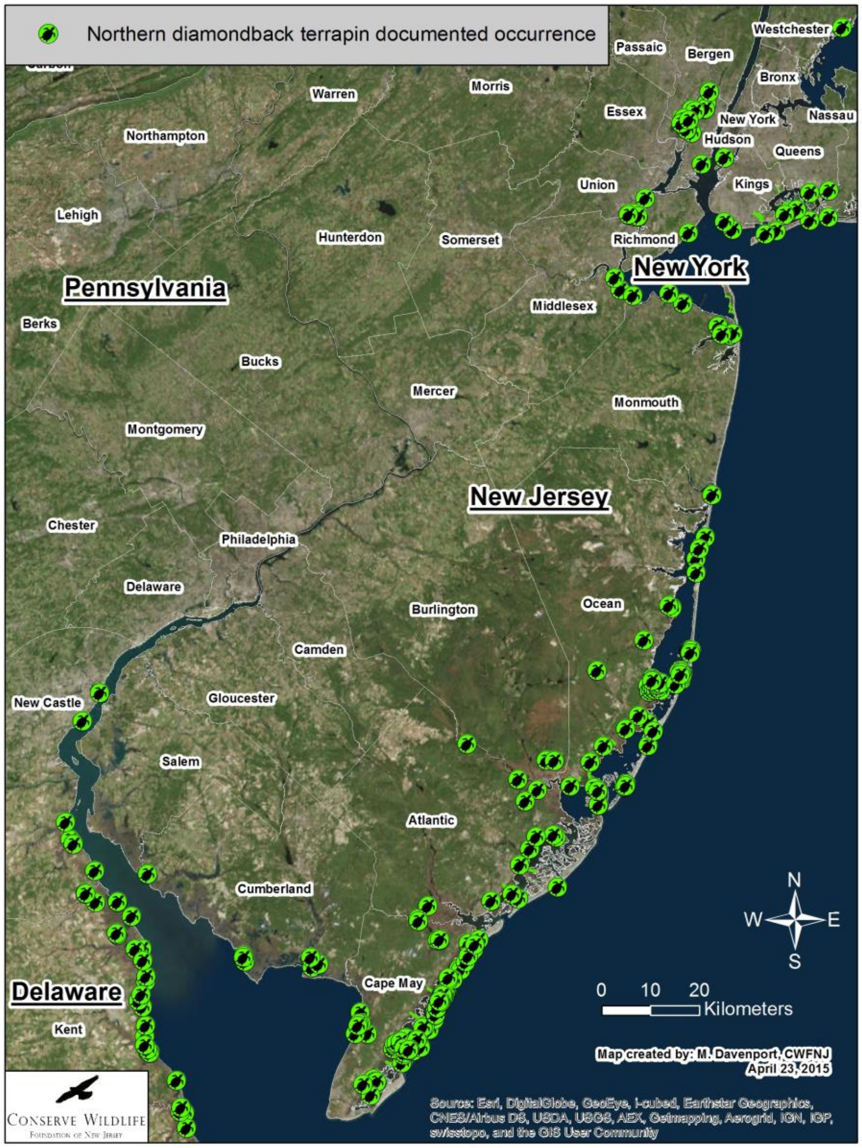



**Figure 7. Documented terrapin occurrence in New Jersey.**

### *Hackensack Meadowlands*

The Hackensack Meadowlands are located in northeastern NJ, approximately seven miles west of Manhattan, NY, and five miles north of Newark, NJ, in Bergen and Hudson counties (USFWS 2015a). The Hackensack Meadowlands are in the lower Hackensack River drainage that flows into the northern end of Newark Bay. The 8,400-acre wetland area is the largest remaining brackish wetland complex in the NY - NJ Harbor Estuary (USFWS 2015a). Terrapins have been observed in the Sawmill Creek Wildlife Management Area, Harrier Meadow, Dekate Park, Anderson Creek Marsh, Laurel Hill Park, Fish Creek, Mill Creek Marsh, mouth of Mill Creek, and Barge Club Marina. Since 2009, the NJ Sports & Exposition Authority (formerly the NJ

Meadowlands Commission) has been working with TWI and Montclair University in order to determine population size and other information about terrapin life history in this area. From 2009-2013, 1,250 terrapins were captured; 1,024 were new captures and 209 were re-captures (B. Bragin, NJ Sports & Exposition Authority, pers. comm. 2016).

***Sandy Hook Unit - Gateway National Recreation Area***

The Sandy Hook Unit (SHU) is the NJ portion the federal GNRA. The SHU is a 1,700 acre peninsula extending north into Raritan Bay, Sandy Hook Bay, and Lower NY Bay (Ner and Burke 2005). Terrapins have been documented nesting on the Raritan Bay side of SHU at the only areas that are not rip rapped - Battery Kingman, Battery Mills, the Critical Zone, Holly Forest (Spermaceti Cove), Skeleton Hill Island, Plum Island, and two sandy spit areas (Ner and Burke 2005, J. McArthur-Heuser, NPS SHU, pers. comm. 2016). Through a year-round use closure to recreational activities at Spermaceti Cove, as well as for the salt marsh and tidal creeks at Horseshoe Cove, terrapins are passively managed as protection occurs for bayside species in addition to any predator management that occurs through the SHU's Integrated Predator Management Plan for beach nesting birds (NPS 2007). Turtle crossing signs are also used throughout the SHU (J. McArthur-Heuser pers. comm. 2016).

***Barnegat Bay Complex***

The Barnegat Bay complex is compromised of open water and tidal wetlands of Little Egg Harbor, Manahawkin Bay, and Barnegat Bay in Ocean County, NJ. It lies between the barrier islands of Island Beach and Long Beach Island and the mainland from Point Pleasant south to Little Egg Harbor (70 miles) (USFWS 2015b). The total terrapin population in Barnegat Bay is not known; however, terrapins have been studied along the mainland and barrier island coasts in salt marsh habitats from the federal Edwin B. Forsythe NWR (Forsythe NWR), Barnegat Division north to Cattus Island Park on the Silver Bay in Toms River. As a result of mark and recapture studies conducted by Drexel University (Pennsylvania) and MATES over 5,300 individual terrapins have been marked since 2005 (J. Wnek, MATES unpublished data). The population along the southern end of Island Beach State Park is estimated at approximately 439 +/- 23 nesting female terrapins (North Sedge Island) and 1,518 +/- 200 of all terrapin captured (Spizzle Creek) and (Wnek 2014). Extensive management of terrapins occurs in this complex (North Sedge Island, Spizzle Creek and other areas) by MATES under Project Terrapin.  A volunteer group, Terrapin Nesting Project, also manages nesting terrapins on Long Beach Island and runs a hatchery (a place where terrapin eggs from another location are transported in and then incubated until they hatch). These areas are usually protected from predators and other disturbances.

***Mullica River/Great Bay Estuary***

The Mullica River/Great Bay estuary is a large and fairly pristine estuary complex in southern NJ in Ocean and Atlantic counties, 87 miles south of New York City and 10 miles north of Atlantic City, NJ (USFWS 2015c). There are approximately 22,000 acres of salt marsh in this system.

Most of the salt marsh to the east of the Garden State Parkway is within the Forsythe NWR, Great Bay Wildlife Management Area (GBWMA) and Great Bay Natural Area (managed by the NJ Division of Fish and Wildlife [NJDFW]), or Mystic Island (owned by NJ Natural Lands Trust) and others. The lower Mullica River and Great Bay fall within the Jacques Cousteau National Estuarine Research Reserve (JCNERR) (managed by NJDFW and Rutgers University). Terrapins are found within both Great Bay and Mullica River (USFWS 2015c). Terrapins are managed by CWFNJ in this area, specifically on Great Bay Boulevard, a five-mile salt marsh access road through the GBWMA. CWFNJ monitors nesting activity and road mortality on Great Bay Boulevard. CWFNJ also patrol roads when possible on Cedar Run Dock Rd. West Creek Dock Rd., Parkertown Dr., and Green St. (between Tuckerton and Stafford Township, Ocean County) (CWFNJ 2015).

***Southern New Jersey – Cape May Peninsula***

The Cape May Peninsula is the southern tip of NJ between the NY Bight and DE Bay within Cape May County. It is comprised of marine, estuarine, wetland, and upland habitats; barrier beaches and back barrier lagoon systems on the Atlantic side, and beaches and marshes on the Delaware Bay shore. In total, the Peninsula has approximately 69,000 acres of salt marsh habitat (USFWS 2015d). The Wetlands Institute in Stone Harbor, NJ has been managing terrapins in Cape May County for over 25 years inclusive of road patrols, installation of barrier fencing to reduce road mortality, head-starting terrapins, an extensive education program, retrieval of derelict crab pots, and other efforts. They have documented thousands of terrapins killed by vehicles in along a 38-mile transect from Stone Harbor to Strathmere on three causeways and roads along two barrier islands (Seven-Mile Island and Sea Isle). The Wetlands Institute also works with partners who document road mortality in Wildwood, and manage roads (fencing) in Ocean City, NJ. From 2000-2015, 7,992 adult female terrapins were killed, averaging about 500 per year. Another organization, The Margate Terrapin Rescue Project, also manages terrapins in southern NJ, specifically on Margate Boulevard Causeway (Atlantic County). From 2009-2015, 453 adult females road mortality were documented on the boulevard with an average of 76 adult female terrapins killed per season (B. Dougherty, Margate Terrapin Rescue Project, pers. comm. 2014 and Lull 2014).

## Delaware

Delaware has approximately 85,398 acres of tidal marsh habitat (TNC n.d.). There are approximately 13,600 acres of tidal salt marsh (mostly fringing [smaller] marshes) in the DE Inland Bays (Tiner 2001), with some extensive back-barrier marshes in Rehoboth Bay (Strange 2008). Terrapins are seen regularly along most of the DE Bayshore and inland bay beaches as well as tidal creeks. Terrapin occurrence has been documented in all three counties in DE - New Castle, Kent, and Sussex counties (Figure 8). Upper DE beaches that were previously surveyed to assess predation and human disturbance on terrapins include Collins Beach in New Castle County and Bowers Beach, Kitts Hummock, Port Mahon, Woodland Beach, and Pickering Beach in Kent County (Lester and Suss 2014). Other bayfront beaches in New Castle County from Smyrna River north to the C & D Canal (including Blackbird Creek, Peach House Ditch, Liston Pt. and Cedar Swamp) were previously assessed in 2006 to document terrapins nesting activity (or presence/absence) and the extent of *Phragmites* cover on the beach (R. Meadows, DE Department of Natural Resources and Environmental Control [DE DNREC] pers. comm. 2014). However, most of the terrapin data for DE has been reported during other projects, road crossings, a nesting habitat creation study and other observations.

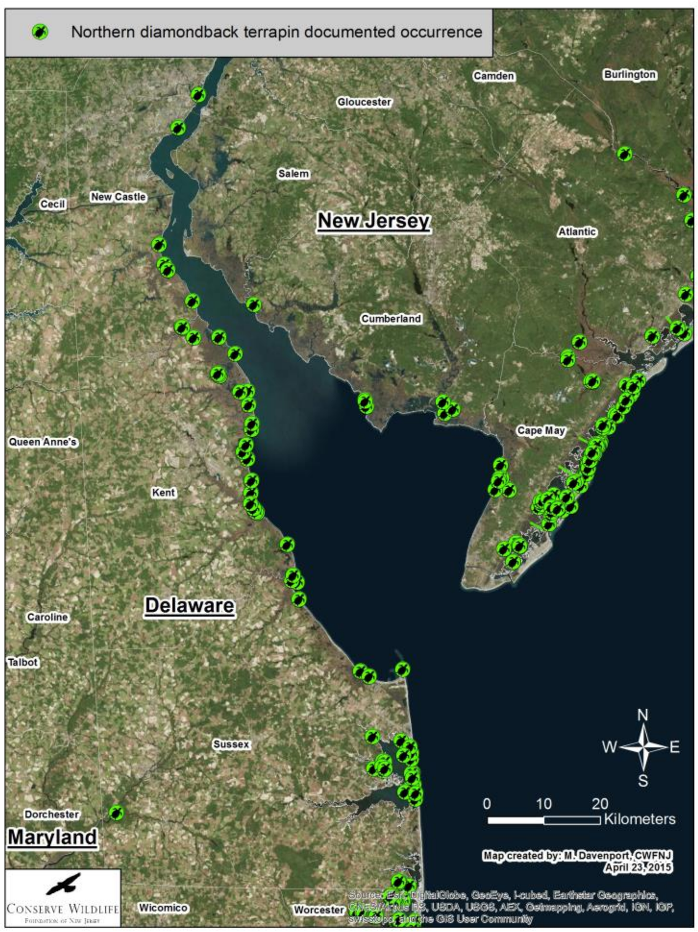



**Figure 8. Documented terrapin occurrence in Delaware.**

The DE DNREC addressed high mortality on Route 1 Coastal Highway, a 4-lane 55 mph highway through DE Seashore State Park, and added snow fencing in high roadkill areas. In an effort to provide nesting habitat on the bayside of the road, DE DNREC and the DE Department of Transportation (DelDOT) created two new nesting sites. The Center for the Inland Bays (CIB) – Terrapin Education and Rescue Program (TERP) previously assisted DE DNREC for terrapins mainly for monitoring on or around Route 1 Coastal Highway from Dewey Beach to Bethany Beach, and other areas in DE. The DE DNREC also took part in habitat restoration with controlled burn of previously sprayed stand of *Phragmites to* restore and improve terrapin habitat in 2007 (R. Meadows pers. comm. 2014). Threats to terrapins in DE include predation and human related activities (boating, vehicles, hardened shorelines with riprap) by limiting recruitment and causing injury and death (Lester and Suss 2014). The DE DNRC Fisheries staff conducted a study that resulted in requiring TEDs for recreational crab pots (Cole and Helser 2001). The DNREC and DelDOT addressed an issue with large riprap trapping terrapins as they tried to return to the DE Bay. Turtle tunnels are being installed in the riprap along with sand berms to guide the turtles to the tunnels (H. Niederriter, DE Division of Fish and Wildlife, pers. comm. 2016).

**Maryland**

Maryland has approximately 245,840 acres of tidal marsh habitat (TNC n.d.). In the northern bays there are approximately 2,500 acres of salt marsh, while the MD's coastal bays have 16,000 acres of salt marsh, generally along the mainland shorelines of Sinepuxent, Newport, and Chincoteague bays (Bleil et al. 2005). Terrapins are prevalent throughout the Chesapeake Bay and the Eastern Shore of MD. Terrapin occurrence has been documented on the western shores of MD in Anne Arundel, Prince George's, Calvert, Charles, and St. Mary's Counties. On the Eastern Shore, terrapins occur in Queen Anne's, Talbot, Dorchester, Wicomico, Somerset, and Worcester counties (Figure 9).

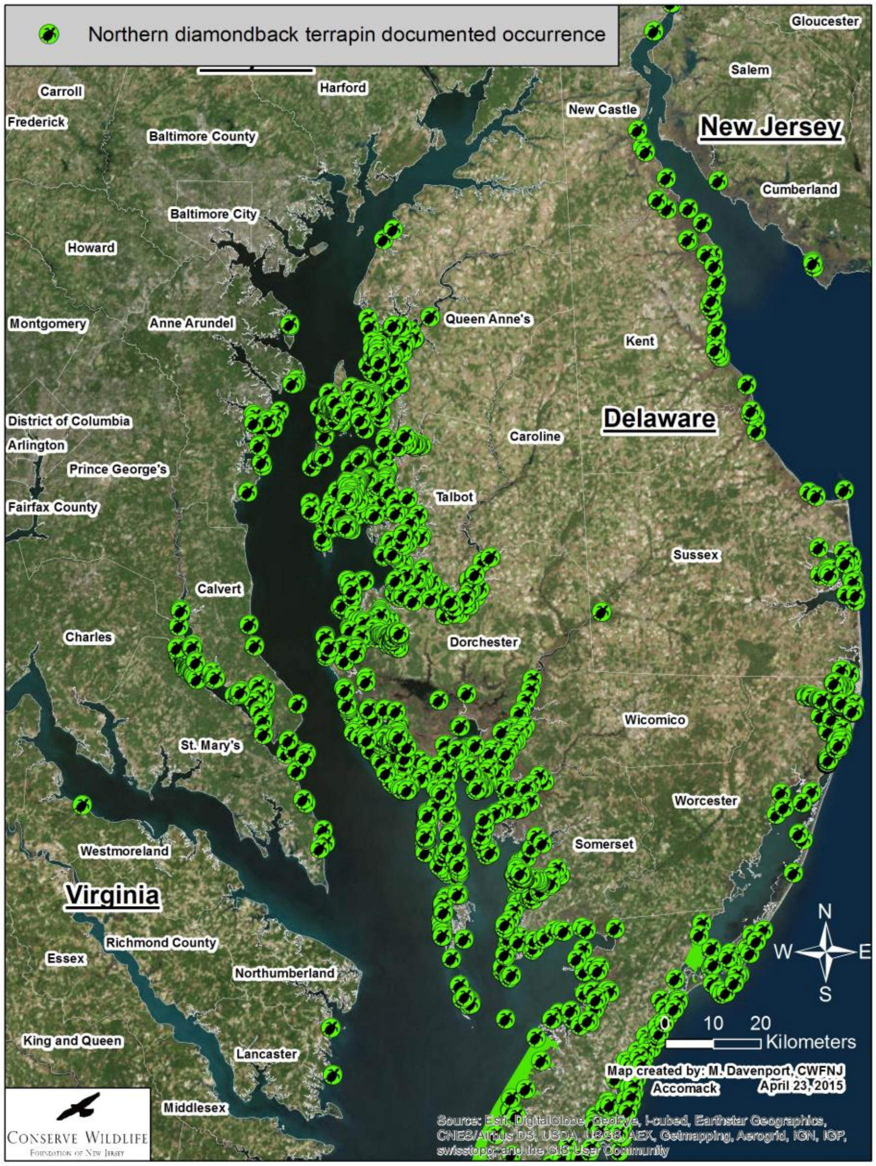



**Figure 9. Documented terrapin occurrence in Maryland.**

### *Patuxent River*

The Patuxent River is a major tributary to the Chesapeake Bay. The river originates in Frederick County and then flows to the bay through seven other counties: Howard, Montgomery, Prince George's, Anne Arundel, Charles, Calvert, and St. Mary's counties (Montgomery County Department of Environmental Protection 2016). In 1980, the Patuxent River Watershed Act was created to protect the river and establish the Patuxent River Commission (PRC). The PRC is responsible for monitoring and implementing the Patuxent River Policy Plan (2015) which provides a regulatory framework, but also actions to preserve and restore the river, and outreach to raise awareness of the importance of the river (PRC 2015). Dr. Willem Roosenburg has studied terrapins on the Patuxent River since at least 1987 with 33,000 captures of more than 10,000 individuals (mostly adult) from 1987-2009 (Roosenburg 2016). However, predation here is high by raccoon and fox. Other threats to this population including past commercial harvesting, mortality from fishing gear, and pollution have led to a decrease in recruitment and a dramatic decline in the population (Roosenburg 2016).

***Poplar Island***

Poplar Island, located in mid-Chesapeake Bay in Talbot County, has become a national model of environmental restoration in which dredged material was used to restore an island that was on the brink of disappearing from the landscape (MD Environmental Service 2016). The island was reduced to about 5 acres by 1993, but through ongoing restoration, the island will be restored to 1,715 acres around 2016 with uplands and intertidal wetlands. The Poplar Island Environmental Restoration Project is lead by the U.S Army Corps of Engineers (USACOE) (MD Environmental Science Service 2016). Terrapins began nesting on the restored island by 2001 (Roosenburg et al. 2014). Dr. Willem Roosenburg has been monitoring terrapins here since at least 2002 and has been provided the opportunity to study the "missing years for terrapins." Nest survival and hatching success is high as there is an absence of raccoon and fox on the island (Roosenburg 2016). Overall nest survivorship has been found to be greater on Poplar Island than the mainland sites due to the absence of these predators (Roosenburg et al. 2014). Dr. Roosenburg has been able to mark large numbers of hatchlings with the goal of generating accurate survival estimates. There is an extensive headstart program with terrapins from Popular Island for MD K-12 students to observe and study throughout the year (Roosenburg 2016).

***Various Locations throughout the Eastern Shore and the Chesapeake Bay – Maryland Department of Natural Resources Head Count Surveys***

The Maryland Department of Natural Resources [MD DNR] with partners from the MD DTWG (including the MD Coastal Bay Program) has conducted terrapin head count surveys since 2011. Data from this survey is inputted into the Maryland Amphibian & Reptile Atlas. Over the last four years, MD Coastal Bays Program has assisted in conducting the annual extensive survey program (land and boat surveys) for citizen scientists to create a source of terrapin occurrence to aide researchers in conservation of this species. Through the headcount survey terrapins have been document throughout the Chesapeake Bay - Chester River, Prospect Bay, Eastern Bay, Poplar Island and on the Eastern Shore - Assawoman Bay, Montego Bay, St. Martin River, Isle of Wight Bay, Sinepuxent Bay, and Chincoteague Bay (Figure 10).

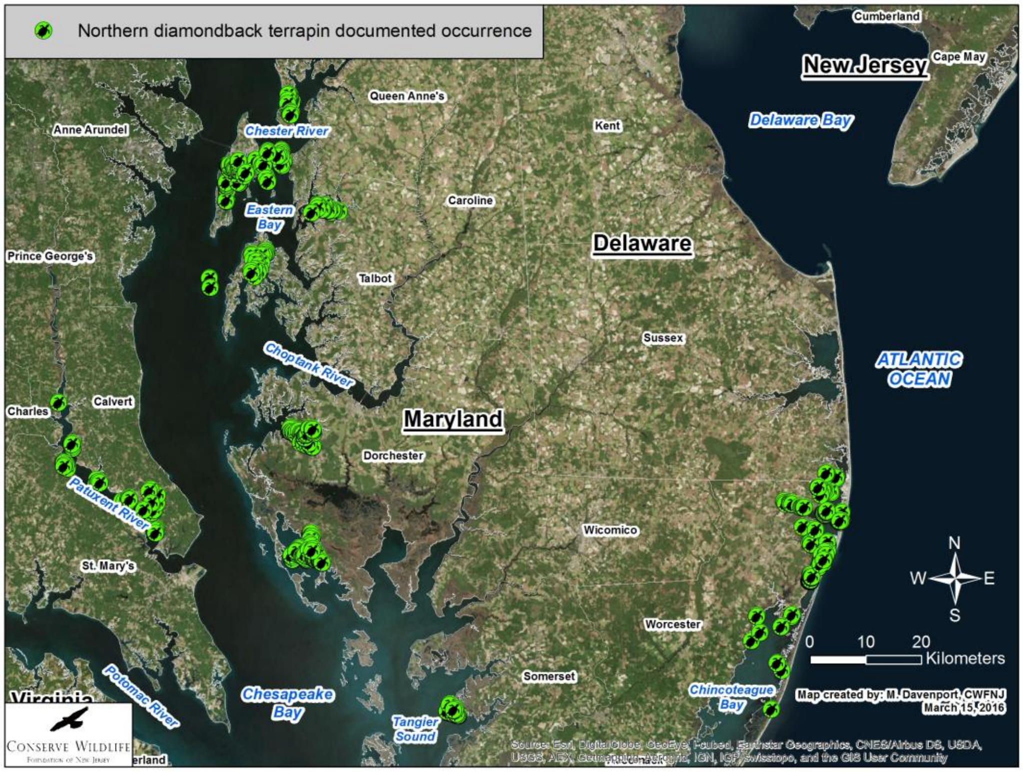



**Figure 10. MD DNR headcount survey locations (2011-2014).**

Specific sites for the headcount surveys include (in no particular order): Assawoman Bay 116th St., Broome's Island-Patuxent, Buzzard's Island – Patuxent, Chester River - Eastern Neck, Cox Creek, Eagle Harbor-Patuxent, Hell Hook Marsh, Herring Creek, Isle of Wight Bay, Jack's Bay – Patuxent, NoName Creek, North Assawoman Bay, Shipping Creek, Snug Harbor, Warehouse Creek, Washington Creek, Worlds End Creek, Worlds End Creek-Dads, Worlds End Creek-Uncle Bills, Wroten Island-Charles Creek, Wroten Island-North Cove, Wroten Island-North Point, Wroten Island-NW Cove, Wroten Island-East Side Channel, Wye East River, Bishopville Prong, Charles Creek Mid, Charles Creek North, Grey's Creek, Holiday Inn Bay, Kirwan Creek, Latcham Creek, Manklin Creek, Moccasin Point, Muddy Creek, Parks Neck South, Parks Neck/Charles Creek, Prospect Bay, Sinepuxent Wetlands, Crab Alley, Fishing Creek/Church Creek, Goodhand Creek, Marlin Farms, Marshall's Creek, Marshy Creek, Muddy Creek, Piney Creek Rum Point, Harris Creek, Hellen Creek, St. Leonard Creek, Rt. 90 Bridge, Sinepuxent Bay-Snug Harbor South, Sinepuxent Bay-Snug Harbor North, Chincoteague Bay, Isle of Wight Bay – A, Isle of Wight Bay – B, and Thompson Creek.

### *Summary of the U.S. Geological Survey Research on Terrapin in the Chesapeake Bay, 2002-2006*

In 2002-2006, the U.S. Geological Survey (USGS) Patuxent Wildlife Research Center conducted a series of research studies on the terrapin in the MD Chesapeake Bay. To document information on harvesting techniques and population structure of terrapins overwintering as groups within hibernacula in the Bay, in 2002-2005, USGS conducted winter sampling at seven sites in the MD upper and lower eastern shore and in the western shores: St Jerome Creek, Smith Island, MD (north and south), Janes Island, South Marsh Island, Bloodsworth Island, and Nanticoke River (Haramis et al. 2011). In June-August 2002, USGS conducted shoreline surveys for the presence/absence of terrapin-related activities, primarily focusing on potential nesting habitats. A GPS location for any signs of terrapin recent or current activity were recorded at over 1300 stopovers, geographically ranging from north of the Bay Bridge (Worton Creek) to Cedar Island Wildlife Management Area in Tangiers Sound on the eastern shore and from the mouth of the Patapsco River (Bodkin Point) to Point Look Out at the mouth of the Potomac River; all the marsh islands within the bay and tidal rivers and creeks. Each "nesting" site was georeferenced and data was recorded in terms of shoreline structures (e.g., rip rap), proximity to marsh, housing developments, roads, agricultural field forest, etc.), and environmental conditions (http://www.pwrc.usgs.gov/terrapin/). In 2003, USGS selected 68 of the sites visited in 2002, to obtain an estimate of true presence/absence recorded in 2002 using multiple visits, and assess aspect, slope and relative cover for each site. In 2003-2005, applying trapping and data sampling methods developed for Dr. Roosenburg's long term population study conducted on the Patuxent River, USGS set up two additional sites, Eastern Neck National Wildlife Refuge and Glenn Martin National Wildlife Refuge to conduct a three-year mark recapture study. In addition to the modified fyke nets previously used we designed a trap that could be placed within the shallow waters of the marsh complex (Henry et al. 2016). For all studies, shells and tissues were collected and submitted for genetic analyses (Hart et al. 2014, Converse et al. 2015). Support for the fieldwork was provided as result of special appeal by the State of MD and the MD Congressional Delegation (2002) and the USGS (2002-2006).

***Other Occurrences in the Chesapeake Bay***

In Balls Creek, Harris Creek, and the Choptank River (Neavitte, MD), research has been conducted since 2009 by The Terrapin Institute and has since tagged approximately 114 terrapins, 76 of which have been recaptured in the subsequent seasons. The focus of The Terrapin Institute's management includes preserving nesting habitat, documenting habitat use, and behavioral observation of adults and hatchlings.

**Virginia**

Virginia has approximately 204,148 acres of tidal marsh habitat (TNC n.d.). Terrapin occurrence has been documented in Accomack and Northampton counties, which together comprise the Eastern Shore of VA. More specifically, terrapins have been documented throughout the barrier island-seaside lagoon system located along the seaward fringe of the lower Delmarva Peninsula as well as in in the lower eastern half of the Chesapeake Bay (Figure 11).

Terrapins have also been observed along the western shores of the Chesapeake Bay and up several major river systems that drain into the Bay. Occurrences have been documented in Northumberland, Matthews, Gloucester, King William, York, James City, Charles City, Surry and

Isle of Wight counties as well as in the cities of Newport News, Hampton, Poquoson, Suffolk, Portsmouth and Virginia Beach (Figure 11).

Currently there are no known sites in VA that are managed specifically for terrapins. However, predator management and area closures implemented for the benefit of beach nesting birds on the barrier islands and a few western shore sites provide considerable incidental protection for terrapins. Effective July 1, 2016, new license fees for recreational crab pots will be instituted that provide a monetary incentive to deploy pots with bycatch reduction devices (BRD). The annual license fee to deploy a maximum of 10 recreational pots with BRD will be $36.00 and $46.00 without BRD (R. Boettcher, Virginia Department of Game and Inland Fisheries [VDGIF], pers. comm. 2016).

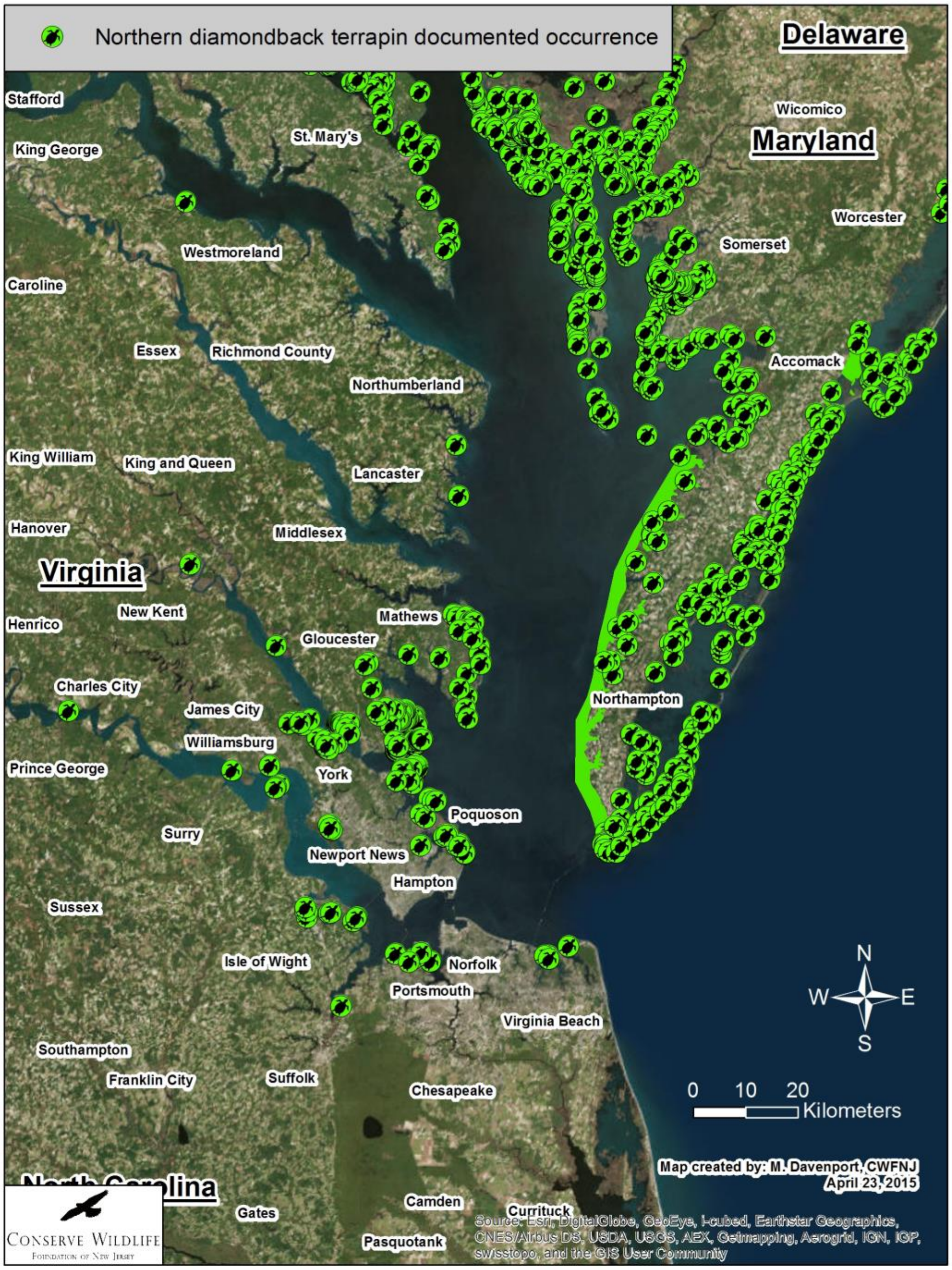



**Figure 11. Documented terrapin occurrence in Virginia.**

## *Eastern Shore*

Terrapins have been documented throughout the salt marshes, creeks and coastal bays eastward of the lower Delmarva Peninsula and have been observed nesting on all the barrier islands. The majority of the barrier islands and seaside marshes and coastal bays are undeveloped and protected in perpetuity. As such, the level of human disturbance and other anthropogenic threats to terrapin foraging and nesting habitat, nesting females, nests and hatchlings are far less than in other regions of the terrapin's range. Moreover, there are management measures in place for beach-nesting and migratory waterbirds, which also benefit terrapins including, predator management, area closures, and other policies that minimize human disturbance (refer to the American Oystercatcher Working Group - inventory of predator management programs along the Atlantic Coast).

The Nature Conservancy Virginia Coast Reserve (TNC VCR) owns and manages the majority of VA's barrier islands. Most are open to the public and allow low-impact, non-commercial recreational day use (i.e., Hog, Cobb, Myrtle, Smith, Sandy, Rogue, Godwin and Mink islands, and portions of Metompkin and Cedar islands). Pets, motorized vehicles, camping and campfires are prohibited on these islands at all times. The remaining VRC-owned islands (i.e., Parramore, Little Cobb, Ship Shoal and Revels Islands) are closed to visitor use year round for scientific research and the possible presence of live ordnance. Additional information on VCR island use policies can be found at: http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/virginia/placesweprotect/virginia-coast-reserve.xml.

The USFWS owns two barrier islands entirely (i.e., Assawoman and Fisherman islands) and partially owns Assateague, Metompkin and Cedar islands. Chincoteague NWR manages the south half of Assateague Island, all of Assawoman Island, the northernmost mile of Metompkin Island and some sections of Cedar Island. Refuge beach use policies are island-specific and can be found at http://www.fws.gov/refuge/Chincoteague/visit/beaches.html. Fisherman Island NWR, located on the south end Virginia's barrier island chain, is closed to the public year round (http://www.fws.gov/refuge/fisherman_island/).

Wallops Island, which adjoins Assawoman Island to the north, is owned and managed by NASA and is closed to the public year round. The island's oceanfront serves as a launching facility for rockets, drones, air balloons and other aerial vehicles. Because of the permanent infrastructure present on the beach, it is the only barrier island that is partially hardened and undergoes sand replenishment on an as-needed basis to protect the island's assets from severe storm events and tidal inundation.

Wreck Island Natural Area Preserve is the only barrier island owned by the Commonwealth of Virginia and is closed from April 15 – Aug. 31. Mockhorn Island Wildlife Management Area, located on south end of the seaside lagoon system is a large marsh island with some sandy shorelines used by nesting terrapins. The island is opened to the public year round and allows leashed dogs, overnight camping and campfires. Camping opportunities are confined to a very small area on the island, which largely consists of low *Spartina* marsh; thus, human disturbance is minimal. The vast majority of the remaining seaside marshes are publicly owned and managed by the Virginia Marine Resources Commission (VMRC).

Many of the eastern Chesapeake Bay islands and marshes are privately owned. Clump and Foxx Islands are owned and managed by the Chesapeake Bay Foundation. Watts Island is owned and managed by Blackwater NWR (R. Boettcher pers. comm. 2016).

There are several locations on the Eastern Shore where road mortality poses a substantial threat to terrapins. One is the Chincoteague Causeway, which bisects Chincoteague Bay marshes and waters. Road mortality monitoring was conducted along the causeway 2012 and 2013 with an average annual mortality of 90.5 terrapins (conservative estimate) on a 9 km stretch of highway (Stone et al. 2014). Currently, much of the efforts along the causeway include the capture of nesting females, nest predation, and mark-recapture/demographics (M. Stone, Kutztown University pers. comm. 2016). Fisherman NWR is another area where high road mortality was observed. Refuge staff successfully reduced the threat on Fisherman Island by installing roadside barriers made of corrugated piping along a section of highway that bisects the island.

The College of William and Mary (under the direction of Dr. Randy Chambers) works on terrapin conservation in the York and James River sub-estuaries to Chesapeake Bay and on the eastern shore of VA. Dr. Chambers and his colleagues and students are investigating the utility and efficacy of different designs of BRDs. They encourage BRD use on both recreational and commercial pots placed in marsh, seagrass and other shallow-water environments where terrapins overlap with blue crabs (*Callinectes sapidus*). They also consider the interactions among nesting female terrapins, nest predators, and the invasive grass *Phragmites australis* (common reed) that increasingly occupies terrapin nesting habitat in VA.

***Western Shore of Chesapeake Bay***

Most of the western shore of the Bay is privately owned, but there are sections owned by The Nature Conservancy and DCR (R. Boettcher pers. comm. 2016).

Terrapin research also occurs on the western shores of the Chesapeake Bay by the Virginia Institute of Marine Science (VIMS) and the College of William and Mary. In 2011, Dr. Diane Tulipani, a former researcher at VIMS, organized and conducted the first statewide, volunteer based survey for terrapin in VA, called VA TerpSearch. The goal of the survey was to record whether or not terrapins occurred in selected areas of VA's portion of Chesapeake Bay in order to be able to provide effective management of threats that contribute to terrapin mortality in VA. The survey was conducted on VA's Chesapeake Bay shoreline, from Hampton Roads and the Northern Neck, but then also on the Eastern Shore along Accomack and Northampton counties. Dr. Tulipani's previous work at VIMS focused on investigating the foraging and community ecology of terrapins, looking at Eelgrass (*Zostera marina*) seed dispersal (Tulipani and Lipcius 2014) and addressing conservation issues facing terrapins to improve protection in VA. Her study sites within the southern Chesapeake Bay, specifically the lower York River, included Catlett Islands (upriver), Goodwin Islands of the Chesapeake Bay National Estuarine Research Reserve and Green Point, Perrin Creek, Allens Island, Browns Bay in southeastern Mobjack Bay, and Felgates Creek and Poquoson in southwestern Chesapeake Bay. Dr. Tulipani is still currently working on terrapins in the York River with Rappahannock Community College.

Additional research is conducted by VIMS by several researchers on terrapins directly or threats that impact their survival such by bycatch mortality in crab pots throughout the Chesapeake Bay on the VA and MD, including Dr. Donna Bilkovic, Kory Angstadt, and Robert Isdell, all of whom have contributed to the development of this Conservation Strategy. Their work is discussed and referenced throughout this document. Tim Russell, a research scientist at the College of William and Mary also conducts terrapin and GIS studies along the Western Chesapeake Bay, in Gloucester, Mathews, and York counties.

## THREATS SUMMARY

Terrapins face a suite of anthropogenic threats across the Northeast including but not limited to habitat loss, predation, fisheries issues (i.e. overharvest, mortality in abandoned crab pots and other fishing gear), road mortality, recreational boating, and sea-level rise. The available habitat for terrapins has been severely impacted by the rapid urbanization of estuaries, which has reduced marsh habitat availability and quality (Ner and Burke 2008).

### Residential and Commercial Development (Habitat Loss)

Development along shorelines, coasts, and marshes from residential and commercial expansion has caused loss of habitat and is the number one threat to terrapin populations. Salt marsh habitat has been impacted by the filling, diking, ditching to create uplands and farmlands and in an effort control mosquitoes (Taylor 2008). The construction of roads (and other transportation related means) that block tidal flow and shoreline hardening with seawalls, riprap, and other structures have blocked inland migration of marsh habitat (Taylor 2008). There has been increased input of water and pollutants from land into the marsh and increases of invasive species such common reed (*Phragmites australis*), diminishing the suitability of the habitat (Taylor 2008). Terrapins have lost areas for breeding, feeding, resting and hibernation with the disappearance of salt marshes (Brennessel 2006). Nesting habitat can be lost or altered from shoreline armoring such bulkheading, revetment, riprap, groins and jetties in order to protect waterfront property. Nesting beaches can become eroded from hardened structures on an adjacent beach, as sediments get trapped on the up-current of those structures, erosion will increase on the down-current side (Brennessel 2006). Agriculture land use and armored shorelines can have a negative association and reduce terrapin occurrence (Isdell et al. 2015). Ultimately, a reduction in habitat availability could translate to smaller populations and isolated resources make it increasingly difficult for terrapins to find suitable nesting habitat, which can put females at a greater risk of mortality (from roads), and increases subsidized predators in the environment (Pfau and Roosenburg 2010).

Since the early 1800s approximately 39% of salt marshes have been lost throughout New England (Bromberg & Bertness 2005). Massachusetts has experienced a 41% loss in salt marsh since 1777, while RI has lost approximately 53%, or 4,000 acres, since 1832, linked to urban growth (Bromberg and Bertnes 2005). There have been a number of changes across the salt marsh landscape in Cape Cod, MA in just over 60 years including, but not limited to, reductions of high-marsh followed by the formation of mudflats and reductions of high-marsh combined with encroachment of the low-marsh. However, it should be noted that these changes are not necessarily easily explained by natural or non-natural (human-related) causes (Smith 2009). In the Narragansett Bay in RI, in a forty-year period at the end of the 20th century, 548 acres of tidal habitat were lost inclusive of 306 acres of estuarine marsh and 205 acres of non-vegetated estuarine shoreline (Tiner et al. 2004). From the 1950s to the 1990s, the Narragansett Bay Estuary experienced a net loss of 548 acres of tidal habitat. Fifty percent of the estuarine marsh was lost due to filling for upland development. In the Long Island Sound, approximately 25-35% of the tidal wetlands were eliminated by development, wetland filling and dredging. Most of these tidal wetlands are in CT and were lost because of previous insufficient tidal wetland regulation (Long Island Sound Study 1994 as cited in Holst et al. 2003). The Hackensack Meadowlands, which extends into NY and NJ, 72% was converted to transportation and communication facilities, a sports complex, land fill, industrial lands and open water (Tiner et al. 2002). Jamaica Bay (NY), although rapidly diminishing, is one of the most productive and largest ecosystems in the NE (Kirchhoff et al. 2009). Almost 65% of all the marshlands in NY have been lost since 1951, from 2,347 acres to 876 in 2003 (Kirchhoff et. al 2009). Although climate change has likely placed a role within recent years, human activities (i.e. urbanization) likely influenced NY's rapid marsh loss and continue to contribute to this loss (Kirchhoff et al. 2009). In NJ, over 71% (10,729 acres) of Barnegat Bay's shoreline has modified due to development or shoreline protection efforts. Twenty-eight percent of Barnegat Bay's salt marshes has been lost due to development (dredging and filling) and mosquito ditching and 45% has been bulkheaded. Development in the Barnegat Bay watershed increased from 18-28% from 1972-1995 (CRSSA 2016). The most recent study indicates that DE lost almost 50% more wetland acreage from 1992-2007 compared to 1982 -1992 with the primary causes of loss being residential development and conversion to agricultural lands. In total, DE has lost 54% of its wetlands since the late 1700s (DE Wetlands Status and Trends 2016). For development and agricultural purposes, 2.8 million acres of wetlands (25% of the original acreage) have been converted or drained in Maryland (MD DNR 2016). Since 1990, the Chesapeake Bay watershed has lost nearly 15,000 acres of wetland to residential and commercial development (Healy and Hsieh 2014). Forty-two acres of tidal wetlands have been lost due to permitted development between 1993 and 2003 (Duhring 2004 as cited in VIMS 2010).

**Transportation (Roads and Boats)**

***Roads***

One major contributing factor of habitat loss is development (inclusive of roadways), which increases the risk of terrapin road mortality. Road mortality is female biased and targets adult females who are nesting. The shoulders of heavily trafficked roads either intersects or are adjacent to salt marshes can often provide suitable nesting substrate, and encourage nesting if no other areas are available (Szerlag and McRobert 2006). Additionally, shoreline bulkheading may also contribute to the use of marginal habitats like roads, as terrapins are forced to find new nesting sites when bulkheads block their access to former nesting sites (Roosenburg 1994). Road mortality may even cause changes in local terrapin populations as Avissar (2006) found significantly lower average carapace size and lower frequency of adult females when comparing current data to 12 years prior in NJ. Depending on how they utilize the roads, terrapins could be more vulnerable to traffic during certain times of the day and in certain areas with higher traffic volumes. Studies have demonstrated there are greater road mortalities of reptiles and amphibians where there is a larger volume of traffic (Szerlag and McRobert 2006). Although outside of the NE, according to a study by Crawford et al. (2014), there was a 70-80% chance of a terrapin occurring on the road within a 3-hour period around the diurnal high tide and within the first 30 days of the 75-day nesting season. Over two nesting seasons, 52% of terrapins occurred on roads within the 3 hour period around high tide and 30% of terrapins were observed crossing in three hot spots that composed less than 10% of the length of the entire causeway (Crawford et al. 2014). As "hot spots" are identified and documented, specific action plans can subsequently be developed to focus higher efforts on those certain portions of wetlands needing more protection than others (Szerlag-Egger and McRobert, 2007).

Terrapin road mortality likely occurs on many coastal barrier island causeways or roads that border salt marshes throughout the NE, but goes undocumented. There are relatively few studies that evaluated the local or regional impacts of roads on terrapins. New Jersey is one of the few states in the Northeast with several organizations conducting monitoring and management of terrapin road mortality. Route 1, a four-lane highway in DE between Rehoboth and Bethany Beaches has been documented to have high terrapin mortality (Thompson 2005). Despite management from road patrols, barrier tubing/fencing, and education by conservation groups and volunteers, relatively high numbers of road mortality continue to occur.

For the last 10 years in northern NJ, the Hackensack Riverkeeper has been working with the NJ Turnpike Authority to reduce mortality on its roadways through the installation & maintenance of snow fencing along specific areas where terrapins are known to leave the water for nesting grounds. Over the last five years in Atlantic and Ocean Counties (NJ), CWFNJ and the Margate Terrapin Rescue Project have managed terrapins along some roadways. The average number killed over the last five years (2011-2015) on Great Bay Boulevard a 5-mile salt-marsh access road in Ocean County, Tuckerton, NJ has been 32.4 turtles/year (B. Wurst pers. comm. 2015). Previous studies on Great Bay Blvd found nearly 10% adult female terrapin road mortality (N = 53, and 51 terrapins, respectively) of the total terrapin occurrence that was documented (Szerlag 2006). A minimum of 400 terrapins have been killed on this stretch of road since 1999; however, it should be noted that varying degrees of monitoring have occurred on this road (and none at all in some years) so the mortality on this road is likely much higher (Hoden and Able 2003, Szerlag 2006, Szerlag and McRobert 2006, CWFNJ 2015). Other roads in Ocean County, NJ (Cedar Run, West Creek, Parkertown, Green St.) and Atlantic County (Route 30) are known roads where mortality occurs with a high of 43 females killed on Route 30 in 2014. Most of this mortality data is collected incidentally by CWFNJ and volunteers, so mortality is likely greater on these roads (B. Wurst pers. comm. 2015).

In southern NJ (Cape May County), TWI has conducted an extensive management program on terrapin road mortality for over 25 years. The Wetlands Institute has documented thousands of terrapins killed by vehicles in along a 38-mile transect from Stone Harbor to Strathmere on barrier island access causeways and roadways closest to the marsh on the barrier islands. From 2000-2015, 7,992 adult female terrapins were killed, averaging about 500 per year (TWI pers. comm. 2015). In Atlantic County, from 2009-2015, the Margate Terrapin Rescue Project has documented 453 adult female killed on Margate Boulevard Causeway with an average of 76 adult female terrapins killed per season (B. Dougherty pers. comm. 2014 and Lull 2014).

There are several locations on the Eastern Shore, VA where road mortality poses a substantial threat to terrapins. Road mortality monitoring was conducted along Chincoteague Causeway (Chincoteague Bay, VA) in 2012 and 2013 with an average annual mortality of 90.5 terrapins (conservative estimate) on a 9 km stretch of highway (Stone et al. 2014). Currently, much of the efforts along the causeway include the capture of nesting females, nest predation, and mark-recapture/demographics (M. Stone pers. comm. 2016).

Existing roads can be adapted to pose fewer threats to wildlife. Fences (or corrugated tubing) can be installed to prevent terrapins from entering the roadway. Signs can be added to alert drivers, or speed limits can be lowered. Modifying existing culverts to allow safe passageways below the roadway may be an option on some roads. Nesting habitat can be created to prevent terrapins from crossing major roadways (e.g. Old Inlet Terrapin Enhancement Project in DE). While strategies may differ by area, the main obstacle is that such actions are often costly to implement. Regular inspection and maintenance are needed for fencing (Ives-Dewey and Lewandowski 2012). However, by applying standards and protocols for new roadways, allowing for them to be designed with such aids as they are being created, it would help to alleviate the more costly option of modification after roadway completion. An example of managing for terrapins before roadways are built in the Northeast Region is a project on Sea Isle Boulevard, Sea Isle City (NJ). The barrier island causeway is being elevated to cope with sea level rise. As a result of data collected by TWI regarding terrapin nesting activity and road mortality along the causeway, permanent terrapin fencing has been incorporated into the construction plans for the roadway. The fencing will be made of metal mesh integrated into the guardrail that stretches the length of the roadway to reduce road crossings if not completely eliminate them. This is one example of terrapin occurrence/habitat use data contributing to mitigation of roadway hazards, and the incorporation of mitigation strategies into road construction projects (TWI pers. comm. 2015).

***Boats***

Mortality and injuries to terrapins from recreational boaters may have a detrimental effect on their population (Lester et al. 2013). In previous studies, 19.7% of female terrapins (227 of 1148 turtles) and 2.2% of male terrapins (16 of 669 turtles) had scars from boat propellers in the Chesapeake Bay, MD (Roosenburg 1991) and 10% of terrapins In Nockum Hill/Hundred Acre Cove, Barrington, RI (Sornborger and Rayner 1994). In more recent studies, 21% of terrapin have scars indicating boat injuries in Barnegat Bay, NJ (J. Wnek, MATES, pers. comm. 2015). This figure is similar to the injury rate for specific locations in Barnegat Bay - North Sedge Island (15%), Spizzle Creek (13%) and Edwin B. Forsythe NWR - Barnegat Division (11% N=291/2,644 turtles) that had documented injuries attributed to boats (Lester, 2012, Lester et. al. 2013). Injuries in adult females showed a significant increase over the years (2006-2011) and larger terrapins were prone to more injuries versus smaller terrapins (Lester 2012, Lester et al. 2013). Terrapins tend to stay near the surface of the water during the breeding season where the water is warmer, thus making them vulnerable to boat strikes (Roosenburg 1991, Sornborger and Rayner 1994). Additionally, terrapins do not react (i.e. change in swimming speed, depth, orientation) to boat sounds (in situ), which may explain elevated mortality and injury rates from boats (Avery and Wnek 2011, Lester et al. 2013).

Speed limits for recreational boaters (see Figure 12), partial or complete closures for terrapin and other wildlife areas to boats, and boater education are conservation actions that should be explored and implemented to reduce terrapin injury and mortality (Lester 2012).

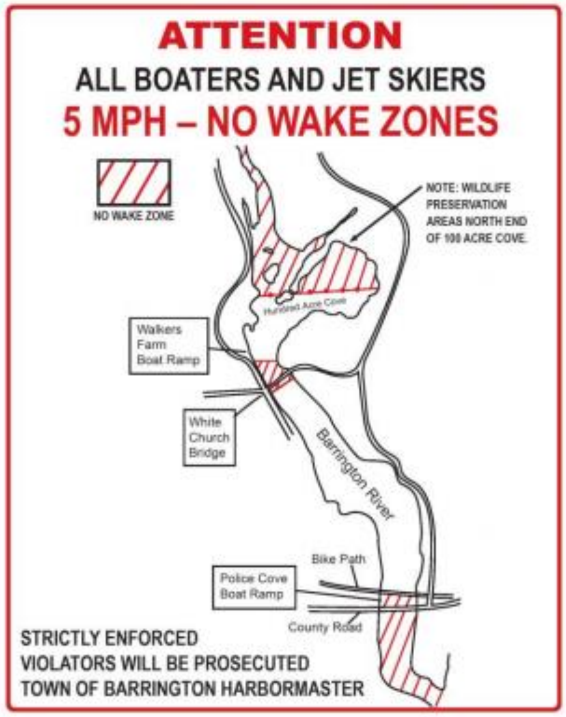



**Figure 12. Boat signs for reduced speed limit in sensitive in Barrington, Rhode Island.**

## Biological Resource Use (Fisheries Interactions)

One of the leading threats to the terrapin is through fisheries interactions, specifically as bycatch in commercial style crab pots, fyke nets, cloth funnel eel pots, and other fishing gear. Terrapin mortality in commercial style crab pots is one of the species' chief conservation concerns (Grosse et al. 2011). Commercial style crab pots are set for the blue crab fishery and for recreational purposes in many areas also inhabited by the terrapin. A recent study conducted in VA estimated that of the suitable terrapin habitat surveyed, 21% was considered vulnerable to crabbing pressures (Bilkovic et al. 2014). Terrapins are attracted to fishing bait and can become trapped in fishing gear and easily drown. Terrapins can endure periods of submergence underwater, but despite this ability, drowning occurs as survival can be dependent on water temperature, activity level and terrapin size (Baker et al. 2013). Terrapins may make quicker dives when the temperature is higher (Baker et al. 2013). In a lab controlled study, the mean voluntary dive time for males and juvenile females was 8.4 min and the maximum voluntary dive time for an adult female was 50 min (Baker et al. 2013). Terrapins may drown in 2 - 4 hours at 20° C or greater (Mann 1995; Roosenburg 2004 as cited in Baker et al. 2013). This knowledge on submergence should be considered when regulations are determined for soak time (check time) for crab pots.

Bycatch mortality estimates can vary greatly by state and on a local level (Chambers and Maerz *in press)*. Wood (1997) reported a 20% mortality rate for terrapins captured in unmodified commercial style crab pots checked twice daily. Higher mortality rates (up to 75%) were observed when pots were checked once a day (Wood 1997). Similarly, Hart and Crowder (2011) found mortality rates increased from 15% to 50% if soak times were increased from 1 to 5 days. Wood (1997) estimated that derelict terrapin crab pot mortality could range from 0.071 terrapins captured per day (t/cp/d) to 0.49 t/cp/d while Roosenburg et al. (1997) estimated 0.17 terrapins/pot/day. For the terrapin population in Patuxent River, MD, a 25% mortality rate may account for 15% of the terrapin population each year. In warmer temperatures 78% of the population may die annually if the mortality rate is 100% (Roosenburg et al. 1997). In a tidal creek in southeastern VA, 42% of terrapins were captured in just 24 days in a study demonstrating the potential impact of crab pots without BRDs (Upperman et al. 2014).

Terrapin population declines, growth, and changes in sex ratios have been directly attributed to bycatch mortality in commercial crab pots (Roosenburg et al. 1997; Wood 1997; Dorcas et al. 2007; Wolak et al. 2010; Hoyle and Gibbons 2000; Grosse et al. 2011). Modeling has shown that if 12% of adults and juvenile are removed yearly it can lead to local population declines (Hart 1999 and Ayers 2010). Commercial crab pots also disproportionately kill small terrapins, particularly males that do not outgrow the opening size limits of commercial crab pots and young females. Populations affected by crabbing may become increasingly female, as well as increasingly older with fewer young individuals surviving, due to selection pressures on smaller turtles (Dorcas et al. 2007, Grosse et al. 2011).

***Derelict Crab Pots***

Derelict crab pots (also known as “ghost” crab pots) are lost or abandoned crab pots in estuary systems that can damage sensitive areas (e.g. submerged aquatic vegetation, oyster beds) and can capture terrapins, crabs and other species as bycatch until the trap is retrieved (VIMS 2009). Organisms trapped in derelict crab pots can be affected by poor water quality, succumb to infections or disease or exposure, or die from starvation and predation (VIMS 2008). Derelict crab pots can capture and drown terrapins. It is estimated that derelict crab pots can continue fishing for an average of 1-2 years, but possibly longer as they do no degrade quickly (Arthur et al. 2014).

In the NE, the number of derelict crab pots is largely unknown. In the Chesapeake Bay (VA), estimates are as high as 30% from 368,900 crab pots set annually (Havens et al. 2008, VIMS 2008) adding another 100,000 lost pots to the bay annually (Havens et. al 2008). The NJDFW does not have a sound estimate on the number of crab pots used and/or information on derelict pots for NJ (B. Muffley, NJDFW, pers. comm. 2013). However, anecdotal evidence from local fishermen estimates that 10% of pots are lost annually in NJ (J. Rizzo, independent commercial crabber and on the New Jersey Marine Fisheries Council, pers. comm., 2013). In the Forked River (NJ), one crabber lost approximately 400 crab pots in Barnegat Bay during Superstorm Sandy in 2012 valued at $18,000, but has only recovered half of them (Sullivan et al. 2014). In 2013, over 1,500 derelict crab pots were located and 491 were recovered in a five square mile radius in a project led by Stockton University, in the Mullica River-Great Bay Estuary (NJ) (NOAA 2013 and Steve Evert, Stockton, pers. comm. 2014). They surveyed Stout's Creek south to Cedar Run (approximately 23.3 $km^2$ area) and found 344 pots with a density of approximately 40 pots/$km^2$ (Mill Creek to Cedar Run). However, the number of derelict pots may be significantly greater from Toms River to Mantoloking (Sullivan et al. 2014). Based on the survey work conducted and density of waterfront homes and marinas in the Toms River, with a conservative estimate of 20 pots/km2, it's estimated that there are approximately 500 derelict crab pots in that system alone. In Barnegat Bay (NJ), CWFNJ, MATES, Monmouth and Stockton Universities are recovering derelict crab pots during the winters of 2015/2016 and 2016/2017 from Brick to Stafford Township. Approximately 388 pots have been retrieved thus far with at least another 315 pots assessed. Scientists under this project estimate that 1,000+ derelict crab pots will be recovered under this two-year program in Barnegat Bay (S. Egger, CWFNJ, pers. comm. 2016). Stockton University will also build on previous work and will identify and remove over 1,000 derelict crab pots from ten coastal bays located from Tuckerton to Ocean City, NJ. Despite the growing problem of derelict crab pots, oftentimes, there are legal barriers preventing the removal of abandoned or derelict traps by private citizens and/or local community associations (Center for Coastal Resources Management 2008). Scientific permits and/or special permission are likely required in most cases to conduct removal programs as pots can be considered private property even after they are lost or abandoned.

Maryland has started to make strides documenting the number of waterfront property recreational crab pots that are registered for the Chesapeake Bay in order to gain a better understanding on how many pots are being fished and how many could potentially become derelict. This is done through licensing and regulation changes that came out in 2014. In 2014, there were 2,548 registrations that were completed with the greatest numbers coming from Anne Arundel (428), Saint Mary's (404), Queen's Anne (234), Calverty (206), Baltimore City (182), and Talbot (126) counties. An additional 286 registrations came from Out-of-State and less than 100 registrations from other counties for the Chesapeake Bay. The MD DNR identification number is on the pot (not individual's personal information) and not on the buoy. This is beneficial as buoys can become severed from pots and if these pots are retrieved through a program cannot be returned to the particular individual if they are in fact still intact. A high percentage of these registrations were completed on-line. The permits are issued to the address of where the individuals reside so it is possible that a percentage are crabbing outside of their county. It has been suggested through the MD DTWG 2014 meeting that this online process should include information on BRD's as compliance is low as 30% even though BRD's are required on recreational pots. This may also be a method to request information on enforcement so the effectiveness of the regulation can be measured.

Table 2. provides some estimates of the number of pots that have been identified and retrieved and some documentation of terrapins alive or dead within the pots in the NE. However, this only provides a snapshot of the number of crab pots that are actually lost within certain estuary systems, specifically the Chesapeake Bay (VA), and Great Bay and Barnegat Bays (NJ). Furthermore, the number of terrapins caught alive or dead is not a reliable indicator of the overall threat lost gear has to local terrapin populations. Terrapin shell fragments that are

broken down may be lost before a pot is retrieved (B. Atkinson pers. comm. 2015). Pots that have been pulled in these systems may not have been lost in terrapin habitat, but deeper waters where terrapins and crab pot interactions are less likely.

**Table 2. Derelict crab pot retrieval and terrapin mortality.**

| STATE/ESTUARY | SIZE OF AREA SURVEYED | NUMBER OF ABANDONED BLUE CRAB POTS IDENTIFIED (I) AND RETRIEVED (R) | NUMBER OF TERRAPIN ALIVE (L) AND DEAD (D) AS DOCUMENTED | SOURCE |
|---|---|---|---|---|
| **New Jersey / Barnegat Bay**<br><br>**Stouts Creek (north) to Cedar run (south)** | 23.2 km$^2$ | 344 pots (I)<br><br>50 pots (R) | None | Sullivan et al. 2014. Derelict crab trap identification and removal in Barnegat Bay, NJ (S1002/CE98212310). Barnegat Bay Partnership Final Report. 29 pp.<br>*Data collected in 2013 |
| **New Jersey / Barnegat Bay**<br><br>**Brick to Stafford Township** | Unavailable at current the time | 315 (I)<br><br>388 (R) | 4 (D) | S. Egger pers. comm. 2016 (CWFNJ, MATES, Monmouth and Stockton Universities)<br>*Data collected Dec 2015 – April 2016. Most pots to date were retrieved in deeper waters or directly on the marsh. |
| **New Jersey**<br><br>**Great Sound, Scotch Bonnet Creek, Jenkins Sound, Mouth of Dung Thorofare, Richardson Sound, Grassy Sound, Mulford Creek** | - | 54 (R) | 1 (L)<br><br>53 (D) | Atkinson, B and Tedesco, L. 2014. Ghost trap recovery locations and contents, 2012-2013.The Wetlands Institute, Stone Harbor, New Jersey.<br>*Data collected in 2012 and 2013<br>TWI 2014, 2015, 2016 |
| **Delaware**<br><br>**Inland Bays Estuary**<br><br>**Indian River, Rehoboth and Little Assawoman Bays** | 60 km$^2$ | @100 (R) | Accurate estimate not available, but some live and dead were observed | E. Chalabala pers. comm. 2014<br>*Data collected in 2004, 2006, 2008 and 2011 |
| **Maryland / Chesapeake Bay** | - | @5,700 (R) | - | Newsletter, Center for Coastal Research Management 2010 |
| **Virginia / Chesapeake Bay**<br><br>**(2013) Chincoteague Bay (the Virginia portion), around Tangier Island, the lower York River and the lower James River**<br><br>**(2014) Same areas as 2013 and seaside Eastern Shore and the lower Eastern Shore (Cape Charles/Oyster) areas** | - | 1,477 pots (R) | 15 (D) | K. Angstadt pers. comm. 2014<br>*Data collected from 2013 and 2014 (previous identified “hot spots” or abandoned crab pots) |
| **Virginia / Chesapeake Bay**<br><br>**Tangier Island, Seaside, Eastern Shore, York River, Upper Bay, Potomac and James River** | 1,664 km$^2$ | 31,952 pots (R) | 1 (A)<br>47 (D) | Bilkovic et al. 2014. Derelict fishing gear in Chesapeake Bay, Virginia: Spatial patterns and implications for marine fauna. Marine Pollution Bulletin. 10 pp.<br>*Data collected from 2008-2012. Individual derelict pots contained between 0 and 7 terrapin. (83%, n = 39) were from pots in shallow waters (>2 m depth) |
| **Virginia / Chesapeake Bay**<br><br>**Area of Lower York River** | 33.5 km$^2$ | 635 – 676 pots (I) | 1 (D) | Havens et al. 2008. The Effects of Derelict Blue Crab Traps on Marine Organisms in the Lower York River, Virginia. North American Journal of Fisheries Management 28: 1194–1200.<br>*Data collected in 2006. Pots retrieved during the 2008-2012 Bilkovic et al. 2014 study<br>K. Angstadt pers. comm. 2014 |
| **Virginia / Chesapeake Bay**<br><br>**Sarah’s Creek** | 0.25 km$^2$ | 252 pots (I)<br><br>75 pots (R) | None | K.Angstadt pers. comm. 2014<br>*Data collected from 2005-2009 |

Monetary loss from pots has been limited to the few available estimates of economic impact of derelict crab pots in the Northeast. Estimates of $304,000 (1% of the annual commercial blue crab landing in VA) could be lost. This is based on the calculated average annual commercial blue crab harvest of $28,600,568 from 2008 to 2012 (Virginia Marine Resources Commission 2014) and that derelict crab pots are catching 913,000 blue crabs annually in the Chesapeake Bay (VA portion) (Havens et al. 2011). There is also a direct loss in the pots themselves as they average $50 per pot. The economic loss for one fisherman in NJ could account for a loss of $1,000 - $2,000 for pots per season ($50 per pot/ 10% lost of 200-400 total pots set). Lost profit from the crabbing industry could be up to a bushel full of crab (market-sized) from a derelict crab pot per season (Havens et al. 2008).

***Crab Pot Regulations***

Regulations on crab pots from checking pots (soak time), BRD size and if and when BRD's are required, vary across the states in the NE (Table 3). Despite requirements on BRD's for crab pots, compliance can be low due in part to a lack of knowledge and enforcement. In MD, BRD compliance is less than 35% on recreational crab pots despite the fact that BRDs are required (Radzio et al. 2013). Only some states require a specific soak time – DE and NJ require a time frame within 72 hours for checking pots (Table 3). However, terrapins generally do not survive past 1-2 days in submerged crab pots. Mortality may be reduced up to 90% with a specified and implemented shorter soak (Grosse et al. 2011).

**Table 3. Current regulations for the blue crab fishery in the Northeast.**

| STATE | REQUIREMENT FOR CHECKING POTS/ SOAK TIME | BRD REQUIREMENTS | REGULATION/CODE INFORMATION |
|---|---|---|---|
| **New York** | Unknown | Required on Commercial and Recreational Pots<br><br>6 in. (w) x 2 in. (h) | *NYSDEC is proposing to require the use of terrapin excluder devices on crab traps set in NY's estuaries in the Marine District. This includes the waters the Hudson River south of the Tappan Zee Bridge.<br>http://www.dec.ny.gov/docs/fish_marine_pdf/bmrcrustaceandoc.pdf<br>http://www.dec.ny.gov/outdoor/75333.html<br><br>If the Department determines that mortality of in blue crab pots is causing a decline in the terrapin population of a given water body or area, the Department may by order mandate use of terrapin excluder devices in such areas<br><br>NY Code 6 CRR-NY 44.2NY For Blue Crabs<br>https://govt.westlaw.com/nycrr/Document/I21d8b5f6c22211ddb7c8fb397c5bd26b?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)&bhcp=1 |
| **New Jersey** | Within 72 hours | Required on Commercial and Recreational pots within 150 ft. from shoreline to shoreline at mean low water and in man made lagoons<br><br>6 in. (w) x 2 in. (h) | Recreational Regulations<br>http://www.state.nj.us/dep/fgw/pdf/non-comm_crabpot_regs.pdf<br><br>Commercial Regulations<br>http://www.njfishandwildlife.com/pdf/2016/comregs16.pdf |
| **Delaware** | Within 72 hours | Required on Recreational Pots Only<br><br>4.75 in. (w) x 1.75 in. (h) | http://www.eregulations.com/delaware/fishing/blue-crabs/<br>Recreational Summary<br>http://www.dnrec.delaware.gov/fw/Fisheries/Documents/rec%20crab%20pot%20summary.pdf<br>Commercial Code<br>http://delcode.delaware.gov/title7/c023/index.shtml |
| **Maryland** | Unknown | Required on Recreational Pots Only<br>(waterfront property owners can set within 100 yards of the shore)<br><br>4.75 in. (w) x 1.75 in. (h) | Maryland Blue Crab Regulations<br>http://dnr2.maryland.gov/fisheries/Pages/regulations/blue-crab.aspx<br><br>BRDs<br>Where to Buy<br>http://dnr2.maryland.gov/fisheries/Documents/flyer_stores.pdf |
| **Virginia** | Unknown | BRD's are not required | See VIRGINIA MARINE RESOURCES COMMISSION<br>CHAPTER 4 VAC 20-270-10 ET SEQ. v possession limits, time limits, season etc. for commercial and recreational crabbers<br>http://www.mrc.virginia.gov/regulations/fr270.shtm#40 |

### *Bycatch Reduction Devices*

Bycatch reduction devices (BRDs) were created to prevent terrapin bycatch while still allowing for the same abundance and legal size catch of crabs, eels, and other fish. If crab pots are fitted with BRDs, then adult female terrapins and some large males cannot enter the pots. These devices also referred to as TEDs, or turtle excluder devices, and have been proven to reduce bycatch of terrapins while not reducing the catch of legal blue crabs (Guillory and Prejean 1998). The most common BRD does not affect the size or number of crabs caught (Roosenburg 2004). BRDs are generally restricted to recreational pots (see Table 3) because those pots are mostly in near the shoreline in shallow areas, and in terrapin habitat. In MD, BRD compliance is less than 35% on recreational crab pots; however, BRD use in the Patuxent River increased from 26% in 2005 to 34% in 2010. This change may be a reflection of increased usage or be based on survey areas differences (Radzio et al. 2013). Despite the availability of BRDs, their use has not been mandated everywhere, and needless bycatch mortalities continue to impact terrapin populations. In NJ, MATES and TWI and likely other organizations in the region distribute for BRDs for free; however, all states could potentially distribute.

The MD DNR will continue to require BRDs on all recreations crab pots, investigate the feasibility (i.e. effects on catch; economic impact) of requiring BRDs on all crab pots set, and encourage fishermen to install BRDs on commercial crab pots (MD Fisheries Management Plan Report 2015). The NYSDEC is proposing to require the use of terrapin excluder devices on crab traps set in NY's estuaries in the Marine District. This includes the waters the Hudson River south of the Tappan Zee Bridge. Recently in VA (March 2016), an amendment was made to *VA Code 28.2-226.2. Commission to establish requirements for commercial gear licenses used for recreational purposes* where the Commission shall not issue to any licensee a recreational gear license which that exceeds the following limitations including up to 10 crab pots, with turtle excluder devices, $36; up to 10 crab pots without turtle excluder devices, $46.

### *Other Fisheries Gear*

Terrapins can be caught in eel pots, fyke nets, and other types of fishing gear as well. Cloth funnel eel pots are used for inshore American eel fisheries in MD, VA, NJ, and DE (Radzio and Roosenburg 2005). According to a study by Radzio and Roosenburg (2003), bycatch in eel pots can lead to sizeable terrapin kills and have deadly effects on local terrapin populations. Catch rates maybe be as high as high as 0.2 terrapins/eel pot/day (Roosenburg 2004). Eel fisheries uses bait favored by terrapins, which may lead to increased terrapin catch rates (Roosenburg 2004). The bycatch and subsequent drowning of terrapins in these pots occurs mainly in the spring and fall (Roosenburg 2004). Radzio and Roosenburg (2005) created a BRD created for cloth eel pots which showed no effect on eel catch, making this a feasible solution for conservationists and fishermen alike. Terrapins have been observed as bycatch in fyke nets as well, however such observations are currently anecdotal. Such observations however, have noted that terrapins can remain submerged in the nets for up to three days with cold temperatures (below 10 degrees C). Under these circumstances, the turtles have lower oxygen demands. Checking fyke nets every 2-3 days may prevent terrapin mortality during cold-water seasons (Roosenburg 2004).

***Conclusion***

Educating the public about the BRDs as well as moving to make them mandatory may help decrease terrapin bycatch and mortality. Mandating all recreational crab pots sold have BRDs already attached is a one way to increase compliance (Roosenburg 2004). Shortening and enforcing soak times in traps might also help reduce terrapin mortality, and checking traps every day to two days could dramatically improve terrapin survival. Additionally, terrapin captures have been observed to be at their highest early in the crabbing season, during mating activity and lasting for the months of early spring, but not continuing into the summer and fall months (Hart and Crowder 2011). Therefore, to greatly decrease mortality by crab pots through seasonal timing, pots could be restricted between the months of April and (Grosse et al. 2011).

**Biological Resource Use (Commercial Harvest)**

Although once a historical dish, turtle soup made from terrapins has not been in great demand in over 50 years (Brennessel 2006). However, a commercial harvest is still permitted in three states in the NE - NY, NJ, and DE (Table 4). Terrapins collected from a commercial harvest may end up in Asian markets or sold as pets (illegally). Each summer in New York City, as estimated 10,000 terrapins are sold with single terrapins sold by the pound for $20 a piece (Brennessel 2006). However, very few individuals actually apply for a legal harvest permit in NY. Only two permits were issued in 2012 and only four issued for the 2013-14 season (J. Ozard, New York State Department of Environmental Conservation, pers. comm. 2014). The recent harvest of more than 3,500 terrapins (mostly gravid females) from two marsh locations in NJ underscores the vulnerability of hibernating turtles to winter harvesting. The terrapins were taken to an out-of-state aquaculture facility that raises them for overseas markets. More than 14,000 offspring of these wild adult terrapins were then exported to Asia. As a result of this incident, a temporary moratorium was placed on a commercial harvest in NJ for the winters of 2015 and 2016 (NJ Administrative Orders 2016-02 and 2015-02). As terrapins hibernate in shallow depths of the intertidal zone, banksides, or at the bottom of the salt marsh creek (Yearicks et al. 1981 as cited in Palmer and Cordes 1988), they are immobile and in large groups so many terrapins may be harvested in a relatively short period of time (Haramis et al. 2011).

**Table 4. Terrapin harvest regulations in the Northeast.**

| STATE | PERMITTED TAKE/HARVEST | HISTORY / CHANGE IN STATUS SINCE 2000 |
|---|---|---|
| **Massachusetts** | Take prohibited | No change. State-listed prior to 2003. |
| **Rhode Island** | Take prohibited | No change. State-listed prior to 2003. |
| **Connecticut** | Take prohibited | Closed by regulation sometime in 2005. Previously permitted limited take (5/day). Connecticut Regulation 26-66-14a |
| **New York** | Commercial harvest permitted w/in specified season, size limit, no take limit, reporting required. | Currently considering closure. |
| **New Jersey** | Commercial harvest permitted w/in specified season, size limit, no take limit, no reporting. | No change since 2003; however, temporary moratorium on the harvest was applied in 2015 and 2016. |
| **Delaware** | Limited take (4/day) permitted in specified season. | Unaware of any recent or proposed changes. |
| **Maryland** | Take prohibited | Legislatively closed in ~2007-08. Chapters 117 & 118, Acts of 2007; Code Natural Resources Article, sec. 4-902). |
| **Virginia** | Commercial harvest and personal possession prohibited. | Changed to closed by regulation in 2007. Previously permitted harvest for personal possession of up to five terrapins. |

*SWAP = State Wildlife Action Plan/ For State Status Refer to Table 1.

### *CITES Terrapin Export Data*

CITES is the Convention on International Trade in Endangered Species of Wild Fauna and Flora. It is a multilateral treaty to protect endangered plants and animals. The focus of CITES is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild. CITES subjects international trade in specimens to certain controls and all import, export, re-export, and introductions must be authorized through licensing system. Terrapins qualified for inclusion in Appendix II by satisfying both Criteria A and B, as proposed at the 16th meeting of the Conference of the Parties, 3-14 March 2013, which were effective June 2013. To satisfy Criteria A, it is known, or can be inferred or projected, that the regulation of trade in a species is necessary to avoid it becoming eligible for inclusion in Appendix 1 in the near future. For Criteria B, it is known, or can be inferred or projected, that regulation of trade in the species is required to ensure that harvest of specimens from the wild is not reducing the wild population to a level at which its survival might be continued harvesting or other influence. Because of the suite of threats that currently impact terrapins, including international trade, it can be inferred that regulation of trade is necessary to avoid eligibility into Appendix I in the near future (Criterion A) and regulation of trade is required to ensure that harvest of wild specimens is not reducing populations to a level at which survival might be threatened by continued harvesting or other influences (Criterion B). The USFWS is provided with oversight responsibility for international trade (import/export) of CITES protected species. Permit approvals are based on whether or not action will be detrimental to survival of the species. Presented below are data provided by the USFWS on terrapin exports.

The U.S. Export Data of 754 shipments for *Malaclemys* terrapin 2000-2015 (Law Enforcement Management Information System [LEMIS] 2015) includes the export of 11,967 (23.70%) wild terrapins and 36,785 (72.92%) captive bred terrapins. In addition, 21,749 (43.11%) of terrapin exported were born in captivity from parents that mated in the wild and 1,704 (3.35%) terrapins originated from a ranching operation. The export of wild caught terrapins has varied over the last 15 years, but with peaks of over 4,000 individuals in 2006 and 2015 (Figure 13). Nearly 80% of these wild caught shipments were exported to Hong Kong followed by 7.7% to Taiwan (Province of China) and 5% to Japan (LEMIS 2015).

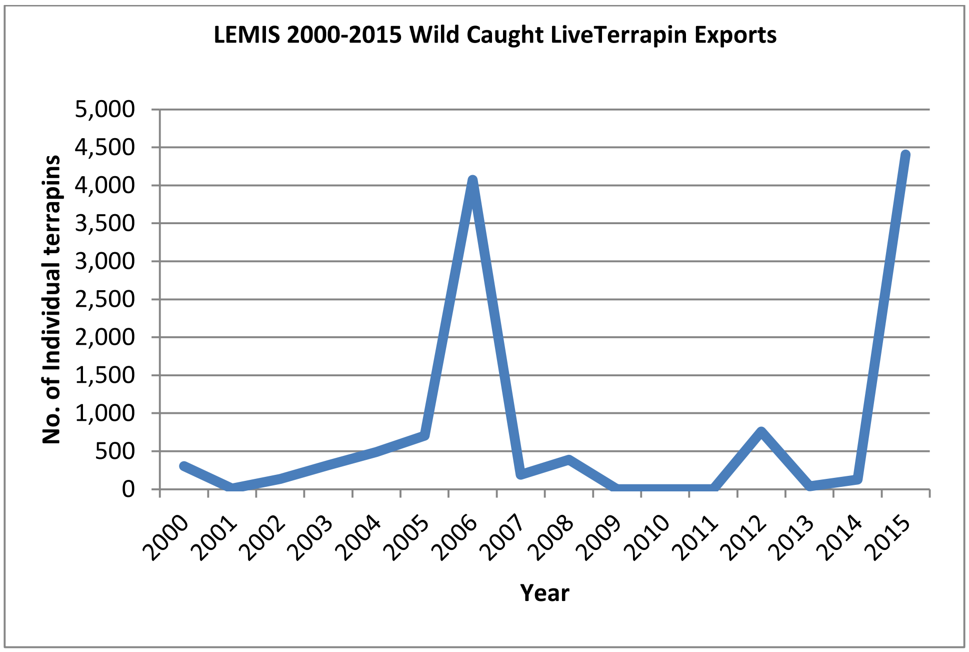



**Figure 13. Wild caught (live) terrapin exports from the United States from 2000-2015 (LEMIS 2015).**

### *Other Factors Contributing to Vulnerability to Harvest*

Significant anthropogenic sources of mortality such as road mortality and crab potting especially impact adult females and are likely additive to the mortality caused by harvest. Road mortality is female biased and targets adult females who are nesting. Over the last 25 years in southern NJ, the TWI has documented thousands of terrapins killed by vehicles (12,368 mature females, mean 495 ± 75) while searching for nesting sites along a 38-mile coastal route (TWI unpublished report 2015). Szerlag and McRobert (2006) and Szerlag (2006) found nearly 10% of adult female terrapin were killed each season along a 5 mile salt-marsh access road in NJ; while Crawford et al. (2014) found 59% and 52% terrapins struck by vehicles on a barrier island causeway (Jekyll Island Causeway, GA), even with intensive survey efforts during both studies. Commercial crab pots also disproportionately kill small terrapins, particularly males that do not outgrow the opening size limits of commercial wire crab pots and young females. This means populations affected by crabbing may become increasingly female, as well as increasingly older with fewer young individuals surviving, due to selection pressures on smaller turtles (Dorcas et al. 2007, Wolak et al. 2010, Grosse et al. 2011). Haramis et al. (2011) found in areas where commercial crabbing occurs, larger females in the pot zones vs. no pot zones; implying that smaller females were being targeted in the pot zones. Using Mitro's (2003) adult survival estimates, Ayers (2010) projected adult survival under various levels of crab potting. Females fell between 74.8% and 97.1% (Ayers 2010) and males, between 0.78.8% and 0.90.1% (Tucker et al. 2001 as cited in Ayers 2010), a decrease from adult survival calculated by Mitro (2003) at 94.4% to 95.9%.

***Modeling***

Modeling shows that population growth depends mostly on the survival of adults and juveniles rather than survival of hatchlings (Mitro 2003, Ayers 2010); therefore, elimination of egg-laying adult females in large quantities relative to their population size (e.g., by commercial harvest) can be extremely detrimental (Haramis et al. 2011). As little as a 10% decrease in adult female terrapin survival can cause a population decline, while a 33% decrease in hatchling survival can destabilize the population (Ayers 2010). Hart (1999) also found through modeling that a harvest level of 15% would reduce the population by half in just 15 years. Increased harvest level of 30% and 75% would be even more detrimental to the population, reducing it by 77% and 92%, respectively (Hart 1999). Terrapins have been found in densely populated winter aggregations of greater than a thousand, many caught within a relatively short period of time, and within the size limits for harvested females, which demonstrates the susceptibility of terrapins to large scale harvesting (Haramis et al. 2011).

Modeling conducted for snapping turtle species that have relatively similar life history parameters also supports the conclusion that terrapins are unable to sustain commercial harvesting. For common snapping turtles, females are sexually mature at 11-16 years (Congdon et al. 1994) while alligator snapping turtles have been estimated to mature at approximately 13-16 years (Reed et al. 2002). Common snapping turtles lay one clutch with a mean clutch size of 28 eggs (Congdon et al. 1994) and alligator snapping turtles lay only one clutch (Dobie 1971 as cited in Reed et al. 2002) and can range from 9-40 eggs (Powders 1978, Ewert 1976 as cited in Reed et al. 2002). Common snapping turtles have been observed to have nest survivorship of 23% (Congdon et al. 1994); whereas, alligator snapping turtle nest survivorship has been estimated at 20% (author notes this value may be higher than what was estimated) (Reed et al. 2002). Juvenile survival for common snapping turtles averaged 77% between ages 2 and 12 (Congdon et al. 1994), while alligator snapping turtle juvenile survival has been estimated at 69% for ages 1-12 (Reed et al. 2002). Adult female survival for common snapping turtles averaged 93% and for alligator snapping turtles 98% (high conservative estimate) (Congdon et al. 1994, Reed et al. 2002, respectively). Comparable to terrapins, the common snapping turtles population is more vulnerable to changes in adult or juvenile survival rather than the number of eggs produced or the survival of nests (Congdon et al. 1994). An annual harvest that increased adult mortality by 10%, over a 15-year period could reduce the adult population by 50% in less than 20 years (Congdon et al. 1994). Similar findings occur for alligator snappers, where an annual harvest of less than 2% of adult females would reduce the population by half in 50 years, and would likely result in local extirpation (Reed et al. 2002).

### *Conclusion*

Removal of adults from the population by harvest occurs within a background of adult morality from other anthropogenic sources that are much less easily controlled, i.e., crab pots and road deaths. Consequently, control of harvest-caused mortality is an important tool available to managers to curtail excessive adult mortality to which terrapin populations are extremely sensitive. Many turtle species have few alternative means to counteract the above sources of mortality, and so it is critical to recognize this with any management choices related to the commercial harvest of juveniles or adults (Crouse et al. 1987 as cited in Congdon et al. 1994). In addition, modeling exercises conducted for terrapins and other turtles concluded that there is no evidence to suggest head-starting programs can counteract the effects of adult mortality (Heppell and Crowder 1996 and Mitro 2003). Smeenk (2010) observed this in local terrapin populations in the Chesapeake Bay (MD), finding similar population declines between a head-started population and a 23-year mark/recapture population. Similar findings for common snapper turtles suggest that programs that focus on headstarting turtles or protecting nests will have little success in terms of population impacts if older juvenile and adult stages are not protected.

## Biological Resource Use (Illegal Markets and Pet Trade)

The extent to which terrapin are subject to illegal trade is unknown. Interest for the terrapin commercial harvest remains high, primarily for the pet trade and as food in Asian markets and countries (see previous section on *Commercial Harvest)* (CITES 2013). In most of the NE possession is prohibited, except for some permitted actions for propagation or small numbers of terrapins for personal possession (Table 5). The policies below are strictly presented as a summary and may be not be all-inclusive for rules and exceptions. Referring to each State’s regulations for a full outline of collection and possession policies is encouraged.

**Table 5. Terrapin collection/possession policies in the Northeast.**

| STATE | COLLECTION OR POSSESSION POLICIES/REGULATION |
|---|---|
| Massachusetts | **Possession is prohibited, except under a permitted captive propagation program.**<br>Under 321 CMR 10:00 Massachusetts Endangered Species Act10.04: Taking and Possession of Species on State and Federal Lists<br>1. Prohibitions**.** Except as otherwise provided in 321 CMR 10.04(2) and (3), no person may take, ***possess,*** *transport, export, process, sell or offer for sale, buy or offer to buy,* nor shall a common or contract carrier knowingly transport or receive for shipment, any plant or animal or part thereof on the state list or federal list; provided, however, that ownership, sale, or purchase of real property on which such plant or animal occurs is not prohibited (Exemption 2a. In Transit).<br>3c. Captive Propagation of State Listed Species.<br>Animals. The Director may permit, in accordance with provisions of M.G.L. c. 131, § 23, and 321 CMR 2.12, the artificial propagation and maintenance of animals on the state list. Such permits may be issued only after the Director approves a written propagation program prepared by the applicant.<br>http://www.mass.gov/eea/agencies/dfg/dfw/laws-regulations/cmr/321-cmr-900-exemption-list.html#9.01 |
| Rhode Island | **Possession is prohibited, except a permitted to identified institutions.**<br>***Possession*** of Native Wildlife. All native wild animals are expressly prohibited from importation or ownership without the issuance of a valid permit by the Department. The possession of native turtles is restricted to those institutions identified within Rule 7.3, and as exempted per Rule 8 of these Rules and Regulations. Turtles considered native to RI and *which possession as pets is prohibited include the terrapin.*<br>Rules and regulations governing importation and possession of wild animals (2016)<br>http://www.dem.ri.gov/pubs/regs/regs/agric/wildanml16.pdf<br>R.I. Gen. Laws Chapter 4-18, and §§ 20-1-18, 20-1-22, 20-37-3, and 42-17.1-2(19) as amended, and in accordance with the procedures set forth in the R.I. Administrative Procedures Act, R.I. Gen. Laws Chapter 42-35. |
| Connecticut | **Possession is prohibited, except under special authorization.**<br>CT General Statute 26-55 and CT Regulation 26-55-6 (b)(4) restricts importation, ***possession***, and liberation. CT Regulation 26-66-14(a) states that there is no open season for taking terrapins in any development stage. Therefore, terrapins cannot be collected or possessed in Connecticut without special authorization. |
| New York | **Possession is prohibited, except under certain conditions and a license is required to take a terrapin.**<br>NY Code 6 CRR-NY 3.1 Diamondback terrapins<br>A valid terrapin license is required to take terrapin and during the open season only.<br>***Possession*** of a terrapin on the waters or shores of New York State during the closed season is prohibited. It is prohibited take, ***possess***, purchase or sale of terrapin which has a straight-line upper shell length less than four inches or greater than seven inches and prohibited to sell May 5 to July 31. Terrapin legally taken during the open season may be sold throughout the year only if they were killed and processed for consumption prior to May 5. |
| New Jersey | **To be determined**<br>Because there is a current moratorium on the terrapin harvest, it is illegal to ***possess*** one. If it is determined that the species is placed on the non-game list than the following would apply – No person shall posses any nongame species without proper permits from the State and any other federal or local permits that may apply (see applicable sections under NJAC 7:25-4 and 7:25-4.6(a)).<br>The New Jersey Department of Health mandates that turtles and tortoises CAN NOT be sold in New Jersey - http://www.njfishandwildlife.com/pdf/pet-dealer_info.pdf |
| Delaware | **Possession is prohibited, except under certain conditions such as scientific or propagating purposes.**<br>Chapter 7, subchapter V, § 784 Terrapin raised in private ponds. Nothing contained in this subchapter shall prevent any person from raising terrapin in a private pond.<br>Chapter 150. It shall be unlawful for any person to catch, take, kill or destroy or have in his ***possession***, except for strictly scientific or propagating purposes, any terrapin from the fifteenth day of March until the fifteenth day of November following in each and every year. That it shall be unlawful for any person to catch, take, kill or destroy or have in his possession any Heifer terrapin which measures less than five and one-half inches lengthwise on the bottom shell, except for strictly scientific or propagating purposes.<br>Refer to 24 Del. Laws, c. 151, § 1; 27 Del. Laws, c. 150; Code 1915, § 2492; Code 1935, § 2972; 7 Del. C. 1953, § 784; 70 Del. Laws, c. 275, §§ 95, 96. |
| Maryland | **Possession is prohibited, except as permitted for non-commercial purposes.**<br>MD Regulation Chapters 117 & 118, Acts of 2007; Code Natural Resources Article, sec. 4-902. It is unlawful to take or ***possess*** terrapins for commercial purposes. A person may ***possess*** up to 3 terrapins for non-commercial purposes.<br>Commercial Trade – Requires a permit. A permittee may sell, offer for sale, trade, or barter any reptiles or amphibians (see specific lists) if the animals are actively produced or legally obtained from out of state. No terrapin is allowed to be taken from the wild in Maryland for commercial trading. http://dnr2.maryland.gov/wildlife/Pages/Licenses/captive.aspx |
| Virginia | **No Possession Allowed.**<br>It shall be unlawful to take, ***possess***, import, cause to be imported, export, cause to be exported, buy, sell, offer for sale or liberate within the Commonwealth any wild animal unless otherwise specifically permitted by law or regulation.<br>No ***possession*** allowed of threatened and endangered species, freshwater mussels, candy darter, eastern hellbender, diamondback terrapin, and spotted turtle.<br>http://www.dgif.virginia.gov/fishing/regulations/nongame.asp |

**Human Disturbance and Intrusion**

Thirty-nine percent of the U.S. population lives along the coastline (NOAA 2016) and there is concern that increases of human disturbance are causing population declines in terrapins. Terrapin encounter many threats from anthropogenic activities such as road mortality, recreational boating activities, drowning in crab pots, habitat loss and habitat alteration etc. all of which are discussed in great detail throughout the *THREATS SUMMARY* section. Anthropogenic activities can cause morality, injury, and limit recruitment to the population (Lester and Suss 2014). Similar findings have occurred for map turtles (*Graptemys flavimaculata*) where interruption of nesting activities may impact numbers of clutches laid and change nest site selection by female turtles (Moore and Seigel 2006). Map turtles also experience a reduction in basking time in areas with higher recreational disturbances than more natural areas (Selman et al. 2014). Human intrusion can prolong or prevent terrapins from nesting. With increased usage of the beach by people, a decrease in the number of terrapin nests and nesting females was observed (Little Beach Island, Barnegat Bay, NJ) (Burger and Garber 1995). Nest failure may occur from dogs at nesting beaches (USGS 2003) and dogs may attack terrapins (K. Testa pers. comm. 2015). At the JBWR (NY), the NPS has closed the "Terrapin Trail" or the sand trail to reduce human/terrapin encounters during the nesting season. Unfortunately, some visitors ignore this closure even though trespassing is prohibited.

**Natural System Modifications (Dredging)**

Dredging is a common "maintenance" activity in harbors and bays to provide access for boats in shallow waters (Brennessel 2006). The JBWR (NY) and nearby areas have been dredged for shipping lanes, construction of the JFK airport, as well as other land recovery (Black 1981 as cited in Feinberg and Burke 2003). Dredging can impact terrapins in several ways. Dredging operations can kill or dislodge terrapins while in hibernacula (Brennessel 2007). Contaminated dredge material can lead to terrapin nest failure and chemical pollutants including PBDEs, DDT, and others can be high enough to cause deformities in hatchlings (Avery and Wnek 2011). One hundred percent nest failure from salts and contaminants in dredge material placed at a nesting site was observed in NJ (Avery and Wnek 2011).

However, there can be benefits to using *uncontaminated* dredge material as it may provide suitable nesting habitats for terrapins (Wnek et al. 2013, TWI et al. 2010). Dredge soil improved after a year by the washout of salt and hatching success increased (Wnek et al. 2013). Clean dredge material can be used for constructing islands to create new nesting habitat with fewer mammalian predators (Wnek et al. 2013). An example of using dredge material as a conservation tool would be Poplar Island (Talbot County, Chesapeake Bay) where dredged material management resulted in the restoration of a disappearing island. Sixty-eight million cubic yards of clean dredged material was taken from Port of Baltimore's approach channels to restore the island (MD Environmental Service 2016). The terrapin population on Poplar Island has high nest survivorship, as this island has remained relatively predator free (Roosenburg et al. 2014).

**Natural System Modifications (Bulkheading and Other Hardened Shoreline Structures)**

Coastal landowners often attempt to protect their property from flooding and erosion using hardened shorelines techniques that result in obstructing terrapin access to nesting sites (Clowes 2013). Studies have shown that estuaries plagued by even 10-25% hardened shorelines can lose their quality and value (Silliman and Bertness 2004; Bilkovic et al. 2006; Bilkovic and Roggero 2008; DeLuca et al. 2008 as cited in Isdell et al. 2015). Creating structures such as bulkheading to harden the coastline can reduce or eliminate terrapin habitat (Winters 2013), cause terrapins to travel farther as they encounter shoreline barriers in search of nesting sites (Avery and Wnek 2011), and force terrapins to nest in suboptimal habitat. In some cases, terrapins travel over three to six times further to nest as they are blocked by hardened shoreline structures (Avery and Wnek 2011, Winters et al. 2015). Some terrapins that are forced to travel further show an increase in stress hormones, compared to terrapins that nested in unhindered suitable habitat (Avery and Wnek 2011). Increased terrestrial travel to find new nesting areas cause greater exertion (Winters et al. 2015) and can lead to an increase in impaired orientation and risk of predation due to exposure (Winters 2013). Barriers to nesting sites, like bulkheading and roads can also lead terrapins to use suboptimal nesting sites (Roosenburg 1994) using locations such as driveways and backyards (Winters 2013). A recent study in NJ found that on a Long Beach Island (a highly developed barrier island) 83% and 78% of terrapins nested on residential property (Moss 2015). Nearly 40% of the first population nested on shorelines classified as erodible and nearly 30% of the second population nested on erodible shorelines, with 63% nests closest to bulkheaded areas (Moss 2015). Poor environmental conditions at marginal nesting sites can reduce nest success for incubation and developing eggs, further contributing to declines in terrapin populations (Clowes 2013). Nesting areas adjacent to bulkheading may also be impacted by various anthropogenic threats. For example, in coastal developed areas there are marinas, recreational docks, and waterfront homes and other properties, which may increase recreational crabbing activities and have higher boat traffic. These pose serious threats not only to nesting terrapins, but to all terrapins living in the area (Winters 2013). Even in more protected park systems terrapin habitat can be limited by armored shorelines. At the SHU in the GNRA (NJ), terrapin nesting habitat is limited with 65% of the bayside shoreline stabilized with hard structures such as riprap and bulkheads (NPS 2007).

Some studies indicate that hardening of coastal shorelines is greatly increasing (Isdell 2014). Over the past century, Barnegat Bay, NJ has lost over 30% of its salt marsh habitat and over 45% of its shoreline now includes bulkheading, constructed of metal, vinyl, concrete or wood, in an effort to reduce shoreline erosion (BBEP 2001, CRSSA 2016). Three hundred miles of MD's coastal shoreline were hardened from 1978 – 1997, while in VA; approximately 19 miles of shoreline in VA were hardened every year from 1998 to 2000 (Healy and Hsieh 2014). It is estimated that 27% of tidal shorelines and 500 miles of VA's shorelines are hardened (VIMS 2010). Rhode Island's Narragansett Bay has approximately 25% of its shoreline hardened (Tiner et al. 2003). While bulkheading, groins, or other wall structures are used to harden the shoreline, the primary form of armoring in RI is rock revetments (Tiner et al. 2004). Much of the

CT shoreline is reinforced with hardened structures, yet there has been increased interest in maintaining a more natural shoreline while also affording protection from erosion.

Bulkheading may be replaced with "living shorelines" to maintain marsh structure and loss of natural shorelines. By using natural materials such as sand, stone, and plants in living shoreline designs, shorelines can be augmented, repaired, and protected from erosion (Bilkovic & Mitchell 2013 as cited in Isdell et al. 2015). Native *Spartina* can help stabilize the environment and encourage growth of new habitat, increasing biodiversity of the salt marsh (Clowes 2013). Living shorelines were considered a positive solution to habitat fragmentation that led to a decline in terrapin population (Isdell et al. 2015). However, any enhancement project must take into account the reason for the loss of such population (Isdell et al. 2015). Most of the NE states including CT, NJ, MD, and VA have passed regulations to require or support living shorelines project as a preferred alternative to traditional shoreline hardening practices. Any decreased shoreline hardening would be beneficial for terrapins throughout the NE.

If removal of hardened structures is not feasible, developing structures to allow terrapin access or constructing adjacent nesting habitat could be beneficial to terrapins. Ramps and other alterations along bulkheads may be a possible alternative and allow access to nesting sites without increased stress in female terrapins (Winters 2013). In areas with reduced access to nesting sites, uncontaminated dredge spoil can be used to construct islands with fewer mammalian predators (Wnek et al. 2013). An example of this used successfully is at North Sedge Island, where 50 years ago a portion of the island was formed with dredge material from Barnegat Bay, NJ. The soil has aged and is now successful for nesting diamondback terrapins (Wnek et al. 2013).

**Pollution**

Terrapins can be directly impacted by pollution from oil spills, heavy metals, and chemical agents (Brennessel 2006). Terrapins have been previously impacted by oil spills including Buzzards Bay, MA (1969, 1974, 2003, and others) (Brennessel 2006, Costa 2016); Exxon Oil Spill in the Arthur Kill, NJ (1990) (Burger 1994); Chalk Point Oil Spill in the Swanson's Creek, Chesapeake Bay, MD (2000) (Byrd et al. 2002a,b; Michel et al. 2001); among others. Oil spills can be very detrimental to terrapins by direct mortality from the oil, contamination of estuarine habitat, and death of food sources for terrapins (Burger 1994, Bouchard120 Natural Resource Trustees 2005). Following the Chalk Point Oil Spill, 122 terrapins deaths were documented as well as a decrease in reproduction (10%) in the year after the spill (Byrd et al. 2002a). However, the total injury to terrapins was calculated to be much higher and estimated as 5,244.6 lost discounted terrapin-years (loss of productivity in the following years of the spill and the morality of hatchlings the year of the spill) (Byrd et al. 2002a). Eleven terrapin females were documented as directly covered by oil, with only three surviving (Burger 1994). The terrapins that died showed lesions on their digestive tract likely from exposure to oil and oil within their tissues (Burger 1994).

Terrapins can be affected by heavy metals from the water and sediments that accumulates in their bodies. In Barnegat Bay (NJ), a study measured heavy metals selenium, arsenic, chromium, cadmium, arsenic, lead, and mercury in terrapin tissues and organs. Most of the metals were significantly greater in the liver than other tissues and could be a concern for scavengers or consumers who eat the liver (Burger 2002 as cited in Brennessel 2006). Similar results were found outside the NE where mercury was found to be greatest in the liver and a minor amount transferred to developing eggs (Green et al. 2010). Another study in Barnegat Bay found terrapins have relevant levels of organic contaminants (persistent organic pollutants [POPs]) in their tissues compared to other wildlife, with the exception of a contaminant class of emerging concern, polybrominated diphenyl ethers (PBDEs) (Basile 2010). The study found maternal transfer of POPS to developing terrapin embryos and some POPs may be associated with immune and endocrine disruption and even disruption in neurobehavioral development (Basile 2010). Polychlorinated biphenyls (PCBs) were also studied in terrapins comparing Cape May (NJ) and Jamaica Bay (NY) and found strong concentrations in the liver and maternal transfer of PCB contaminants (Ismail 2010). Contaminated dredge material can lead to terrapin nest failure and chemical pollutants including PBDEs, DDT, and others can be high enough to cause deformities in hatchlings (Avery and Wnek 2011). There was 100% nest failure from salts and contaminants in dredge material placed at a nesting site (Avery and Wnek 2011).

Both point and non-point sources pollution (chemical agents) can impact the aquatic environment. Excessive nutrient loading from agricultural run-off, urban wastewater and storm water pollution can increase nitrogen in an estuarine environment causing harmful algal blooms and may be responsible for terrapin die off events (see *Mass Die-Off* section). For example, excess nitrogen from fertilizer and waste water is the main ecological concern in the Peconic watershed (NY) (Lloyd, 2014; Total Maximum Daily Load for Nitrogen in the Peconic Estuary Program Study Area, NYSDEC 2007 and Peconic Estuary TMDL Review, USEPA, 2013 as cited in the Suffolk County Comprehensive Water Resources Management Plan 2015).This is the watershed of where a terrapin die-off event occurred in 2015.  Pollution is the most frequently identified threat to SGCN in NY; particularly industrial and military oil spills can impact terrapins (NY SWAP 2015 - [NYSDEC 2015]). Mercury is a growing concern in NY, while newer contaminants, such as micro-plastics and pharmaceuticals are identified and quantified (NY SWAP 2015 - [NYSDEC 2015]).

**Climate Change and Severe Weather**

Climate change and severe weather are threats to the NE (and globally) that will intensify other existing threats (e.g. habitat loss) and affect conservation actions over the long-term (Klopfer et al. 2012, Kane et al. 2013 as cited in VDGIF 2015). Increased sea-level rise as a result of climate change can contribute to increased shoreline erosion, flooding of low-lying coastal areas and increased wave heights during storms, all of which will impact terrapin nesting and marsh habitat. Severe changes in weather may contribute to unusual mass mortality and cold stun events in terrapins (see *Mass Die-Off* section). Sea-level rise, increased number of storms, heat waves, and greater average temperatures and changes in precipitation are already occurring in the NE (NYSDEC 2015).

The NE will experience a substantial increase in temperature by the end of the century as predicted by all available climate models. Over the last century, temperatures in the NE have risen by 0.7°C and are predicted to increase 3-5°C (NE Climate Science Center 2016, Staudinger et al. 2015). Increased precipitation is predicated to occur due to increased and intense rainfall events (Staudinger et al. 2015). Storm surges and flooding will intensify in coastal areas as a result of increased storm events (Staudinger et al. 2015). Flooding is becoming more extreme, yet droughts are also increasing (Staudinger et al. 2015). By the end of the century, the NE may experience 1.5 to 6 feet of sea-level rise within a warming ocean that is becoming more acidic (Staudinger et al. 2015).

Climate change information and guidance can be found in Integrating Climate Change into the State Wildlife Action Plans (Staudinger et al. 2015), developed by the Northeast Climate Science Center and partners, which presents trends in climate variables that are significant to coastal habitats and SGCN wildlife. Recent studies evaluate our current understanding of the vulnerabilities of wildlife and habitat to sea-level rise and climate change, the areas of scientific uncertainty, and future research recommendations to protect these resources including: *Impacts of Climate Change on Wildlife in the Northeast* (Spring 2014), *The Vulnerabilities of Northeastern Fish and Wildlife Habitat to Sea Level Rise* (National Wildlife Federation and Manomet Center for Conservation Science 2014), and in *Climate Change Impacts in the United States: The Third National Climate Assessment* (Horton et. al. 2014). These and other useful materials are being organized in the U.S. Climate Resilience Toolkit and NOAA's Digital Coast. An extensive collection of climate change resources can be also be found at Surging Seas – Sea-level rise analysis by Climate Central where many plans, actions, and resources are listed with links on a national level and for each individual state in the Northeast.

Climate Change has also been thoroughly analyzed in each of the NE SWAPs. With individual SWAPs, state-specific links for climate adaptation reports, vulnerability assessments, and climate action tools can be found. The SWAP chapters dedicated to climate change evaluate the SGNC (or their habitat) vulnerability, assessments used in each state, and the results for SGCN and their key wildlife habitats. The SWAPS may also include adaptation strategies to conserve biodiversity under projected climate change conditions.

- ***Massachusetts*** – Chapter 5 of the MA SWAP (entire chapter dedicated to climate change) (Massachusetts Division of Fisheries and Wildlife 2015).

- ***Rhode Island*** – Climate change section (3-19) within Chapter 3 of the RI SWAP (Rhode Island Department of Environmental Management 2015).

- ***Connecticut*** – Climate change section (3-22) within Chapter 3 of the CT SWAP (CT DEEP 2015).

- ***New York*** - Climate change section (page 39) within Chapter 5 of the draft NY SWAP (NYSDEC 2015).

- ***New Jersey*** - The 2015 draft SWAP is not currently available, however, NJ summarized the threat of climate change in preparation for the final NJ SWAP, *draft Climate Change Summary for the New Jersey Wildlife Action Plan* (VanLuven 2015).

- ***Delaware*** – Climate change section (3-23) within Chapter 3 of the draft DE SWAP (Delaware Department of Natural Resources and Environmental Control [DE DNREC] 2015).

- ***Maryland*** - Chapter 6 of the MD SWAP (entire chapter dedicated to climate change) (MD DNR 2016).

- ***Virginia*** – Climate change section (3-28) with Chapter 3 of the draft VA SWAP (VDGIF 2015).

**Invasive and Other Problematic Species (Invasive Plants)**

Introduced *Phragmites*, an invasive reed, can deteriorate suitable terrapin habitat (Simoes and Chambers 1999) by outcompeting and eliminating native *Spartina* grasses. Although little research has been done to quantify the direct impact from the threat of *Phragmites* on terrapins, some efforts have been made to remove this invasive reed. In Delaware, during the summer of 2006, a comprehensive survey of all bayfront beaches from Smyrna River, north to the C & D Canal was conducted to document terrapins nesting activity and presence and extent of *Phragmites* cover along the beach. Most beaches had well-established stands of *Phragmites* that extended well out beyond the high tide line. Little terrapin nesting was documented in these stands due to the dense nature of the above ground culms and below ground rhizome mat. The affected beaches were sprayed with glyphosate in the fall of 2006 and the residual culms removed by controlled burn in the winter of 2007. A nesting survey was conducted in 2013 that documented significant nest density in former *Phragmites* dominated areas of the beach, comparable to that found in unaffected beach habitat. (R. Meadows pers. comm. 2016).

Some important questions to consider regarding this threat (provided by R. Meadows DE DNREC pers. comm. 2014) include:

- Has *Phragmites* been identified as a serious threat to nesting habitat in the lower salinity areas of their various ranges in the estuary along the east coast?
- Has it been quantified (number of nesting beach habitat lost, percent of habitat lost/impaired, miles of beach shoreline impaired)?
- How many (if any) of the Northeast states have conducted comprehensive surveys (both on the ground, and with historic aerial photos, and literature searches) of all terrapin habitats in their respective state? If any assessments have been made, have the assessments been based on well-vetted data/surveys?

In other cases, a volunteer removal effort by Norwalk Land Trust was made to enhance terrapin and bird habitat on Hoyt Island, a three-acre wildlife preserve and bird sanctuary on Long Island

Sound in Norwalk, CT by removing Wing Euonymus, *Euonymu spp.* (Norwalk Land Trust 2016). The Wing Euonymus is an exotic invasive native to central and Northern Asia, Japan, and Central China that can reach up to 20 feet in height (NPS 2010).

**Predation**

The main observed predators on terrapins are fox (*Vulpes vulpes and Urocyon cinereoargenteus*) and raccoons (Seigel 1980b, Roosenburg 1990, Roosenburg 1991, Feinberg and Burke 2003, Bennett et al. 2009). Other varieties of predators include Norway rats (Draud et al. 2004, Ner and Burke 2008), gulls (*Larus atricilla* and *L. argentatus*) (Seigel 1980b, Ner and Burke 2008), and crows (*Corvus brachyrhynchos*) (Seigel 1980b). Occasional predators have been observed such as Yellow-Crowned Night Herons (*Nycticorax violacea*) (Draud et al. 2004), fish crows (*Corvus ossifragus*), Willet (*Triunga semipalmata*) Eastern kingsnakes (*Lampropeltis getula*) and white-footed deer mice (*Peromyscus leucopus*) (Roosenburg et al. 2014) and (*Felis catus*) (VDGIF 2015).

Terrapin populations are declining in some areas due to subsidized predators (Feinberg and Burke 2003) and can even be eliminated (Seigel 1980b). Subsidized predation occurs when resource availability for predators is altered (usually anthropogenically) in a way that increases predator density to levels that would not occur without these additional resources. These resources, such as food waste left in garbage cans and dumpsters by humans, as well as food litter, keep predators safe from normal natural effects that might limit their populations, such as declines in prey populations. Subsidized predators such as raccoons and fox, may eat terrapin eggs, hatchlings or adults. However, raccoons appear to be the most detrimental predator to terrapins (Ner and Burke 2008). As coastal habitats continue to become urbanized, terrapin nesting density may increase because there are fewer habitats available for them to nest (Bennett et al. 2009). This can lead to higher predation rates as fewer habitats are available for nesting (Roosenburg 1991). Nest predation rates from fox and raccoon range from 70 to 100% on the mainland of the Chesapeake Bay, MD (Roosenburg 1991). A similar rate (69%) was observed by Bennett et al. (2009) on the lower Patuxent River, MD. Raccoons wiped out nearly all terrapin nests, with 100% and 92% mortality rate between 1998 and 1999 on JBWR (Ruler's Bar Hassock, NY) (Feinberg 2004). Draud et al. (2004) determined a 67% mortality rate of radio-tracked hatchlings due to rats (NY). In a study in DE, 6.3 ± 0.2 SE eggs were depredated per nest (N=238) with potential terrapin nest predators including raccoons, red foxes, rats, and feral cats (Lester and Suss 2014). In MA, predation rates from subsidized predators range from 85-93% in control areas, where nests are not protected. Although the net effect on population demographics is unknown, an expansion of the types of predators has been observed. Over the past decade, increasing fox populations have been very effective in decreasing the numbers of terrapin eggs and hatchlings, even in nests that are protected with wire cages (B. Brennessel pers. comm. 2015). In the absence of predation, terrapins have increased nest survival rates and recruitment (Roosenburg et al. 2014). Calculating nest predation may be potentially underestimated in some cases where raccoons have been found to change their predatory behavior throughout the nesting season, eating the contents of terrapin eggs and leaving the shells behind in June, while in July eating the entire egg and leaving the nest "empty," which could be counted as a failed nest attempt (Burke et al. 2009).

Potential options to protect the terrapins from subsidized predation may include scent aversion, electric fences (Bennett et al. 2009), and predator excluders (nest protectors). Raccoons may use cues such as the smell of saltwater or disturbance of nesting substrate to located terrapin nests (Burke et al. 2005). In a recent study by Burke et al. (2015) habanero pepper powder used at terrapin nests did not reduce predation by raccoons. Electrical fencing can reduce predation as Bennett et al. (2009) found a significant difference between numbers of nests predated between electrified nests and those unprotected. Predator excluders vary in design and can be made from different materials including wood, plastic, metal, or PVC cloth (Rahman and Burke 2010). Currently, there are no published literature sources on comparisons of predator excluder designs for terrapins. However, this has been included as a conservation action (Action #4) for the NE states (MA, RI, CT, NY) to implement a research study to evaluate nest cage (nest protector, predator excluder) design and determine the most effective types of nest protection structures for various locations. Rahman and Burke (2010) compared unprotected nests to metal boxes and found that nest protectors did not impact size of terrapin hatchlings, but there was a significant difference in incubation temperature between nests without excluders and nest protected with metal boxes. There are some downfalls to predator excluders, as they can make nests exposed and easier to detect by predators as well as illegal collectors, and also can be considered a hazard to human safety (Rahman and Burke 2010).

**Disease**

The threat of disease is relatively unknown, but appears to be a lower priority threat at the present time. One study in NJ compared disease in captive and wild caught terrapins and found both groups were not infested with blood or intestinal parasites. Salmonella was present, but researchers concluded terrapins do not shed this pathogen in very large numbers (Werner et. al. n.d). *Ranavirus* a disease known for causing mass morality of amphibians and fish (Langdon and Humphrey 1987; Daszak et al. 1999; Green et al. 2002 as cited in Johnson et al. 2008), with infrequent cases in reptiles (Hyatt et al. 2002, Marshang et al. 2005, De Voe et al. 2004 as cited in Johnson et al. 2008), may be a disease that is monitored for terrapins. It has already been found in Eastern box turtles (*Terrapene carolina carolina*) in five Maryland counties (S. Smith pers. comm. 2015). An additional conservation action identified in this plan for MD which was also included its MD's SWAP Conservation Actions (see page 7-141) calls for monitoring the spread of individuals (terrapins) affected by *Ranavirus*; determine impact of emerging pathogens.

**Mass Die-Off**

Although not classified as a threat, mass die-off events can be a result of and linked to one or multiple threats identified above. Little information is known for mass die-off events that have been reported for terrapins and any die-off is likely go unreported. It is unknown whether these terrapins survived. For the purpose of this Conservation Strategy mass die-off is defined as greater than 10 terrapins being found dead within a weeks time. Possible explanations for these events could be due to terrapin bycatch in active and derelict crab pots, poisoning due to chemical and oil spills, diseases, harmful algal blooms - marine biotoxins (e.g. saxitoxin), and possible winter freezes and other weather conditions.

Terrapin bycatch due to drowning from active and derelict crab pots can potentially kill a number of terrapins quickly, and if dumped in the ocean they may wash ashore in a group. In Nandua Creek, VA (bayside, Eastern Shore of VA), 54 terrapins were found in one crab pot, with 49 dead, and five that were released alive (Figures 14 and 15) (K. Angstadt, VIMS, pers. comm. 2014).

**Figure 14. Fifty-four terrapins recovered from a derelict crab pot. Forty-nine were found dead and four were released back into the marsh.**
**©Shannon Alexander, Bay Country Kayaking, Williamsburg, Virginia.**


**Figure 15. Forty-nine dead terrapins recovered from a derelict crab pot. © Shannon Alexander, Bay Country Kayaking, Maryland.**

Crabbers have been observed emptying crab pots in Jamaica Bay, NY with terrapin carcasses washing up on shorelines shortly after (R. Burke, pers. comm. 2015). Locals in Jamaica Bay, NY have observed crabbers using fyke nets, producing similar results (R. Burke pers. comm. 2015).

During April and May, 2015 there were at least three cases of reported cases of mass die-offs in terrapins in DE, NY, and MA. In April 2015, 39 dead terrapins were found on one beach in Rehoboth Bay, DE (Northeast Wildlife Disease Cooperative 2015). The DE DNREC could only send one specimen for analysis. Cornell's Animal Health Diagnostic Laboratory could not determine the cause of death (Northeast Wildlife Disease Cooperative 2015). The second case occurred in Long Island, NY, where more than 100 terrapins washed ashore on Jamesport and Flanders Bay Beaches (inclusive of Simmons Point and Iron Point sandbar) starting in April and into May 2015. There were shellfish closures in the area due to saxitoxin during this time period. Lab testing for saxitoxin from terrapins of Flanders Bay was inconclusive, but suggested saxitoxin was present. The evidence suggested that terrapins were poisoned; but the saxitoxin present in the terrapin stomach contents could mean that the contaminated contents were ingested shortly before death, and not that the terrapins died from the toxin itself (Northeast Wildlife Disease Cooperative 2015). From this event 76 adult terrapins (live) were taken in by the Turtle Rescue of the Hamptons (NY), but it is unknown whether these turtle survived. Additional analysis is currently being conducted and pending results may provide important data to better characterize the role of the algal bloom in this terrapin mass mortality event.

In Wellfleet Bay on Cape Cod, MA, 70 terrapins washed up on beaches from mid-April 2015 (with more washing in), when water temperature was still in the mid-40s degrees Fahrenheit.

When the first few terrapins were found, surveys of beaches and shorelines around Wellfleet Harbor were conducted with many terrapins still alive, but lethargic and unable to swim. It was unlikely that these terrapins were foraging as they were just coming out of brumation; with some still covered in mud (B. Brennessel, pers. comm. 2015). In total of 88 terrapins washed up with half were alive and "cold-stunned," and the other half were dead. The vast majority of the terrapins found were females, 76 of the 88 total terrapins (Northeast Wildlife Disease Cooperative 2015). Research in MA, believed it was cold-stun event (B. Brennessel, pers. comm. 2015). The terrapins may have come out of brumation before they were physiologically ready as their platelet count was extremely low (Northeast Wildlife Disease Cooperative 2015). Platelet counts become low during hibernation, but return to normal before terrapins emerge in the spring. The terrapins may have come out of brumation before they were physiologically ready potentially due to a number of environmental conditions (Northeast Wildlife Disease Cooperative 2015). The winter of 2014 was mild, followed by a particularly cold February. Ice may have formed too quickly and there were large amounts of ice in the creeks and the bay, which may have hurt or disrupted the terrapins during brumation. The ice may have also increased the salinity and possibly led to dehydration (many of the cold-stunned terrapins were extremely dehydrated). Terrapins may have experienced shock in the spring as the shallow creeks were warm, but the open bays were still very cold. The spring of 2015 was late and quick and could have caused these water temperature differences (Northeast Wildlife Disease Cooperative 2015).

In September and October 2014, at least two cases of mass die-offs occurred in NJ and MD, respectively, but no determinations could be made as terrapins were not collected for necropsies and no information regarding any cause was provided. In September 2014, approximately 12-20 terrapins were reported as dead/washed up on Moore's Beach, Cape May, NJ. In October 2014, anywhere from 50-70 to a couple hundred (no exact count determined) were reported to MD DNR as dead (floating) on or along the sandbar just north of Barren Island near Hooper's Island in an area called Swan Harbor in MD. The terrapins did not appear to be injured or damaged and the people that reported the dead terrapins reported no unusual events, such as boats, water color, dead fish or birds, fishing boats or nets, etc., in the area. Information on size was unavailable (S. Smith, MD DNR pers. comm. 2015).

## THREAT ASSESSMENT

The NE States partook in a Threat Assessment outlined by the NE Lexicon, which is a hierarchical Threat Classification System adopted by the IUCN threat classification system to classify and name threats. We therefore organized threats for terrapins under the broadest categorization including: Residential and Commercial Development (Habitat Loss), Transportation (Road Mortality), Transportation (Boat Strikes), Biological Resource Use (Fisheries), Biological Resource Use (Pet Trade Industry), Biological Resource Use (Illegal Markets), Human Intrusions and Disturbance, Natural System Modifications (Dredging), Natural System Modifications (Bulkheading), Pollution (Oil Spills), Climate Change and Severe Weather, Invasive and Other Problematic Species and Genes  (Invasive Plants). We added our own broad categories of Predation and Disease as well.

Threats were then ranked by risk using the definitions provided by the NE Lexicon including: *Severity*, *Reversibility, Immediacy*, *Spatial Extent*, *Certainty*, and *Likelihood*. Each threat was considered under these risk definitions and rated as a *Low Impact*, *Moderate Impact* or *High Impact* (see Table 6). Determining priority threats was somewhat subjective as those that had the most High Impact rankings determined which threat should be considered priority for the state or the region. No weighted system was used to determine if one threat characteristic should be weighted higher than another.

**Table 6. Threat characteristics and categorical ratings.**

| THREAT CHARACTERISTIC | *LOW IMPACT* | *MODERATE IMPACT* | *HIGH IMPACT* |
|---|---|---|---|
| Severity | **Slight Severity:** Degree of ecological change is minor | **Moderate Severity:** Degree of ecological change is substantial | **Severe:** Degree of ecological change is major |
| Reversibility **(Consider the likelihood of reversing the impacts within 10 years)** | **Reversible:** Effects of the threat can be reversed by proven actions | **Reversible with difficulty:** Effects of the threat may be reversed but costs or logistics make action impractical | **Irreversible:** Effects of the threat are irreversible |
| Immediacy **(This characteristic assesses the time scale over which impacts of the threat will be observable.)** | **Long-term:** Effects of the threat are expected in 10-100 years given known ecosystem interactions or compounding threats | **Near-term:** Effects of the threat are expected within the next 1 - 10 years | **Immediate:** Effects of the threat are immediately observable (current or existing) |
| Spatial Extent **(Consider impact of threat within 10 years)** | **Localized**: (<10%) A small portion of the habitat or population is negatively impacted by the threat. | **Dispersed or Patchy:** (10-50%) | **Pervasive:** (>50%) A large portion of the habitat or population is negatively impacted by the threat. |
| Certainty | **Low Certainty:** threat is poorly understood, data are insufficient, or the response to threat is poorly understood | **Moderate Certainty:** some information describing the threat and ecological responses to it is available, but many questions remain | **High Certainty:** Sufficient information about the threat and ecological responses to it is available |
| Likelihood **(Consider impact of the threat within 10 years) (This characteristic is used to assess the certainty surrounding the threat and its impacts.)** | **Unlikely:** Effects of the threat are unlikely to occur (less than 30% chance) | **Likely:** Effects of threat are likely to occur (30-99% chance) | **Occurring:** Effects of the threat are already observable (100% chance) |

The value of this comprehensive and strategic approach is the potential of the NE states to enhance interstate collaboration for habitat management and conservation (Crisfield and NEFWDTC 2013). To facilitate this collaboration, the states are using the NE Lexicon (used for all revised SWAPs), which will it make possible to classify the threats these species face, and conservation actions proposed to support their populations in a unified manner (Crisfield and NEFWDTC 2013). Understanding threat characteristics can help highlight opportunities for species and habitat management or protection. In addition, it may be possible to prioritize threats (and/or associated actions) for regional coordination if multiple states have identified them as pervasive, severe, and/or immediate.

Priority threats were similar across the NE range with Habitat Loss and Predation identified as a priority threat in all eight states and both regional assessments (Table 7). Similar themes are seen within the NE states (MA through NY) with predation and climate change occurring in all four states and in the NE regional assessment. In the Mid-Atlantic states (NJ through VA), predation and habitat loss occurred in all four states and in the Mid-Atlantic regional assessment. The threat of fisheries was identified in all Mid-Atlantic states and the Mid-Atlantic regional assessment, except for DE. Fisheries are still considered a threat in DE, but were not identified as a priority threats during the threat assessment exercise.

**Table 7. Priority threats identified.**

| | PRIORITY THREATS DETERMINED BY THREAT ASSESSMENT |
|---|---|
| Northeast | **Predation, Habitat Loss (Nesting), Climate Change, Human Disturbance, Bulkheading** |
| Massachusetts | Predation, Habitat Loss/Climate Change, Human Disturbance, Bulkheading |
| Rhode Island | Predation, Climate Change, Habitat Loss (Nesting), Road Mortality, Human Disturbance |
| Connecticut | Predation, Habitat Loss, Climate Change, Road Mortality, Pollution |
| New York | Habitat Loss, Climate Change, Predation, Road Mortality |
| Mid-Atlantic | **Fisheries, Road mortality, Bulkheading/Shoreline Hardening, Habitat Loss, Predation** |
| New Jersey | Fisheries, Bulkheading, Predation, Road Morality, Habitat Loss |
| Delaware | Bulkheading, Predation, Climate Change, Habitat Loss, Road Mortality |
| Maryland | Habitat Loss (Nesting), Predation, Fisheries, Habitat Loss (Terrestrial, Aquatic), Human Disturbance |
| Virginia | Fisheries, Habitat Loss (Beach), Climate Change, Predation |

## SPECIES DISTRIBUTION MODELING

Various federal and state agencies, NGOs, conservation groups, researchers and other stakeholders across the NE and Mid-Atlantic have collected data on terrapins over many decades. As one major objective in the development of this Conservation Strategy, we have compiled and synthesized these data and used species distribution modeling to evaluate the probability of terrapin occurrence in coastal terrestrial habitats during nesting excursions within its known range in the NE. This modeling was conducted by Rutgers University (Dr. Brooke Maslo and Karen Leu) with occurrence data collected and compiled by CWFNJ. We demonstrate the utility of applying a composite, region-wide dataset to investigate conservation implications at the regional scale. We examine landscape-scale habitat characteristics influencing terrapin nest site selection and provide maps delineating probable suitable coastal habitat. This can be applied to a suite of conservation questions to identify priority conservation areas, assess regions of population vulnerability to current and future threats such as the threat of road mortality and climate change/sea-level rise, and to serve as a tool for conservation practitioners to develop management strategies.

### Methodology

#### *Occurrence data and study area*

Terrapin occurrence data spanning a 75-year period were gathered by 60 sources including federal and state agencies, non-governmental conservation groups, researchers and stakeholders across the Northeast and Mid-Atlantic U.S. An occurrence was defined as the confirmed sighting of a terrapin nesting, crossing a road, or in water. Occurrence data represent terrapin data within the Northeast Region and include MA, RI, CT, NY, NJ, DE, MD, and VA (Figure 16).

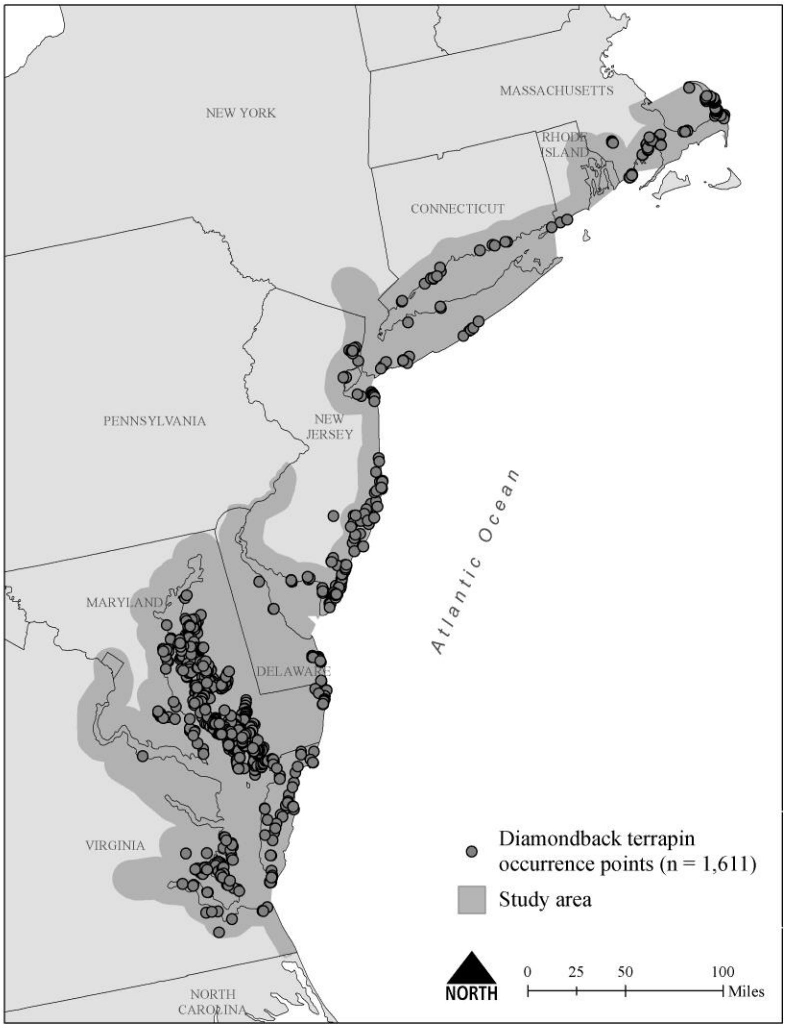



**Figure 16. Map of confirmed terrapin occurrence points plotted on the study area.**

Occurrence points collected between 2000-2012 were extracted to maximize the accurate reflection of current distribution patterns. Points collected after 2012 were removed to avoid inconsistencies with environmental data resulting from landscape changes (e.g., flattened dunes, marshland inundation, altered tidal creeks) caused by Superstorm Sandy (October 29 - November 2, 2012). Environmental data portraying landscapes prior to Superstorm Sandy would not accurately reflect the habitat conditions selected by terrapins after the event.

Because we wished to model probability of terrapin suitable coastal habitat (during nest excursions) across the landscape, points that fell in aquatic land cover types (i.e. bays, tidal creeks) when overlaid with the land use data were eliminated. We considered all remaining occurrence points to represent female terrapins approaching, utilizing, or leaving nesting areas. To mitigate bias from spatial autocorrelation, we spatially rarefied the points (Brown 2014), removing duplicate points and points that occur within 30 m of one another. The final dataset consisted of 1,611 occurrence points (Table 8).

**Table 8. Number of occurrence points for each state in the study area.**

| STATE | # OF OCCURRENCE POINTS |
|---|---|
| CT | 16 |
| DE | 15 |
| MA | 238 |
| MD | 843 |
| NJ | 161 |
| NY | 51 |
| RI | 3 |
| VA | 284 |
| Total | 1,611 |

The designated study area included all land and water within 15 km of the coastline from Cape Cod, MA to the VA-North Carolina border (approximately 23,150 km). This approach allowed inclusion of all marshlands accessible to terrapins via coastal waterways.

***Species distribution model***

Species distribution modeling is used to predict the probability of species occurrence across a study area based on environmental inputs that describe important habitat characteristics. The availability of geospatial landscape data, combined with comprehensive occurrence data, allows for the examination of species-habitat relationships through statistical modeling methods (Franklin 2009). We used maximum entropy modeling software (Maxent version 3.3.3k) (Phillips et al. 2006) to predict the probability of occurrence for terrapins across the study area. Maxent has been applied to an assortment of conservation issues at varying geographic scales (Elith et al. 2011) and is advantageous for its relative ease of use and ability to generate robust results for presence-only input data. Since absence data were not included in the terrapin dataset (nor could true absences be confirmed), the data were considered presence-only. Given geographic occurrence points and a set of environmental variables, Maxent builds a predictive model using maximum likelihood algorithms to compare environmental conditions at locations without known species occurrence to the values at known input points (Elith et al. 2011). We assume no bias in the sampling of occurrence data but removed duplicate points from efforts in overlapping years to mitigate spatial autocorrelation; therefore, we assume equal probability of occurrence across the study area (Merow et al. 2013). We applied the Maxent default parameters and settings for the model, which have been shown to perform well for most models (Phillips and Dudík 2008).

We tested the model using 10-fold cross-validation and evaluated the average area under the curve (AUC) scores from the runs. The AUC value is the sum of the area under the receiver operating curve (ROC) for each model iteration; it ranges between 0 and 1, and is interpreted as an indicator of model fit, representing the probability that a presence location is ranked higher than a random background point of unknown presence. Models with an AUC score ≥ 0.7 are considered to have good fit (Phillips and Dudík 2008).

To examine the influence of individual predictors on the model, we analyzed the permutation importance and response curves for each predictor. The permutation importance indicates the predictor's explanatory power and is calculated as the drop in AUC resulting from the random permutation of each predictor’s values against the model’s training points (Phillips 2006). To ascertain the range of habitat conditions that terrapins on nesting excursions select for, we examined the response curve for each predictor. The response curves plot the probability of species presence against all possible values of a predictor without the influence of the other variables. A probability of presence of 0.5 indicates that the predictive power of the variable is no better than random, while probabilities of presence > 0.5 represent a range of preferred values for that predictor.

Maxent generates a continuous surface of values across the study area, where each cell value represents the probability of species occurrence (bounded by 0 and 1) relative to the predictor variables (Phillips and Dudík 2008). We applied the 10$^{th}$ percentile training presence threshold to define these values as either preferred or not preferred nesting habitat (Phillips and Dudík 2008, Rödder et al. 2009, Maslo et al. 2015). This threshold designates that 90% of the data used in fitting the model will be included in determining preferred habitat, accounting for some error inherent in the data (Young et al. 2011).

***Environmental data***

We generated seven landscape-scale environmental predictors that likely influence probability of occurrence of terrapins on nesting excursions, using temporally relevant, and publicly available spatial datasets (Table 9).

**Table 9. Model predictor variables and their sources.**

| PREDICTOR VARIABLE | DATA SOURCE | TIME PERIOD OF DATA | DESCRIPTION |
|---|---|---|---|
| **Land cover** | MRLC[1] National Land Cover Database (Homer et al., 2015) | 2011 | 30-meter resolution land cover classifications |
| **Distance to estuarine emergent wetland** | Derived from land cover data | - | Euclidean distance (m) to nearest estuarine emergent wetland |
| **Area of emergent wetland** | Derived from land cover data | - | Area ($m^2$) of estuarine emergent wetland within a 100-meter radius |
| **Elevation** | USGS National Elevation Dataset, 2000-2013 | 2000-2013 | 30-meter resolution digital elevation models |
| **Slope** | Derived from elevation data | - | Slope (% rise) calculated from elevation |
| **Shoreline type** | NOAA[2] Environmental Sensitivity Index (NOAA, 2014) | 1999-2014 | Classifies shorelines based on ESI ranking |
| **Distance to shoreline** | Derived from shoreline data | - | Euclidean distance (m) to nearest shoreline |

1: Multi-Resolution Land Characteristics Consortium; 2: National Oceanic and Atmospheric Administration

We obtained land cover data from the National Land Cover Database (Homer et al., 2015) and collapsed them into 23 classifications (Table 10).

**Table 10. Land use classifications used in the land use variable for the species distribution model.**

| LAND USE TYPES |
|---|
| Developed, high intensity |
| Developed, medium intensity |
| Developed, low intensity |
| Developed, open space |
| Cultivated crops |
| Pasture/hay |
| Grassland/herbaceous |
| Deciduous forest |
| Evergreen forest |
| Mixed forest |
| Scrub/shrub |
| Palustrine forested wetland |
| Palustrine emergent wetland |
| Estuarine forested wetland |
| Estuarine scrub/shrub wetland |
| Estuarine emergent wetland |
| Unconsolidated shore |
| Bare land |
| Estuarine aquatic bed |
| Palustrine aquatic bed |
| Non-ocean open water |
| Atlantic Ocean |

Importantly, we separated the original category "open water," which included all aquatic land use types such as bays and tidal creeks, into two categories, "Atlantic Ocean" and "non-ocean open water," to distinguish general characteristics such as salinity, tidal movements, and depth. To examine the importance of estuarine emergent wetlands on terrapin distribution, we calculated the area of estuarine emergent wetland within a 100-m radius using Fragstats (McGarigal et al. 2012). The 100-m neighborhood reflects the areal land coverage that terrapins would likely encounter after emerging from the water in search of nest sites (Burger and Montevecchi 1975, Roosenburg 1994, Roosenburg and Place 1994). We also measured the Euclidean distance to the nearest estuarine emergent wetland using ArcMap (ESRI 2014).

We obtained digital elevation models for each state in our study area from the USGS National Elevation Dataset, and calculated the slope in percent rise from these elevation data. Elevation and slope have been cited as determinants of suitable terrapin nesting habitat (Burger and Montevecchi 1975, Palmer and Cordes 1988). Nests must be made at elevations sufficiently above the mean tide line to prevent inundation at high tides (Roosenburg and Place 1994, Butler et al. 2004). Shallow slopes facilitate the digging of nests and mitigates nest erosion and exposure (Burger and Montevecchi 1975).

We obtained shoreline data from the NOAA's Environmental Sensitivity Index maps (NOAA ESI 2014), which classify shorelines based on shoreline composition (e.g. salt- and brackish-water marshes; exposed, solid man-made structures; coarse-grained sand beaches). Shoreline composition represents the accessibility of upland nesting sites to terrapins from the water. Natural shorelines facilitate upland movement across the land-aquatic interface, while hard structures such as bulkheads prevent terrapins from accessing land (Wnek 2010, Roosenburg et al. 2014). We condensed the original NOAA classifications into eight categories, grouping them based on broader composition categories and likelihood of terrapins successfully crossing them (Table 11).

**Table 11. Shoreline classifications used in the shoreline type variable for the species distribution model, condensed from original (NOAA ESI 2014) classifications.**

| SHORELINE TYPES |
|---|
| Hard, man-made structures |
| Hard, natural structures |
| Scarps and steep slopes in sand |
| Beaches |
| Gravel beaches |
| Exposed tidal flats |
| Vegetated/sheltered flatlands |
| Marsh shores |

For shoreline segments consisting of more than one shoreline type (e.g. a shoreline composed of sand on the seaward front, and rocky shores landward), we first determined whether any of the shoreline compositions were "uncrossable" by terrapins (i.e. hard man-made structures, hard natural structures, or scarps and steep slopes in sand) and if so, we reclassified the segment as a singular shoreline of its respective "uncrossable" attribute. For example, a shoreline classified as "fine-grained sand/ sheltered riprap / salt-water marsh" would be reclassified as simply "sheltered riprap". If none of the multiple shorelines were "uncrossable", we used the landward-most shoreline type because this attribute was most consistently present in the dataset. Since the original data from NOAA is in a line vector format, which has no width, we generated shoreline type zones by expanding the shoreline data perpendicularly by 300 m on either side, enough to capture the maximum distance that terrapins have been observed to travel to nest sites (Palmer and Cordes 1988, Roosenburg 1994, Feinberg and Burke 2003). An occurrence point falling within a shoreline zone would be assigned to the respective shoreline type. Though terrapins may not travel perpendicularly from the shoreline, we make the simplifying assumption that the nearest straight-line distance from the shoreline represents where an individual left the waterway. We also calculated the Euclidean distance to the nearest shoreline because suitable nesting habitat must be located within reachable distance from open water, but far enough up shore to avoid inundation at high tide (Burger and Montevecchi 1975).

We used ArcMap 10.2.2 (ESRI 2014) to prepare environmental data for spatial modeling at a 30-m resolution. We projected all geospatial data in Albers Equal Area Conic projection (WKID: 102003) and clipped all data layers to the study area extent. For each predictor variable included in the model, we obtained the best available data for our study area and time period.

**Results**

The Maxent model performed well, with a mean AUC of 0.922 (±0.005; Phillips et al. 2006). Probabilities of terrapin occurrence within suitable coastal habitat ranged from 0.31 to 0.78 (Figures 17-24). We calculated a total of 332,691 hectares of suitable coastal habitat within the study area. Suitable coastal habitat occurred along bay shorelines and estuarine creeks across the study area, with larger, more contiguous expanses located in areas such as, but not limited to, Wellfleet Harbor and Westport River (Figure 17) (MA); Mount Hope Bay (Figure 18), Point Judith Pond, Nockum Hill Wildlife Refuge, and Quonochontaug Pond (RI); Little Narragansett Bay (RI)/Fishers Island Sound (Figure 19)(CT), and much of the CT coast of Long Island Sound; Smithtown Bay, Peconic Bay, Shinnecock Bay (Figure 20), and Jamaica Bay (NY); Arthur Kill, Navesink River (Figure 21), Shark River, Barnegat Bay, Great Egg Harbor Bay (NJ), much of the coastal marshland in southern NJ and the NJ shore of the Delaware Bay; Rehoboth and Indian River Bays (Figure 22) (DE), several tributaries on the eastern side of Chesapeake Bay, Smith Island, and Martin National Wildlife Refuge (Figure 23) (MD); along the southern shore of Potomac River, Ingram Bay (Figure 24), Rappahannock River, and marshlands along the northern coast of Virginia Beach (VA).

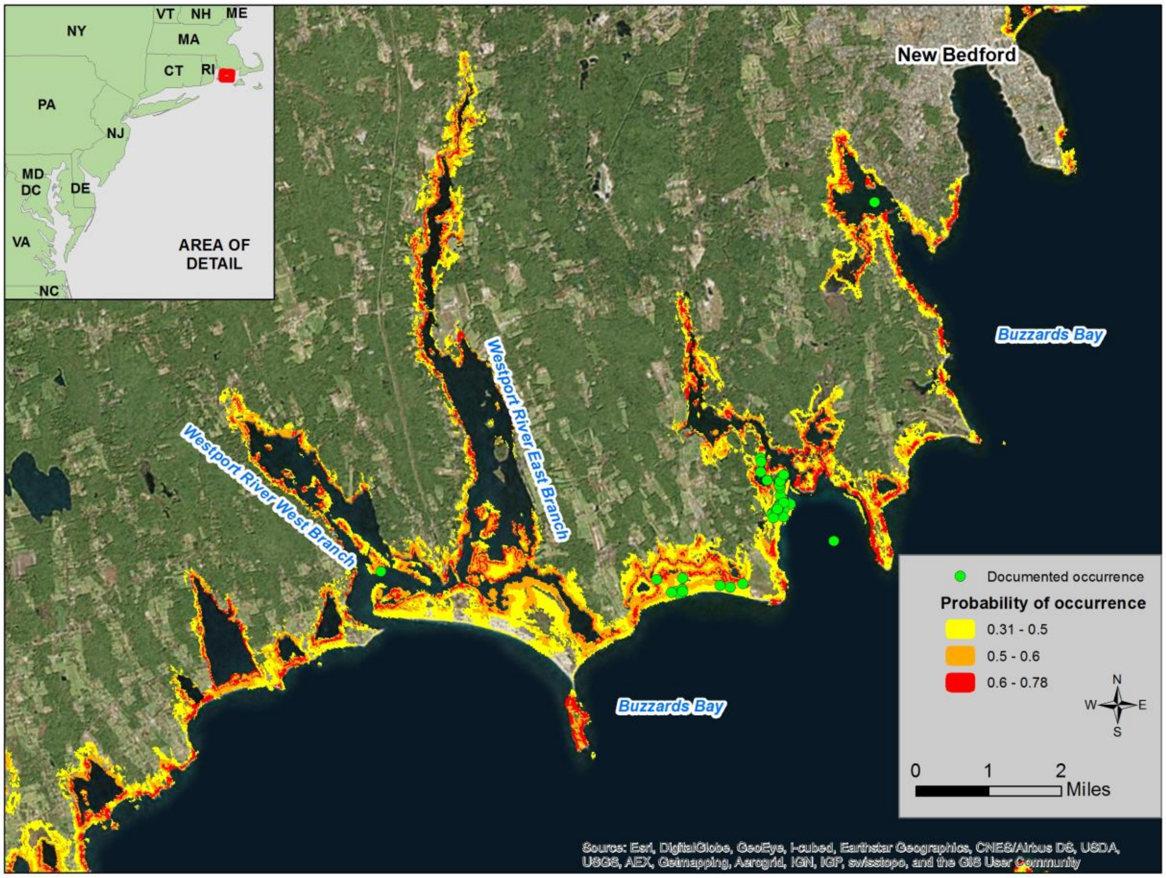



**Figure 17. Westport River, Massachusetts. This area is a potential focal area for terrapin surveys as there is some documented terrapin occurrence, and the model predicts there are areas of contiguous habitat and high probability of occurrence.**

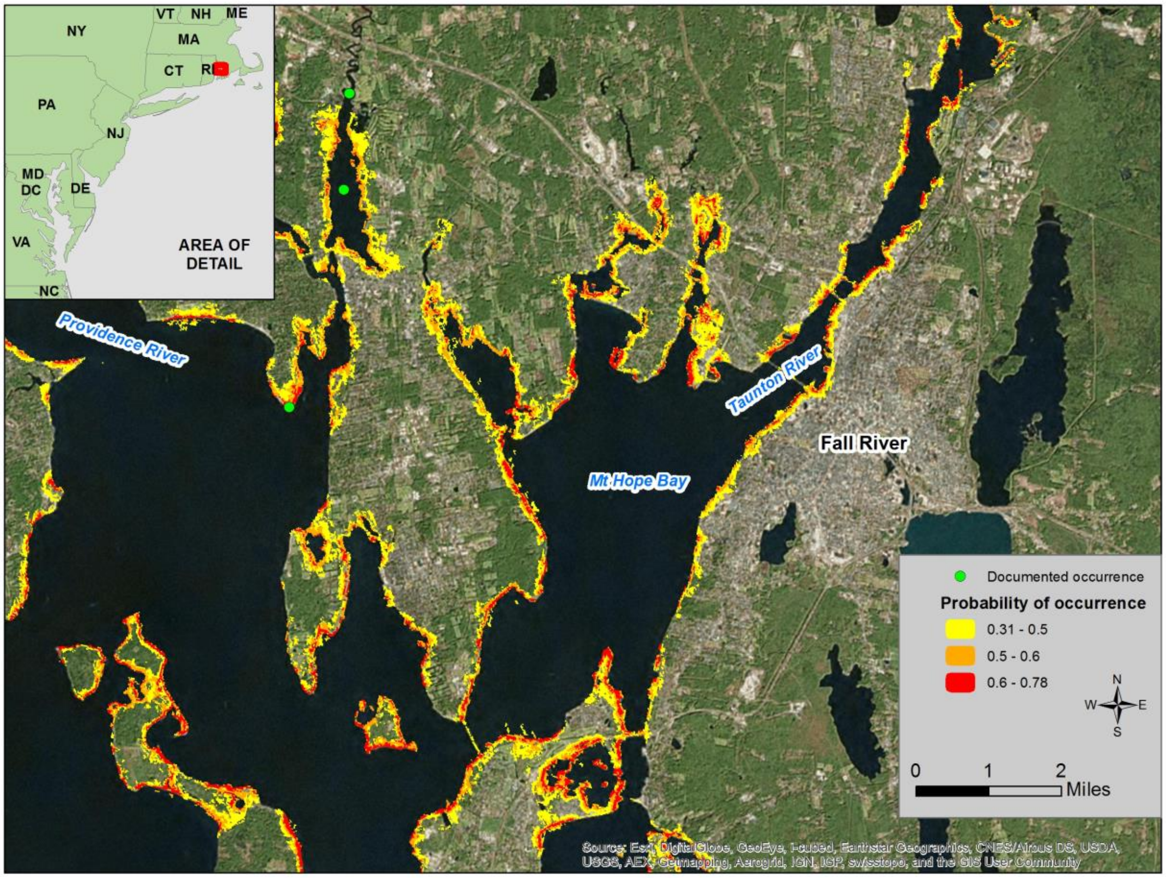



**Figure 18. Mt. Hope Bay, Rhode Island. This area is a potential focal area for terrapin surveys as the model predicts there are areas of contiguous habitat and high probability of occurrence.**

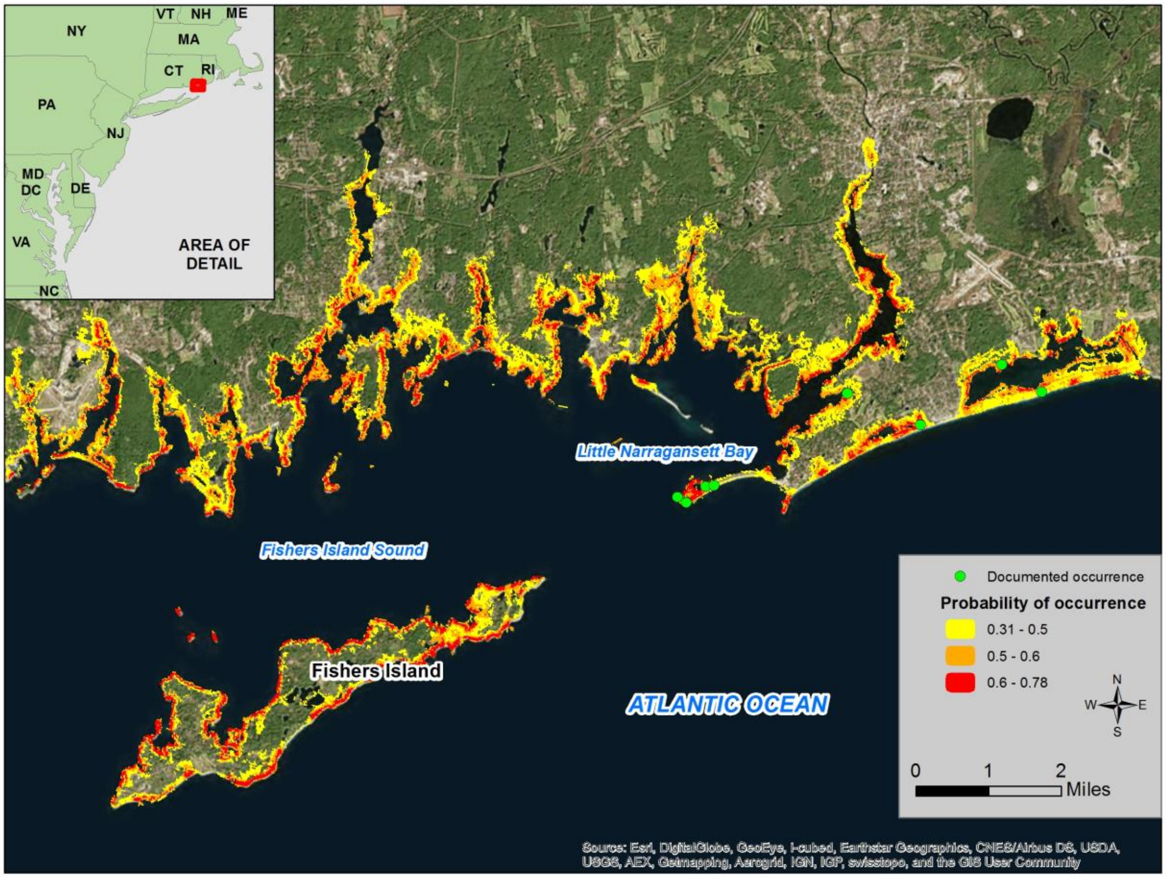



**Figure 19. Little Narragansett Bay, Rhode Island/Fisher's Island Sound, Connecticut. This area is a potential focal area for terrapin surveys as there is some documented terrapin occurrence, and the model predicts there are areas of contiguous habitat and high probability of occurrence.**

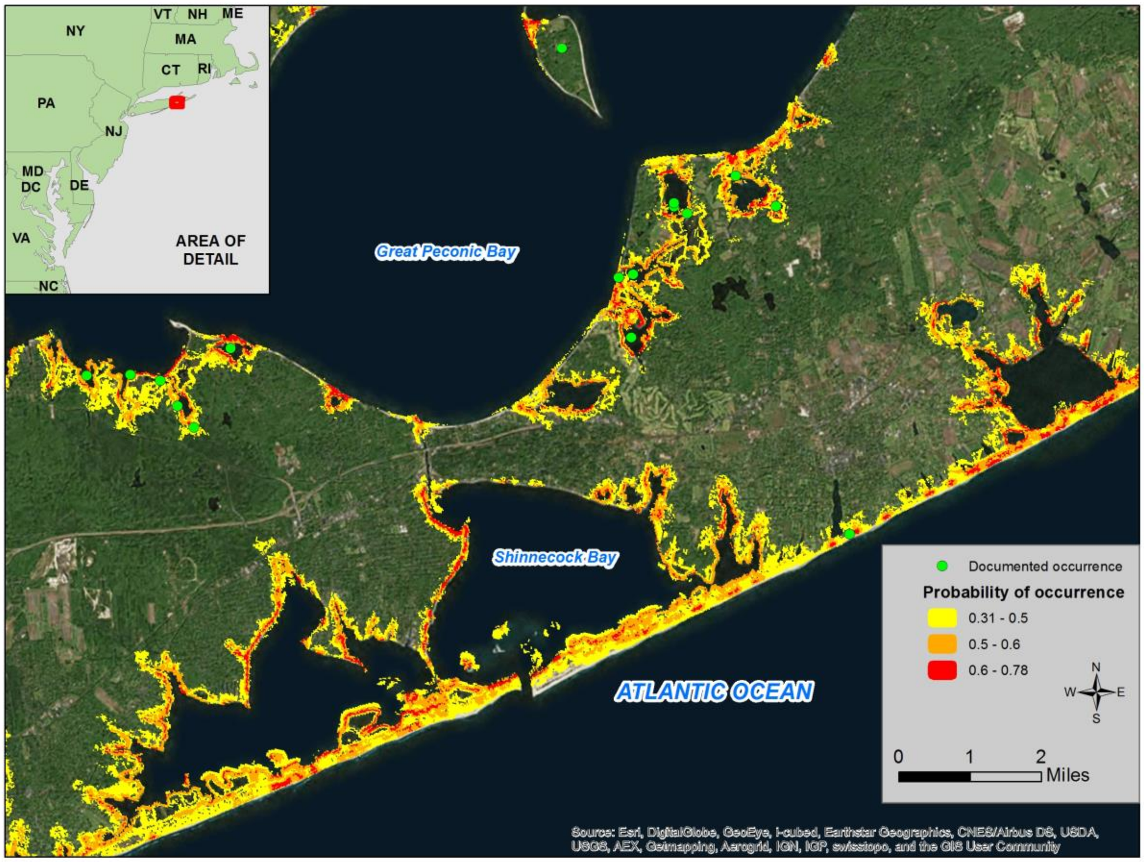



**Figure 20. Shinnecock Bay, New York. This area is a potential focal area for terrapin surveys as there is some documented terrapin occurrence in the surrounding areas, and the model predicts there are areas of contiguous habitat and high probability of occurrence.**

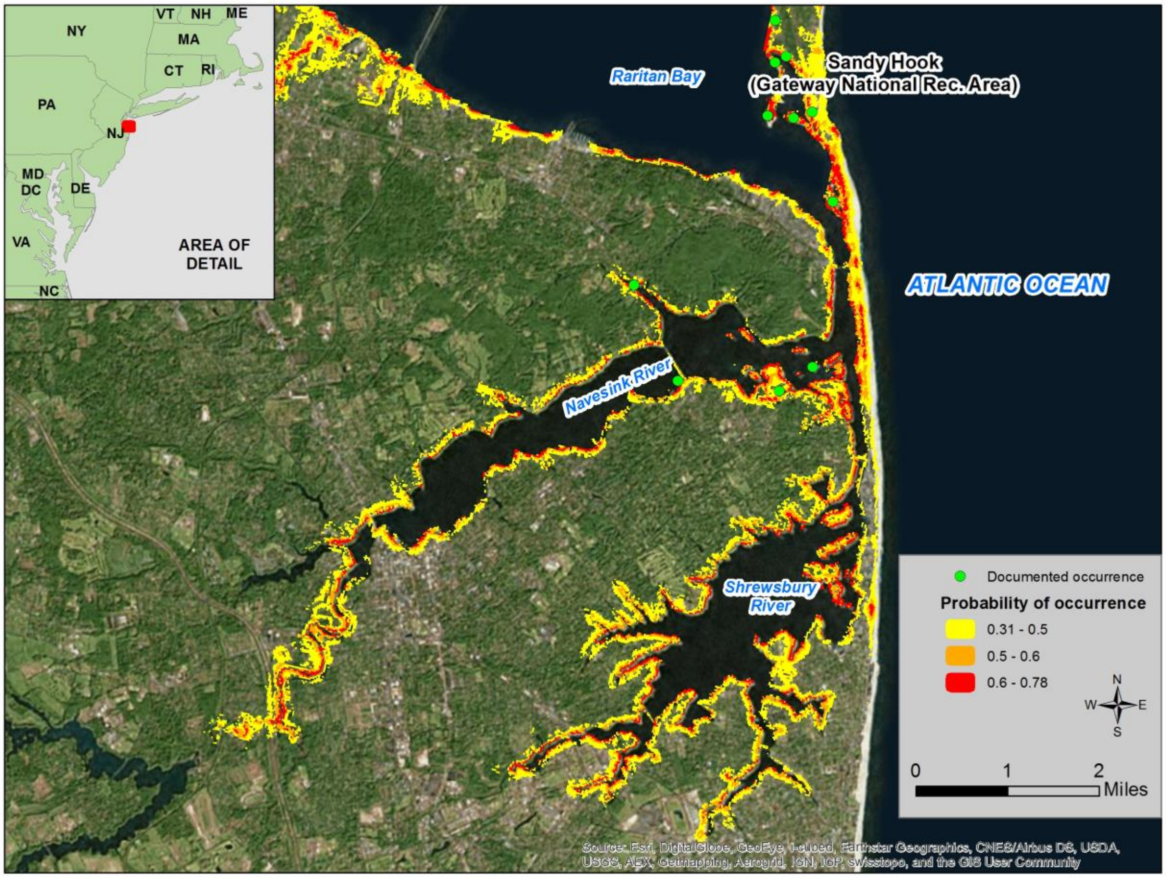



**Figure 21. Navesink River, New Jersey. This area is a potential focal area for terrapin surveys as there is some documented terrapin occurrence; and the model predicts there are areas of contiguous habitat and high probability of occurrence.**

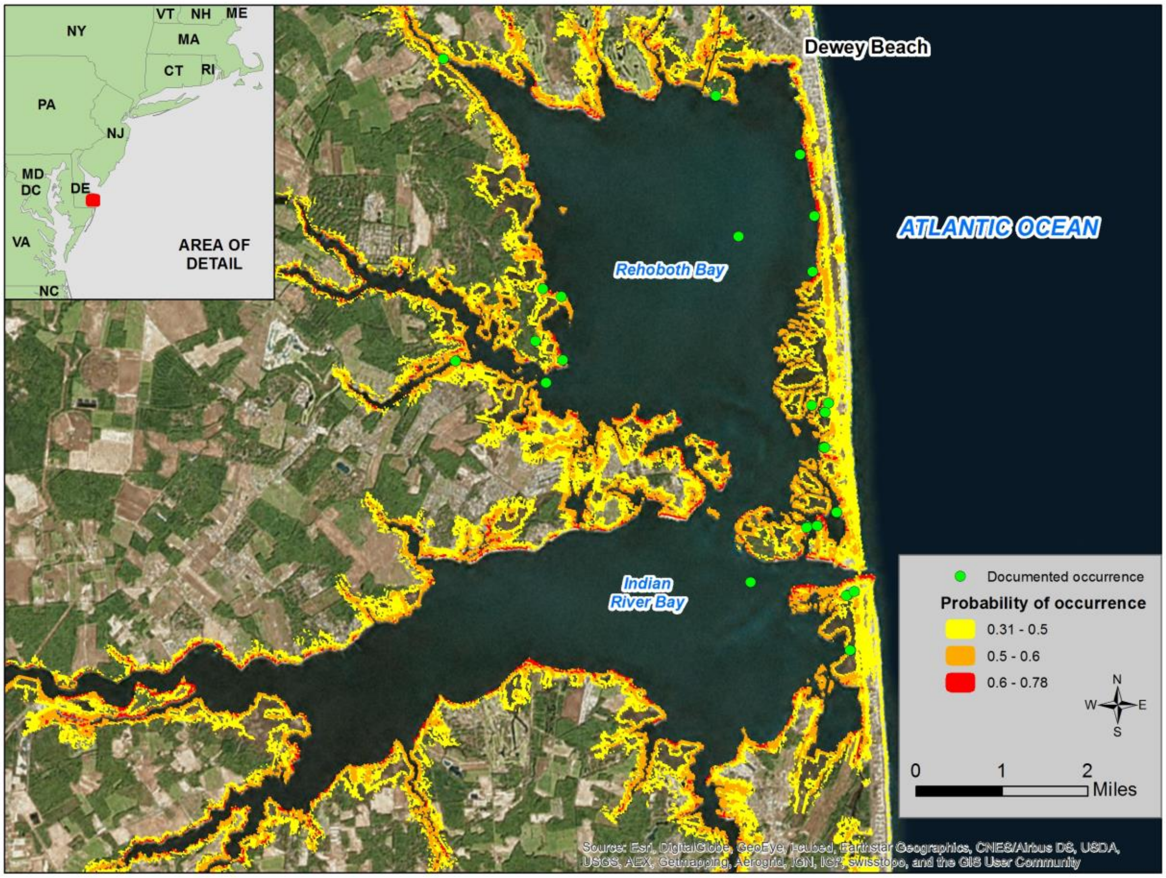



**Figure 22. Rehoboth Bay, Delaware. This area is a potential focal area for terrapin surveys as there is some documented terrapin occurrence; however, the model predicts there are areas of contiguous habitat and high probability of occurrence.**

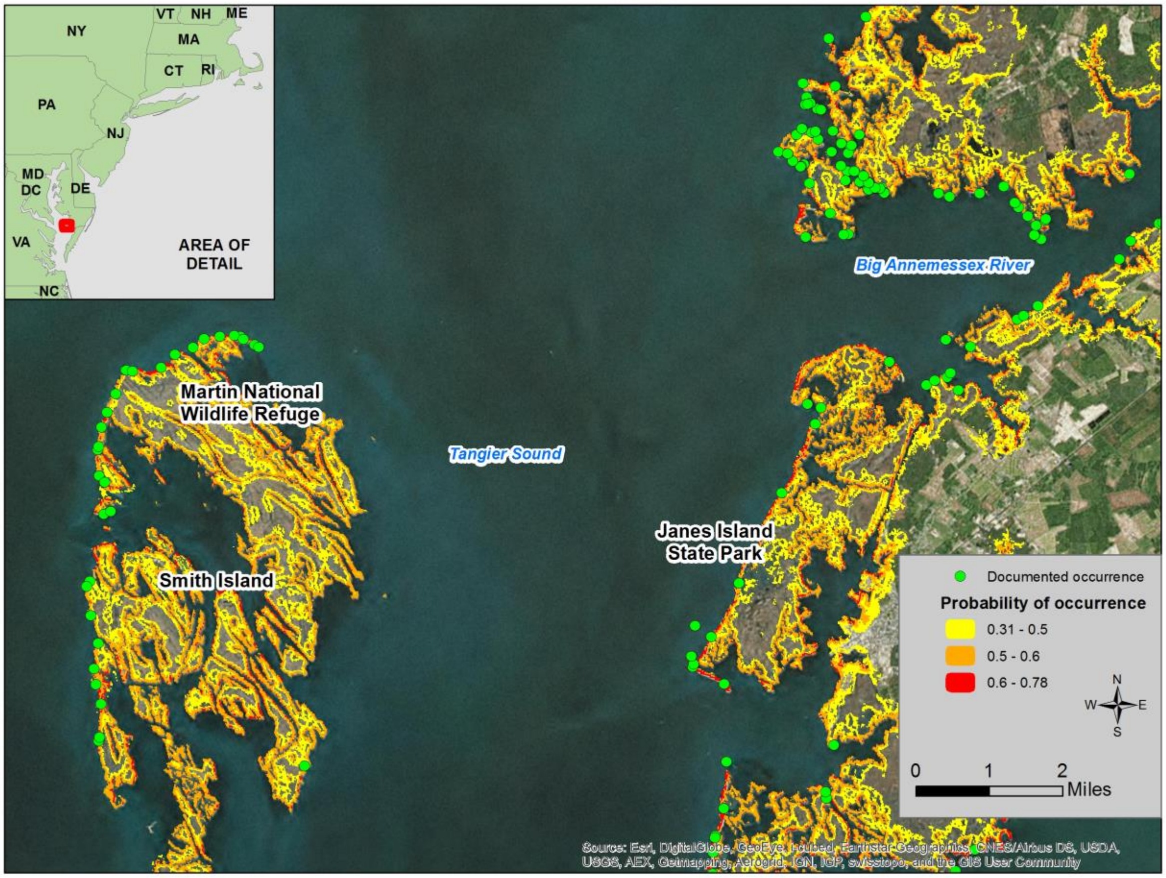



**Figure 23. Martin NWR, Maryland. This area is a potential focal area for terrapin surveys as there is documented terrapin occurrence, and the model predicts there are areas of contiguous habitat and high probability of occurrence. There may other areas within the Martin NWR and Smith Island that is suitable.**

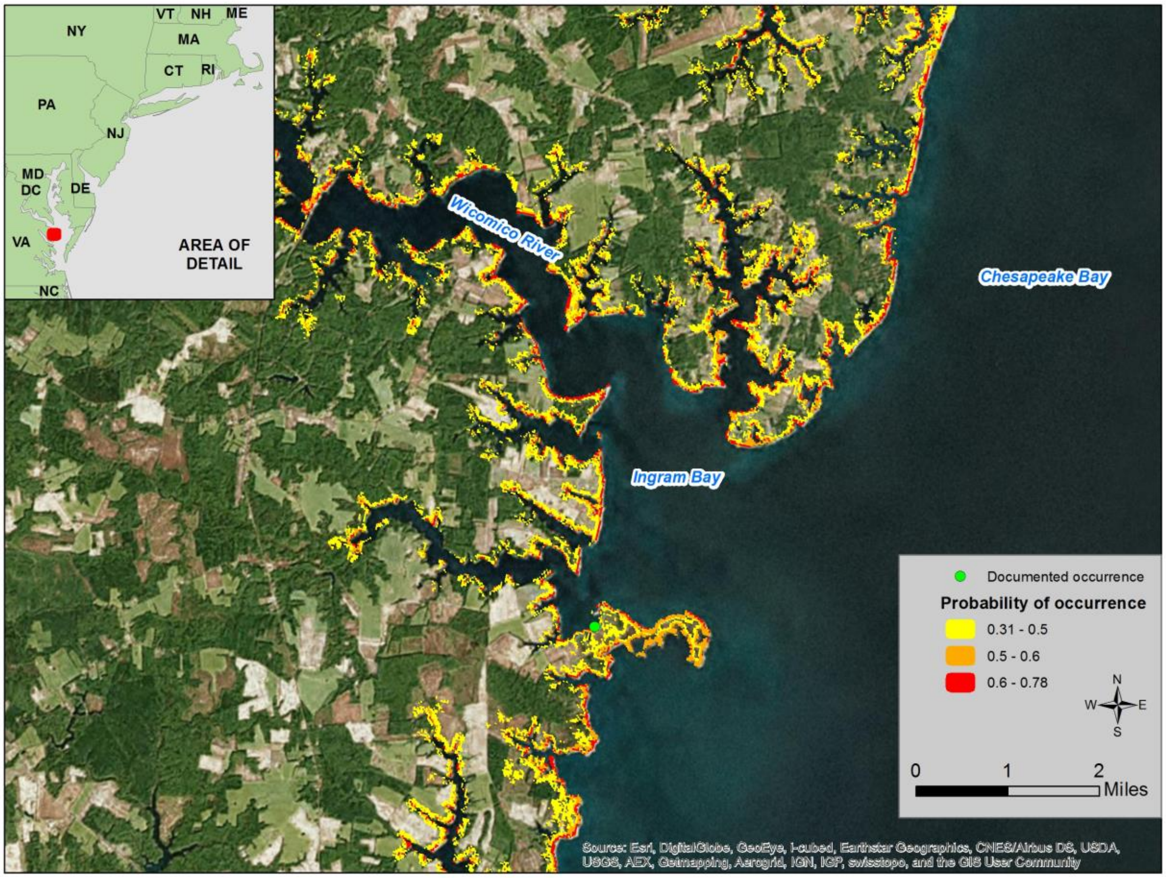



**Figure 24. Ingram Bay, VA. This area is a potential focal area for terrapin surveys as there is some documented terrapin occurrence; and, the model predicts there are areas of contiguous habitat and high probability of occurrence.**

Distance to estuarine emergent wetland and distance to shoreline were the most important indicators of terrapin occurrence (Table 12). Suitable nesting habitat is most likely to be found within 34 m of the nearest estuarine emergent wetland and within close proximity to the nearest shoreline (Figure 25). Although distance to shoreline was a significant predictor, the model indicated no preferred range of values for this variable. Land cover was also a significant predictor; estuarine emergent wetland, unconsolidated shore, and bare land are most preferred as suitable coastal habitat during nest excursions. The remaining land cover types predicted terrapin occurrence no better than random.

**Table 12. Permutation importance (%) of the model predictors.**

| VARIABLE | PERMUTATION IMPORTANCE (%) |
|---|---|
| Distance to estuarine emergent wetland | 41.4 |
| Distance to shoreline | 37.5 |
| Land cover | 14.7 |
| Elevation | 2.8 |
| Area of estuarine emergent wetland within 100-m radius | 1.6 |
| Shoreline type | 1.0 |
| Slope | 1.0 |

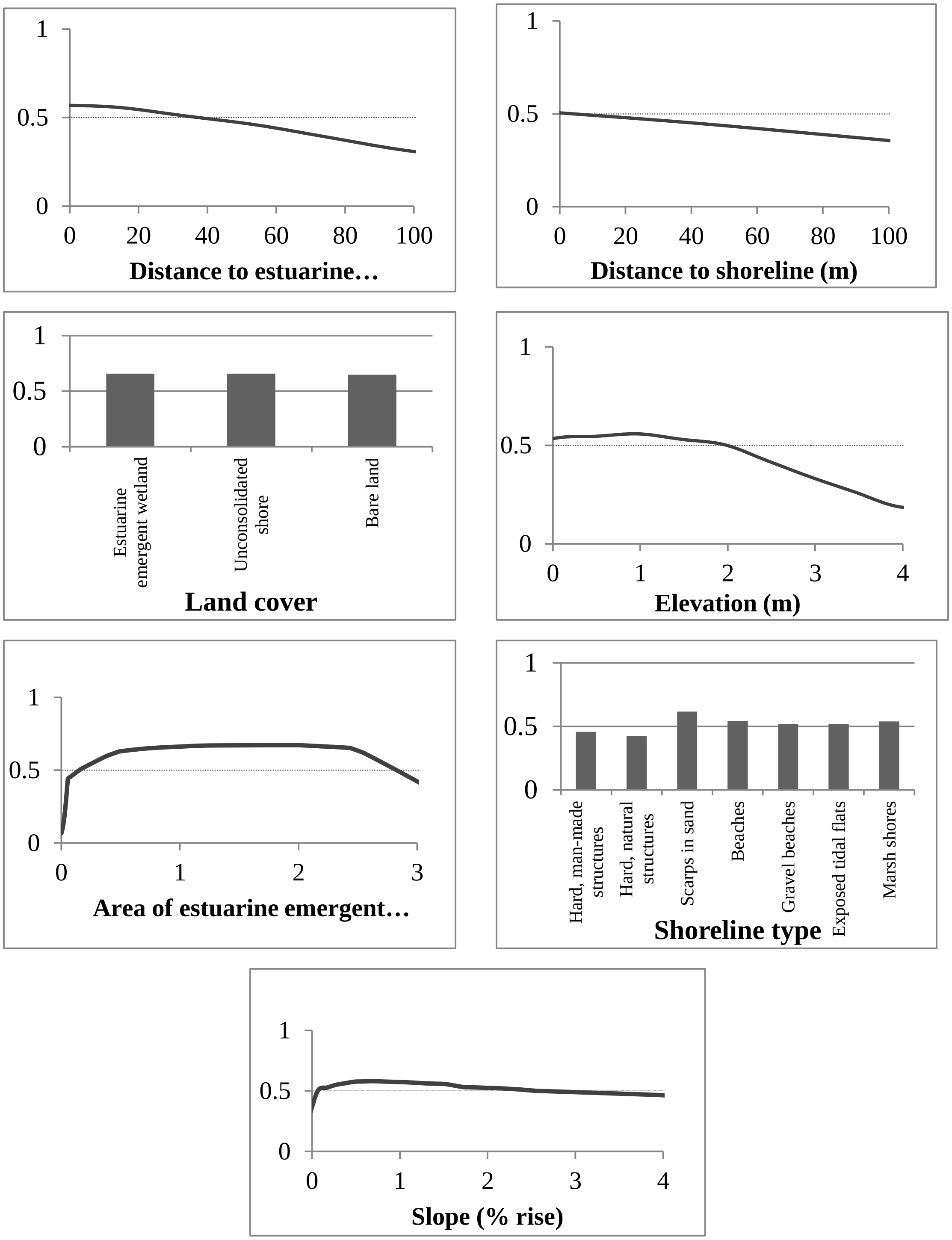



**Figure 25. The response curve for each model predictor plots probability of species presence (y-axis) against predictor values.**

Elevation, slope, shoreline type, and area of estuarine emergent wetland within 100-m radius contributed relatively low predictive power to the model; however, the response curves for these variables impart preferred metrics for terrapin habitat (Table 12, Figure 25). Nesting terrapins prefer low-lying areas, with an elevation between 0 – 2 m, and a slope of less than 2.8% gradient rise. Nest sites are most likely to be chosen where terrapins cross shorelines composed of beaches, marshes, or exposed tidal flats. The model also denoted shorelines of gravel beaches and scarps in sand as indicators of terrapin occurrence; however, these findings are thought to be idiosyncrasies caused by the model over-inflating the importance of these shoreline types due to their extreme rarity in the landscape. Shoreline types of hard man-made structures and hard natural structures predicted terrapin occurrence no better than random. Area of estuarine emergent wetland within a 100-m radius produced no preferred conditions, with suitable coastal habitat likely to occur across a wide range of 0.2 – 2.8 hectares.

## Discussion

We have generated the first regional scale distribution model for the northern diamondback terrapin. We synthesized disparate, wide-ranging occurrence data gathered from multiple sources to produce a regional species distribution model examining landscape-scale habitat factors influencing terrapin nest-site selection. The model results and accompanying maps provide valuable insight into habitat conditions preferred by this imperiled species, which can be used to inform future research and management decisions. We utilized datasets compiled across the species' range to generate map products that allow for multiple-scale examination of a threatened species. We demonstrate examples of these applications below.

### *Landscape-scale nest-site selection factors*

Model results reflected the terrapin's habitat fidelity for estuarine marshland, with distance to the nearest estuarine emergent wetland resulting in the highest percent permutation importance among model variables. Similarly, Isdell et al. (2015) found that proportion of marsh was the most significant variable positively associated with terrapin occurrence, compared to other environmental variables. However, the wide range of preferred area of estuarine emergent wetland within a 100-m radius, coupled with this variable's low predictive power, suggest that terrapins are less selective about the amount of marshland coverage near the nest site. Rather, proximity to marsh appears to be the more critical factor.

The importance of proximity to the shoreline closely matched that described in other studies as well, including a habitat suitability model which found that areas beyond 250 m from the shoreline were considered unsuitable for nesting (Palmer and Cordes 1988, Feinberg and Burke 2003, Butler et al. 2004). Terrapins have been found mostly to travel short distances (< 10 m) from the water to their nest sites (Burger and Montevecchi 1975, Roosenburg 1994, Roosenburg and Place 1994), with < 1% travelling great distances (> 200 m).
Land cover types of estuarine emergent wetland, unconsolidated shore (i.e. beach), and bare land (i.e. sand dunes with < 10% vegetative cover) represent the open, sandy areas utilized by terrapins during nesting (Burger and Montevecchi 1975, Roosenburg 1991, Mitchell and Walls

2013). The remaining land cover types were not predictors of suitable coastal habitat during nesting; among these are developed areas known to be used by terrapins despite being poor choices of habitat. Due to expanding coastal development and loss of natural habitat, terrapins often must migrate through and may even nest in sandy or grassy patches in coastal residential yards (Mitchell and Walls 2013, Winters 2013, Moss 2015), where human activity such as mowing and construction keep vegetation sparse (Kolbe and Janzen 2002). Such areas are considered ecological traps, as adult and hatchlings alike are subject to increased mortality rates from vehicle collisions and the increased presence of human-subsidized predators such as crows and raccoons (Roosenburg 1994, Roosenburg and Place 1994, Schlaepfer et al. 2002).

Elevation and slope reflected low predictive power in the model, consistent with habitat studies throughout the northeast and mid-Atlantic, which reveal regional geographic variations among nesting habitat. Nest elevations varied among sites within the Chesapeake Bay (Roosenburg and Place 1994), with some successful nests occurring on flat beaches along the shores of the Patuxent River, MD (Roosenburg 1994), while in NJ, terrapins were found to nest in high dunes (Burger and Montevecchi 1975). Terrapins also nest on varying elevations of roadsides, construction areas, and residential areas (Wood and Herlands 1997, Szerlag and McRobert 2006, Szerlag-Egger and McRobert 2007, Wnek 2010, Moss 2015). The preference for shallow slopes, which facilitate the digging of nests and mitigate nest erosion and exposure, is consistent with the literature; however, the model suggests that even shallower slopes (< 2% rise) are preferred, whereas Burger & Montevecchi's (1975) New Jersey study found terrapins to nest on an average slope of 12% rise.

Model results for shoreline type mirrored the importance of land-aquatic linkages that facilitate upland movement for terrapins. Terrapins are more likely to nest in areas accessible via natural shorelines of beaches, marshes, and tidal flats (Wnek 2010, Roosenburg et al. 2014, Isdell et al. 2015). Hard man-made structures, including bulkheads, riprap, and docks, act as barriers preventing terrapins from accessing nest sites from the water (Wnek 2010, Roosenburg et al. 2014). The model also denoted shorelines of gravel beaches and scarps in sand as indicators of terrapin occurrence. However, true scarps are not crossable by terrapins; when examined, only 2% of the occurrence points fell within the shoreline type zone of scarps in sand, and none fell within gravel beaches. Within the study area, both these variables made up < 1.5% of all shoreline types. Terrapins are capable of nesting on the other side of short, fragmented sections of scarps by accessing those areas from neighboring crossable shorelines, such as beach or marsh. The model's designations of these variables as predictors of suitable habitat are overinflated by their rarity in the landscape.

***Regional scale conservation***

Our model serves as a foundation from which conservation questions can be asked and management actions can be developed and implemented. One use of the regional model is the ability to identify and evaluate poorly documented areas, which may have fallen outside the jurisdictions of local conservation efforts. Other data gaps, such as the lack of confirmed terrapin occurrences in areas predicted suitable by the model, may become candidate locations for additional field investigations that would allow for more refined delineations of suitable habitat and provide explanations for these unoccupied areas. Conservation applications can be derived from the model at multiple scale levels (e.g. county, state, regional) depending on management goals. Among the topics that can be investigated using this model are evaluation of priority areas for conservation, threat assessments of anthropogenic stressors, and the effects of sea level rise.

**Model Applications and Future Research**

***Establishing areas for restoration and protection***

The protection and restoration of existing habitat and the creation of new habitat for imperiled species hinges on the management practitioner's ability to identify prospective areas in the landscape. Candidate areas for terrapins must support habitat features that drive nest site selection. Terrapins have been shown to successfully detect and utilize newly created and restored nesting habitat (Roosenburg et al. 2014), which bodes well for management plans that seek to attract terrapins from threatened populations both within and beyond local systems. We demonstrate how the regional model can be used to identify areas for evaluation of restoration or protection potential.

We identified suitable nesting habitat across the study area by applying a threshold to the continuous surface of probabilities of occurrence and converting it to a binary map delineating preferred and not preferred habitat (Figure 26). Individual states or other governing entities can extract sections of the regional model to suit localized conservation needs by simply clipping the suitability map to their desired extent. Additionally, other threshold values can be applied to filter areas of relative suitability; any threshold deemed appropriate for meeting management goals and logistical constraints can be assigned. For example, we identified approximately 9,200 ha of suitable nesting habitat in RI and 23,000 ha in MA using the 10th percentile training presence threshold value (0.3188) (Figure 27a and 27b). These areal extents may be appropriate for a smaller state such as RI to consider for management actions, but impractical for larger territories. With a larger area of interest in question, management practitioners may only wish to protect habitats where nesting is almost certain and thus choose a higher threshold probability to trigger evaluation. Figure 27c and 27d shows preferred coastal habitat where probabilities of occurrence meet or exceed a threshold of 0.5. These restricted areas may be more feasible for consideration.

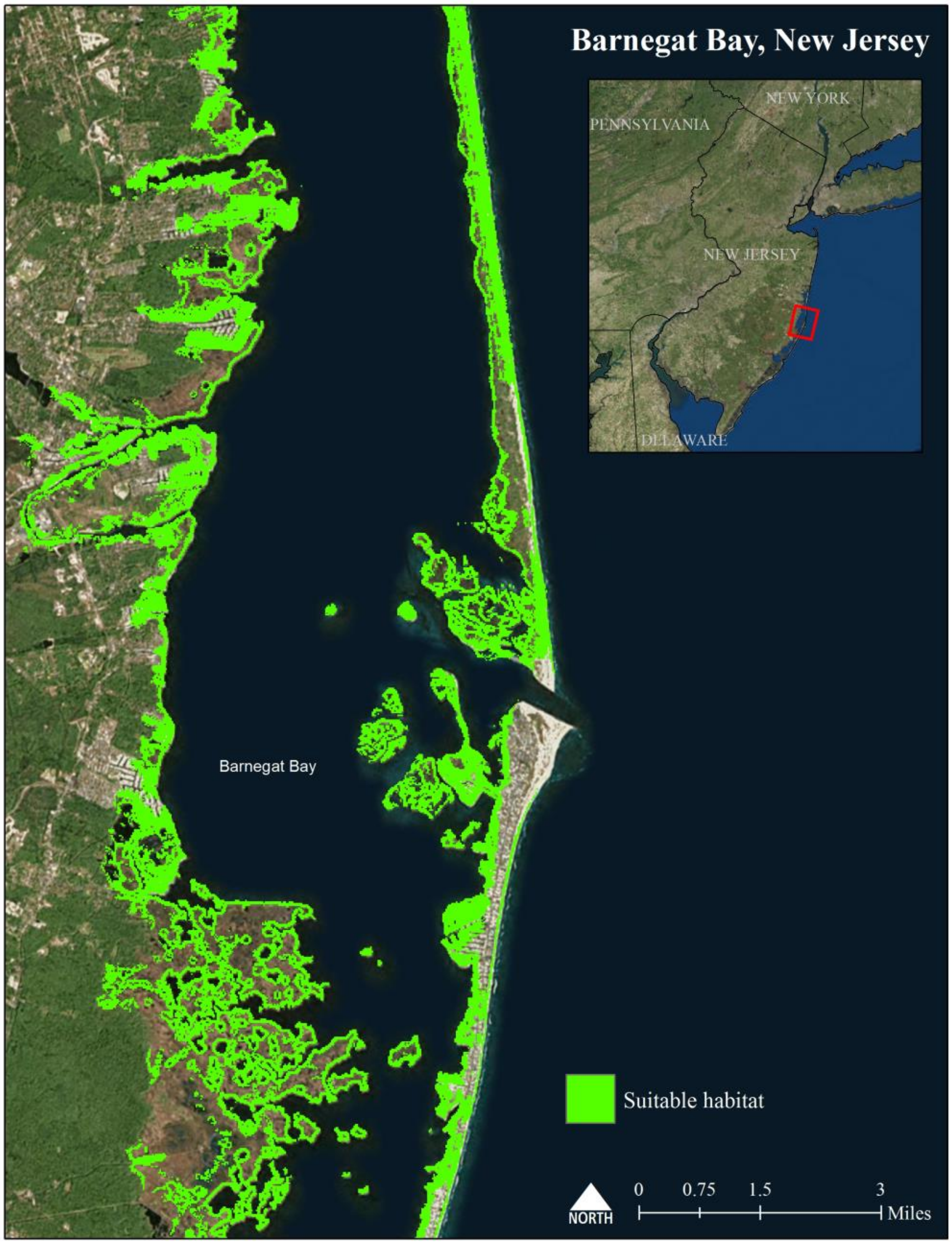



**Figure 26. Detail of suitable terrapin nesting habitat at Barnegat Bay, New Jersey, showing areas where probabilities of occurrence exceeded the 10th percentile training presence.**

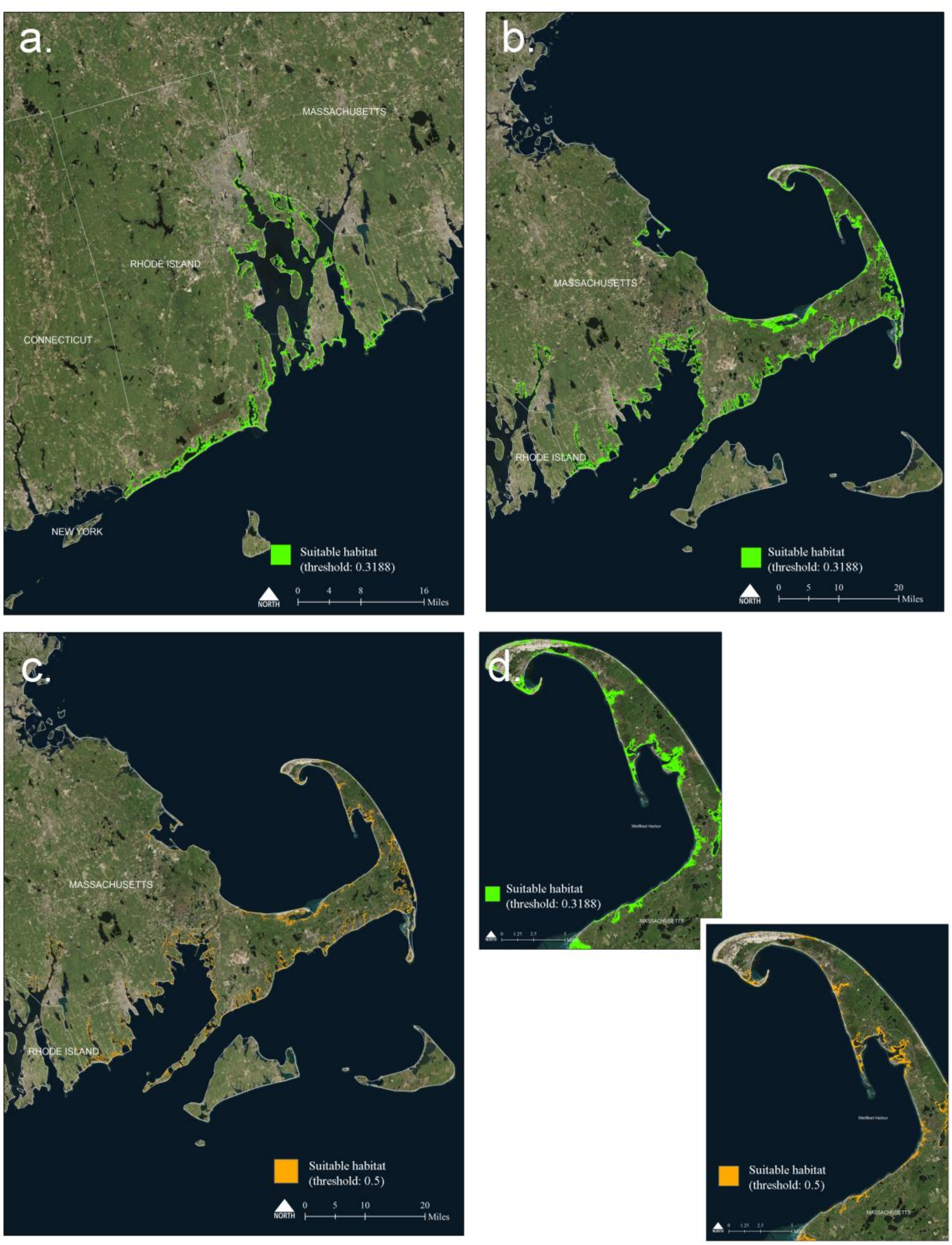



**Figure 27. Alternative threshold values used to designate preferred coastal habitat can be applied depending on management goals and logistical constraints such as the size of the area of interest. Using the 10th percentile training threshold (0.3188), ~ 9200 ha are designated as suitable coastal habitat in Rhode Island (a.) while ~23,000 ha are designated in Massachusetts (b.). These extents may be suitable for a small state such as Rhode Island, but unfeasible for larger management units. Conservation practitioners may wish to target areas with greater nesting certainty and apply a higher threshold to restrict manageable areas. For example, using a threshold of 0.5, ~10,800 ha are designated as preferred coastal habitat (c.). A detailed look at Wellfleet Harbor, MA shows the differences in areal coverage between the applied thresholds (d.).**

### *Target areas for abandoned crab pot removal*

Derelict or abandoned crab pots, also known as “ghost pots”, continuously attract and entrap terrapins for as long as they are left in the water (Bishop 1983, Roosenburg 1991, Roosenburg et al. 1997, Wood 1997). Bycatch reduction devices fitted in the openings of crab pots are effective in reducing the number of terrapins caught (Cuevas et al. 2000, Butler and Heinrich 2007); however, juvenile females and the majority of all male terrapins, due to their smaller size, are still able to fit through such devices (Bishop 1983, Roosenburg et al. 1997). Bycatch mortality in commercial crab pots is believed to be the cause of female-biased populations in areas with prevalent crabbing activity (Dorcas et al. 2007), in addition to population declines and reduced growth (Hoyle and Gibbons 2000, Gibbons et al. 2001, Wolak et al. 2010). The removal of derelict crab traps from waters occupied by terrapins is critical for reducing bycatch mortality.

The model results can be used to prioritize areas for abandoned crab pot search and retrieval, and for consideration of seasonal crabbing bans (Figure 28). Entrapped terrapins are most frequently found in crab pots occurring in shallow waters ≤ 2 m in depth (Bilkovic et al. 2014), where abandoned traps often end up due to tidal action (Bishop 1983). Waters frequented by gravid terrapins are of particular concern. In Figure 28, areas where terrapins are most likely to encounter crab traps are highlighted by overlaying the map of suitable coastal habitat with bathymetry of the Chesapeake Bay.

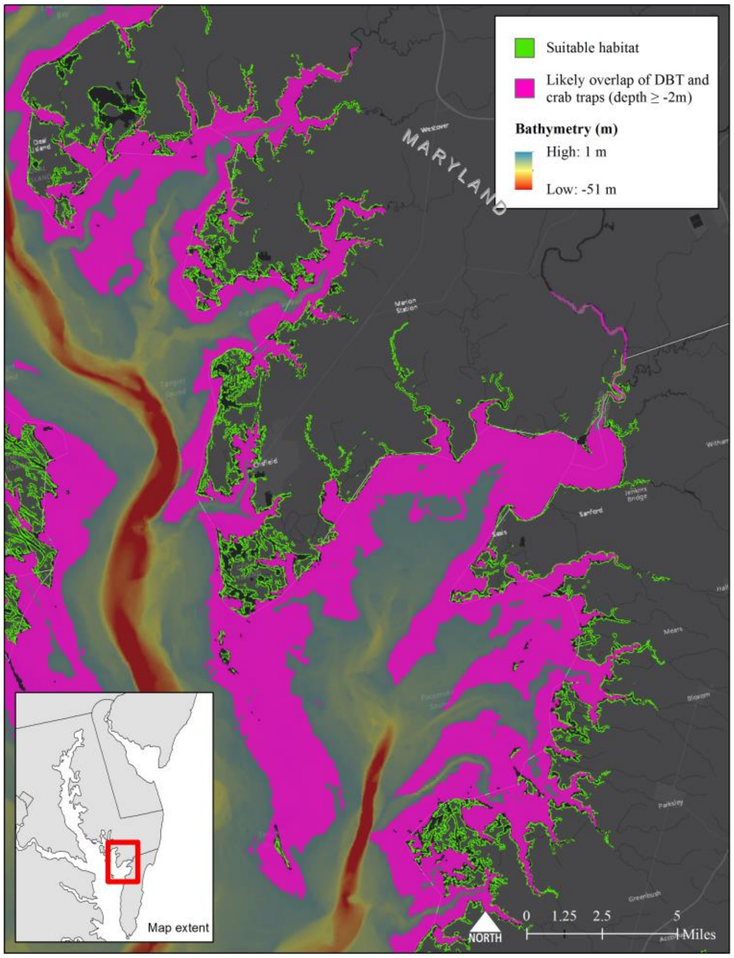



**Figure 28. Preliminary overlay analysis to identify candidate areas for abandoned crab pot removal or seasonal crabbing bans in a section of the Chesapeake Bay. Terrapins are more likely to encounter crab pots in shallow water (≤ 2 m deep, highlighted in magenta) and in waters bordering their suitable coastal habitat. Areas in green represent highly suitable coastal habitat for terrapins.**

### *Protection against vehicle collisions*

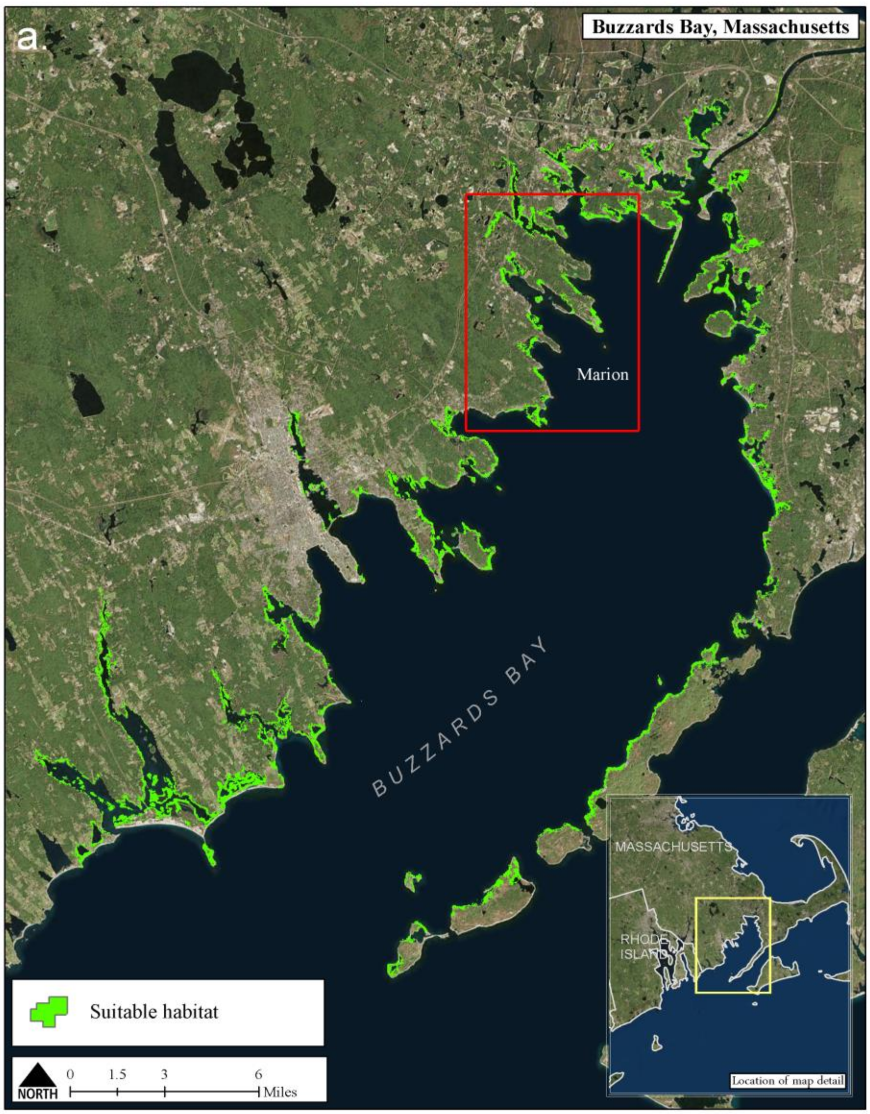
In areas closed to crabbing activity, vehicle strikes are likely the most detrimental anthropogenic factor affecting terrapin populations (Avissar 2006). In developed coastal areas, gravid females often must cross roads to reach nesting grounds and are subject to high rates of mortality (Wood and Herlands 1997, Szerlag and McRobert 2006, Crawford et al. 2015). The selective removal of mature females from the population by vehicle strikes is thought to skew population makeup towards a male bias, and is responsible for overall population declines (Avissar 2006, Steen et al. 2006). Management actions to mitigate road mortality include installing fences to prevent terrapins from entering roads; implementing speed limit reductions using signs or speed bumps; and closing roads during the nesting season (Aresco 2005). Identifying areas where terrapins are at greatest risk of encountering roads has been recommended as an important precursor for management action (Beaudry et al. 2010, Crawford et al. 2014). Suitable habitat during nesting excursions can be overlaid with road data to examine areas where female terrapins are likely to encounter roads (Figure 29). Roads that intersect this suitable coastal habitat can be selected for management actions.


**Figure 29. Preliminary overlay analysis to identify roads where terrapins on nesting excursions are at heightened risk of mortality. Terrapins accessing nesting areas that are intersected by roadways (red) are most vulnerable to vehicle strikes. Areas in green represent highly suitable coastal habitat for terrapins during nesting.**

### *Effect of sea level rise on habitat*

Sea level rise is a consequence of climate change that is expected to threaten biodiversity on a global scale (Galbraith et al. 2005, Menon et al. 2010). Coastal wetlands and the species that depend on these areas are at particular risk, with the inundation of low-lying marsh habitat resulting in the loss of foraging and nesting habitats (Najjar et al. 2000, Baker et al. 2006). Intertidal zones become permanently inundated, and the natural landward shift of habitat is blocked by man-made shoreline stabilization structures (Najjar et al. 2000).

The species distribution model can be used in conjunction with projected sea level rise maps to identify and quantify terrapin habitat at greatest risk of loss (Figure 30a-e).



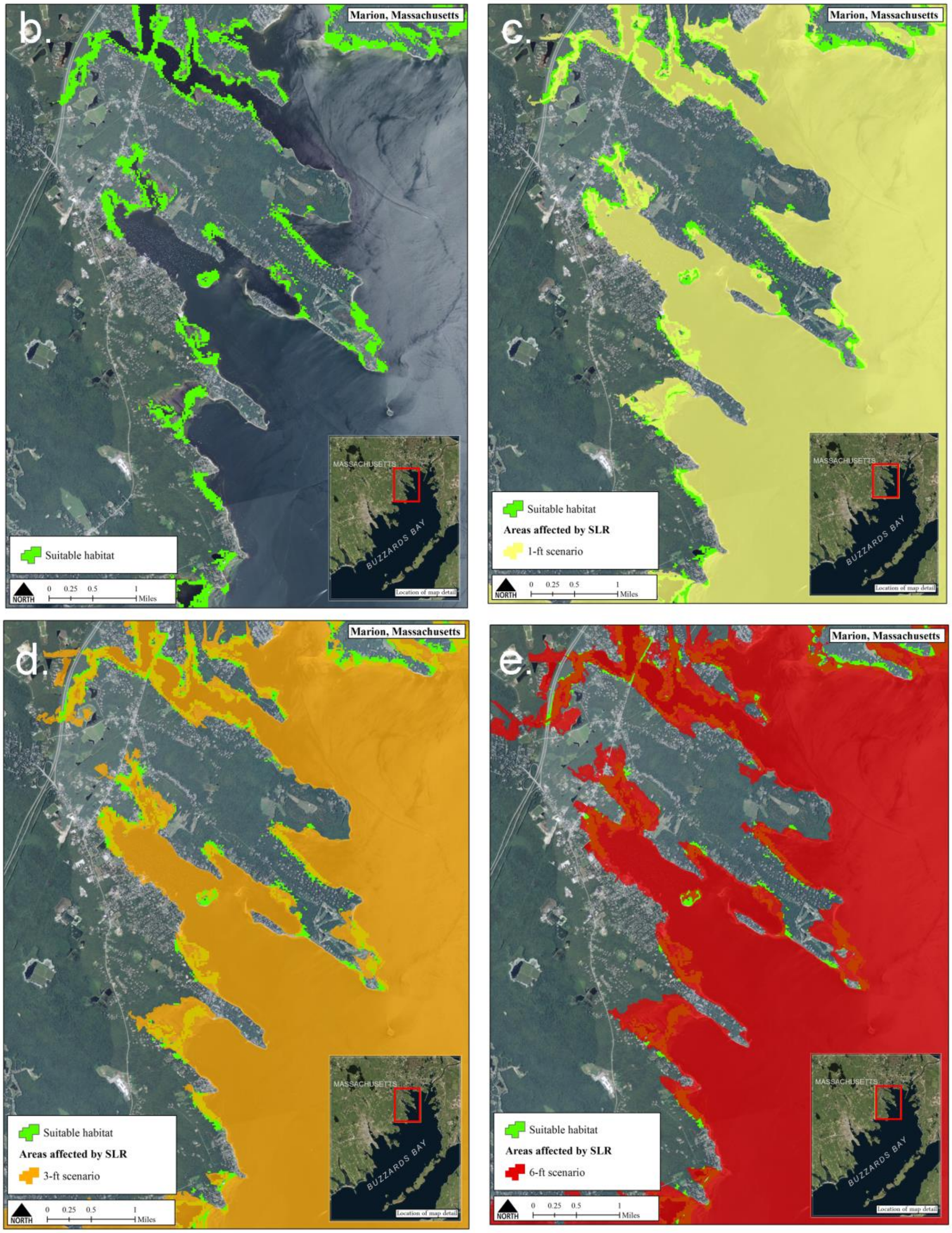



**Figure 30**(a-e): **Highly suitable coastal habitat, shown in green, in Buzzards Bay, MA total approximately 3965 ha (Figure 30a). The effects of sea level rise as projected by NOAA's DigitalCoast Sea Level Rise Viewer on habitat are displayed in a close-up of Marion, an estuary within Buzzards Bay (Figures 30b-30e). At just a 1-ft sea level rise scenario, over half of the suitable habitat is inundated and only 1861 ha of habitat remain (c). A 3-ft sea level rise leaves 1387 ha habitat remaining (c.), and at a 6-ft sea level rise nearly 80% of all habitat is inundated, with 876 ha remaining (d).**

Over half of the suitable habitat in Buzzards Bay, MA is lost under just a 1-ft sea level increase; nearly 80% is lost under a 6-ft sea level rise scenario. In addition to visualizing where current nesting habitats are directly impacted under sea level rise, the map can be used to identify suitable habitat to which terrapins may disperse to in response to the loss of this coastal habitat. These "safe" areas outside the projected at-risk zones can be proactively established as protection areas.

**Conclusion**

A grouped, region wide effort, strengthened by existing local efforts, may be the most effective formula for conserving biodiversity (Press et al. 1996). The population status survey taken by the DTWG revealed a need to understand terrapin populations, the sources of the greatest threats to populations, and which management actions should be prioritized (Butler et al. 2006). This demonstration of likeminded conservation priorities lends value to the importance of a grouped region wide effort and is being addressed in this Conservation Strategy. The collaboration of various federal and state agencies, NGOs and others, and the sharing of knowledge will streamline efforts to establish policies and execute this Conservation Strategy as well as other local or state management plans that may be developed in the future. Many management actions are facilitated by the support of numerous organizations. The transparency of sharing knowledge and specific research goals will also prevent needless overlapping of similar studies, so that funding resources may be better allocated. This regional Conservation Strategy allows each of the participating agencies to visualize the role of their own efforts in relation to others pursuing the same conservation actions. The maps produced from the compiled terrapin occurrence data provide a visual framework for researchers to formulate strategies beyond the scope of usual population perimeters and administrative boundaries.

## TERRAPIN POPULATION ESTIMATES AND TRENDS IN THE NORTHEAST

Studies of terrapins have generally focused on small areas and local populations. No statewide or even regional assessments have been done to determine overall population size and trends. That said, population studies have occurred for local populations using mark/recapture over many years throughout some of the NE states including MA, RI, NY, and NJ.

### Rhode Island - Doug Rayner Wildlife Sanctuary at Nockum Hill, Hundred Acre Cove

The BLCT has been collecting data on terrapins at Doug Rayner Wildlife Sanctuary at Nockum Hill, Hundred Acre Cove since 1991. This local population has been estimated at 588 terrapins (Sornborger 2015). There is evidence of a decline in the numbers of new females when evaluating data from 1991-2015 (Figure 31, Sornborger 2015); however, the cause of this decline is unknown. The main potential threat to this population now is sea level rise and the degradation of the marshes, but the impacts on the population are unclear. Other potential threats including vehicles, boat propellers, and development are considerably less because of the actions implemented at this study site (i.e. prohibition of vehicles, dog, and motorboat speeds in excess of 5 mph by ordinance) (Sornborger pers. comm. 2015).

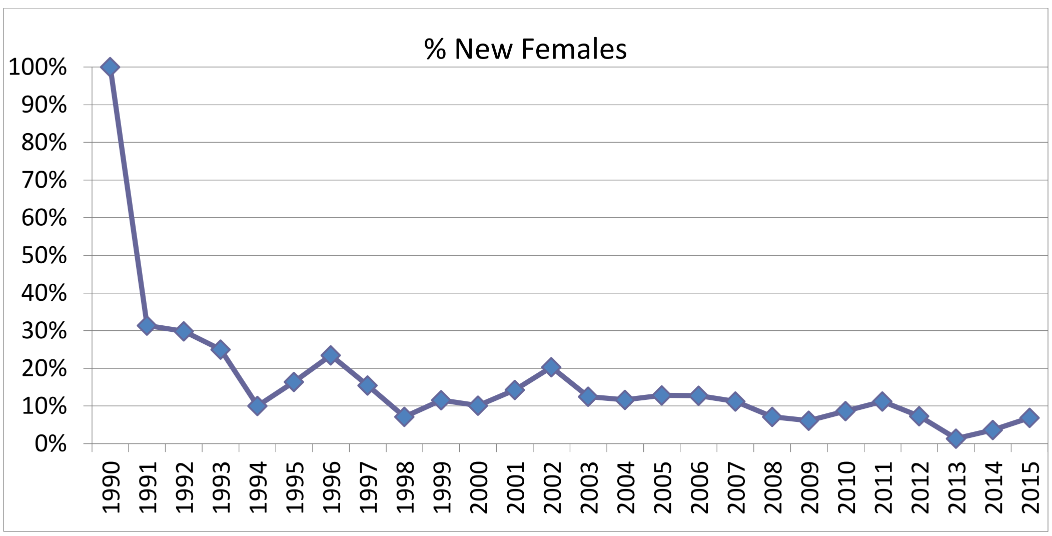



**Figure 31. The percentage of new nesting females at Doug Rayner Wildlife Sanctuary at Nockum Hill in Barrington, RI from 1991 to 2015. A decline in the number of new nesting females is detected. Used with permission, C. Sornborger, Project Leader Barrington Land Conservation Trust 2015.**

## New Jersey

### *North Sedge Island and Spizzle Creek, Barnegat Bay*

Project Terrapin (MATES) has been conducting mark/recapture on a local terrapin population at North Sedge Island and Spizzle Creek, Barnegat Bay, NJ since 2003. The North Sedge Island population is estimated between 385 and 476 individual adult females from mark/recapture data (2002 to 2009) using MARK (POPAN – Jolly Seber) (Wnek 2014). The other population monitored by Wnek (2014), Spizzle Creek, has also been estimated using MARK (POPAN – Jolly Seber) to estimate the population of terrapins (males, females and juveniles) from mark/recapture data (2005 through 2007). The Spizzle Creek population is estimated between 1,216 and 2,010 individuals. Of note, there was a 1.88:1 female-bias in Spizzle Creek from 2005-2009. Four hundred thirty-seven female terrapins were captured versus 236 males and 70 juveniles with few recaptures in the years following (2010-2013) (Wnek 2014).

The North Sedge Island terrapin population has been declining over the past decade with the fewest recorded female terrapins landing (nesting) in 2015 (only 63 total terrapins) (J. Wnek pers. comm. 2015). The decline in the nesting females coupled with the low recruitment of nesting females (Figure 32) could indicate a future decline in the overall population at North Sedge Island. The nesting site at North Sedge Island is within the Sedge Island Marine Conservation Zone yet, 21% of the population has scars indicating boat injuries (J. Wnek pers. comm. 2015). This percentage is similar to other locations in Barnegat Bay (i.e., Forsythe Refuge - Barnegat Division) with a reported 18% injury rate of the local population and 11% of the population have injuries attributed to boats (Lester 2012, Lester et. al. 2013). A decrease in the number of terrapin nesting events has also been observed over the past eight years in other areas within the Sedge Island Marine Conservation Zone (i.e. southern Island Beach State Park [J. Wnek pers. comm. 2015]).

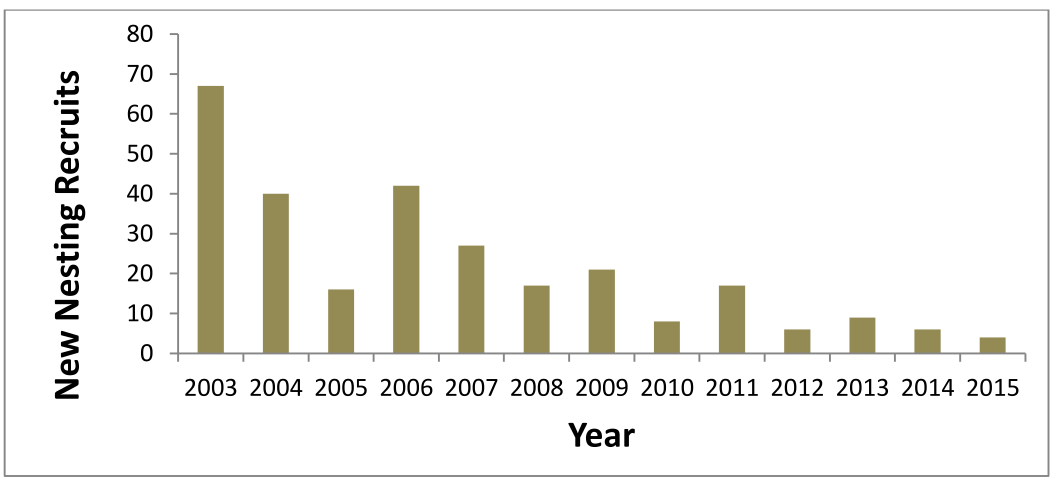



**Figure 32. New Recruits on North Sedge Island, Barnegat Bay, New Jersey. In 2002, 104 terrapins were marked and a decline in new nesting female terrapins has been observed over the last 13 years. Used with permission, J. Wnek, MATES 2015.**

***Cape May***

Since 1997, TWI has been conducting a long-term mark-recapture study of the terrapin population near Stone Harbor, NJ. Terrapins are captured by hand during nesting excursions or in traps placed in tidal creeks, and marked with PIT tags. In addition, TWI headstarts female terrapins in order to help mitigate threats to the local population, which include drowning in crab pots and road mortality (approx. 110 per year (2013-2015)). All headstarters over 6.4 cm in length are PIT tagged at release. Analysis of the full 19-year dataset is ongoing; however, the population of adult female terrapins that nested at TWI for the past three years has been estimated using MARK (Jolly Seber-POPAN). Results of this analysis indicate that the population of adult female terrapins that nest at TWI is 505.4 ± 1.9 individuals (TWI 2016, unpublished data). Future analyses will include all marked terrapins from all years in effort to better understand local terrapin population trends and annual survival probabilities.

**TERRPAIN POPULATION MODELING USING MARK/RECAPTURE IN THE NORTHEAST**

We present data from MA, RI, NY, and NJ where mark/recapture data was shared for this Conservation Strategy and adequate for population modeling. For each observed population, we cleaned the data by removing any individuals that did not have a clear tag so that they could be appropriately tracked throughout the study years. Then, the data was transformed so we had an IxT matrix, where I is the number of tagged individuals and T is the number years. This matrix is simply filled with Booleans indicating whether or not each individual was captured in each of the study years.

We used an individual Cormack-Jolly-Seber (CJS) model to estimate population sizes. This is an open-population model in which the population may change over time due to death. The input to the model consists of the IxT matrix mentioned previously, and the output is a population estimate for every time t excluding the first year (since there cannot be recaptures in the first year, by definition).

In the model, there are two Bernoulli parameters: $q_t$ (the probability that the animal survives until t+1) and $p_t$ (the probability that the animal alive at time t is captured at time t), as well as a latent discrete parameter $z_{i,t}$ that indicates for each animal I whether it is alive at time t.

More specifically, this was implemented as an individual CJS model in the language STAN, through the python package pystan, code attached below. We ran the model 500 times for each population, and present the estimates as mean and standard deviation across the 500 runs. We then correlated these mean estimates with the study years using a Pearson's correlation, to determine the trend for each population.

```
"""
functions {
 int first_capture(int[] y_i) {
  for (k in 1:size(y_i))
   if (y_i[k])
    return k;
  return 0;
 }
 int last_capture(int[] y_i) {
  for (k_rev in 0:(size(y_i) - 1)) {
   int k;
   k <- size(y_i) - k_rev;
   if (y_i[k])
    return k;
  }
  return 0;
 }
 vector prob_uncaptured(int T, vector p, vector phi) {
  vector[T] chi;
  chi[T] <- 1.0;
  for (t in 1:(T - 1)) {
   int t_curr;
   int t_next;
   t_curr <- T - t;
   t_next <- t_curr + 1;
   chi[t_curr] <- (1 - phi[t_curr])
          + phi[t_curr]
           * (1 - p[t_next])
```

```
                  * chi[t_next];
    }
   return chi;
   }
}

data {
  int<lower=2> T;
  int<lower=0> I;
  int<lower=0,upper=1> y[I,T];
}

transformed data {
  int<lower=0,upper=T> first[I];
  int<lower=0,upper=T> last[I];
  vector<lower=0,upper=I>[T] n_captured;
  for (i in 1:I)
    first[i] <- first_capture(y[i]);
  for (i in 1:I)
    last[i] <- last_capture(y[i]);
  n_captured <- rep_vector(0,T);
    for (t in 1:T)
      for (i in 1:I)
        if (y[i,t])
          n_captured[t] <- n_captured[t] + 1;
}

parameters {
  vector<lower=0,upper=1>[T-1] phi;
  vector<lower=0,upper=1>[T] p;
}

transformed parameters {
  vector<lower=0,upper=1>[T] chi;
  chi <- prob_uncaptured(T,p,phi);
}

model {
  for (i in 1:I) {
    if (first[i] > 0) {
      for (t in (first[i]+1):last[i]) {
        1 ~ bernoulli(phi[t-1]);
        y[i,t] ~ bernoulli(p[t]);
      }
      1 ~ bernoulli(chi[last[i]]);
    }
  }
}

generated quantities {
  real beta;
  vector<lower=0>[T] pop;
  beta <- phi[T-1] * p[T];
  pop <- n_captured ./ p;
  pop[1] <- 1;
}
"""
```

## Massachusetts – Wellfleet

We analyzed 3,779 mark/recapture records of reproductively mature female terrapins provided by Massachusetts Audubon, with contributions from many partners and organizations in MA from 1980 – 2013 (Table 13). We removed the first two years of estimates for Wellfleet because the standard deviation was too large. Using the CJS model, we found no significant increase of the population, but there appears to be a decline in the number of nesting females in Wellfleet beginning around 2010 (Figure 33). It should be noted that sampling effort for this population has been inconsistent and quite variable from year to year. There were some years when dip-netting was conducted in areas where it was known adults would be found to assist a graduate student with a tagging study, and other years when sampling only occurred once or twice the entire summer as part of a field school program (B. Brennessel pers. comm. 2016). A more consistent mark/recapture study is needed to make further conclusions regarding the status of the population in Wellfleet.

**Table 13. Annual numbers of recaptured and newly marked reproductively mature female terrapins as part of a mark-recapture study on M. terrapin of Wellfleet, Massachusetts, 1982-2013.**

| YEAR | NEW | RECAPTURE | TOTAL | % RECAPTURE |
|---|---|---|---|---|
| **1982** | 1 | 0 | 1 | 0.00 |
| **1983** | 5 | 0 | 5 | 0.00 |
| **1984** | 4 | 0 | 4 | 0.00 |
| **1986** | 2 | 0 | 2 | 0.00 |
| **1987** | 15 | 0 | 15 | 0.00 |
| **1988** | 26 | 2 | 28 | 7.14 |
| **1989** | 69 | 3 | 72 | 4.17 |
| **1990** | 81 | 18 | 99 | 18.18 |
| **1991** | 28 | 7 | 35 | 20.00 |
| **1992** | 52 | 11 | 63 | 17.46 |
| **1993** | 6 | 2 | 8 | 25.00 |
| **1994** | 13 | 1 | 14 | 7.14 |
| **1995** | 28 | 10 | 38 | 26.32 |
| **1996** | 23 | 8 | 31 | 25.81 |
| **1997** | 23 | 5 | 28 | 17.86 |
| **1998** | 53 | 4 | 57 | 7.02 |
| **1999** | 75 | 18 | 93 | 19.35 |
| **2000** | 149 | 58 | 207 | 28.02 |
| **2001** | 102 | 76 | 178 | 42.70 |
| **2002** | 209 | 128 | 337 | 37.98 |
| **2003** | 98 | 124 | 222 | 55.86 |
| **2004** | 66 | 100 | 166 | 60.24 |
| **2005** | 46 | 44 | 90 | 48.89 |
| **2006** | 77 | 67 | 144 | 46.53 |
| **2007** | 105 | 109 | 214 | 50.93 |
| **2008** | 124 | 116 | 240 | 48.33 |
| **2009** | 121 | 111 | 232 | 47.84 |
| **2010** | 102 | 85 | 187 | 45.45 |
| **2011** | 137 | 101 | 238 | 42.44 |
| **2012** | 57 | 65 | 122 | 53.28 |
| **2013** | 66 | 52 | 118 | 44.07 |

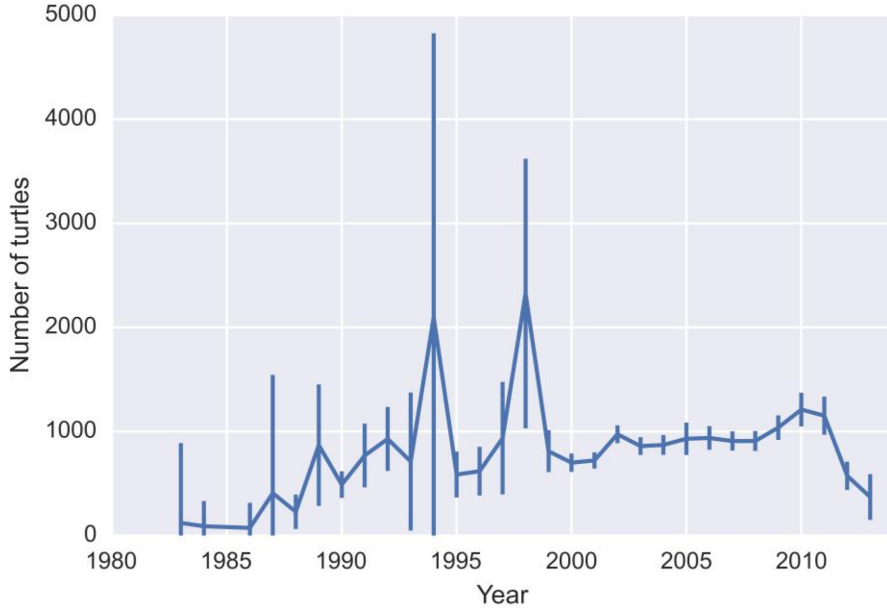



**Figure 33. In Wellfleet, Massachusetts, there has not been a significant increase detected in the adult female terrapin population from 1982-2013 (r=0.35, p= 0.06); however, there appears to be a declining trend in nesting females since 2010.**

**Rhode Island – Nockum Hill/Hundred Acre Cove**

We analyzed 437 mark/recaptures records of reproductively mature female terrapins by C. Sornborger as part of the BLCT from 1990 – 2015 (Table 14). Using the CJS model, we found an overall significant increase in the population; however, note the declining trend since 2012 (Figure 34).

**Table 14. Annual numbers of recaptured and newly marked reproductively mature female terrapins as part of a mark-recapture study on M. terrapin of Nockum Hill/Hundred Acre Cove, Rhode Island, 1990-2015.**

| YEAR | NEW | RECAPTURE | TOTAL | % RECAPTURE |
|---|---|---|---|---|
| **1990** | 78 | 0 | 78 | 0.00 |
| **1991** | 26 | 45 | 71 | 63.38 |
| **1992** | 32 | 55 | 87 | 63.22 |
| **1993** | 27 | 80 | 107 | 74.77 |
| **1994** | 7 | 55 | 62 | 88.71 |
| **1995** | 13 | 60 | 73 | 82.19 |
| **1996** | 19 | 67 | 86 | 77.91 |
| **1997** | 17 | 86 | 103 | 83.50 |
| **1998** | 6 | 53 | 59 | 89.83 |
| **1999** | 10 | 64 | 74 | 86.49 |
| **2000** | 13 | 92 | 105 | 87.62 |
| **2001** | 15 | 97 | 112 | 86.61 |
| **2002** | 29 | 121 | 150 | 80.67 |
| **2003** | 15 | 109 | 124 | 87.90 |
| **2004** | 15 | 119 | 134 | 88.81 |
| **2005** | 11 | 78 | 89 | 87.64 |
| **2006** | 18 | 126 | 144 | 87.50 |
| **2007** | 14 | 102 | 116 | 87.93 |
| **2008** | 9 | 106 | 115 | 92.17 |
| **2009** | 7 | 109 | 116 | 93.97 |
| **2010** | 12 | 111 | 123 | 90.24 |
| **2011** | 9 | 84 | 93 | 90.32 |
| **2012** | 20 | 157 | 177 | 88.70 |
| **2013** | 2 | 153 | 155 | 98.71 |
| **2014** | 5 | 139 | 144 | 96.53 |
| **2015** | 8 | 114 | 122 | 93.44 |

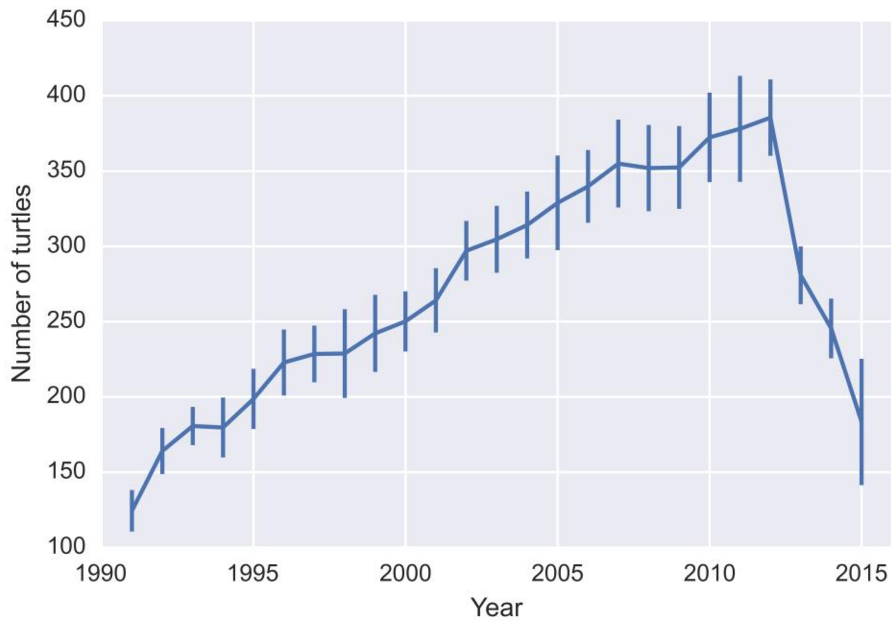



**Figure 34. In Nockum Hill/Hundred Acre Cove, Rhode Island there has been a significant increase of the reproductively mature female terrapin population from 1991-2015 (r=0.69, p=0.0002); however there appears to be a declining trend since 2012.**

### New York –Jamaica Bay and Oceanside Marine Nature Study Area

In Jamaica Bay there has been a decline in the number of terrapin nests from a high of 2,040 nests to 1,032 nests per year with some females laying fewer but larger clutches (Burke and Francoeur 2014). Our modeling for NY shows at least one population that is significantly declining (N. Neeman, Via/Hofstra University, pers. comm. 2015). We analyzed 2,828 records mark/recapture records of reproductively mature female terrapins for Jamaica Bay (provided by R. Burke) (Table 15) and 217 for the Oceanside Marine Nature Study Area (provided by M. Farina) (Table 16). Using CJS model a significant decline was detected for Jamaica Bay over the last decade (Figure 35). We removed the first year of estimates for Jamaica Bay because the standard deviation was too large. The decline of the Oceanside Marine Nature Study Area was not as evident compared to Jamaica Bay and determined to be not significant (Figure 36). However, there does appear to be a declining trend in the population. The number of terrapins analyzed in the Ocean Marine Nature Study Area was very small and there were some oscillations in the first few years. The cause of population decline in Jamaica Bay is unclear at this time. There is essentially no harvest of any kind, deliberate or bycatch in those waters. Marshes are continuing to decline throughout most of the bay, with the cause of decline uncertain. Most major pollutants have lessened, but pharmaceuticals have increased (R. Burke pers. comm. 2015).

## *Jamaica Bay*

**Table 15. Annual numbers of recaptured and newly marked reproductively mature female terrapins as part of a mark-recapture study on M. terrapin of Jamaica Bay, New York, 2001-2015.**

| YEAR | NEW | RECAPTURE | TOTAL | % RECAPTURE |
|---|---|---|---|---|
| **2001** | 11 | 0 | 11 | 0.00 |
| **2003** | 147 | 0 | 147 | 0.00 |
| **2004** | 152 | 27 | 179 | 15.08 |
| **2005** | 123 | 42 | 165 | 25.45 |
| **2006** | 32 | 16 | 48 | 33.33 |
| **2007** | 62 | 40 | 102 | 39.22 |
| **2008** | 80 | 64 | 144 | 44.44 |
| **2009** | 155 | 162 | 317 | 51.10 |
| **2010** | 156 | 257 | 413 | 62.23 |
| **2011** | 64 | 141 | 205 | 68.78 |
| **2012** | 49 | 96 | 145 | 66.21 |
| **2013** | 41 | 136 | 177 | 76.84 |
| **2014** | 83 | 123 | 206 | 59.71 |
| **2015** | 58 | 138 | 196 | 70.41 |

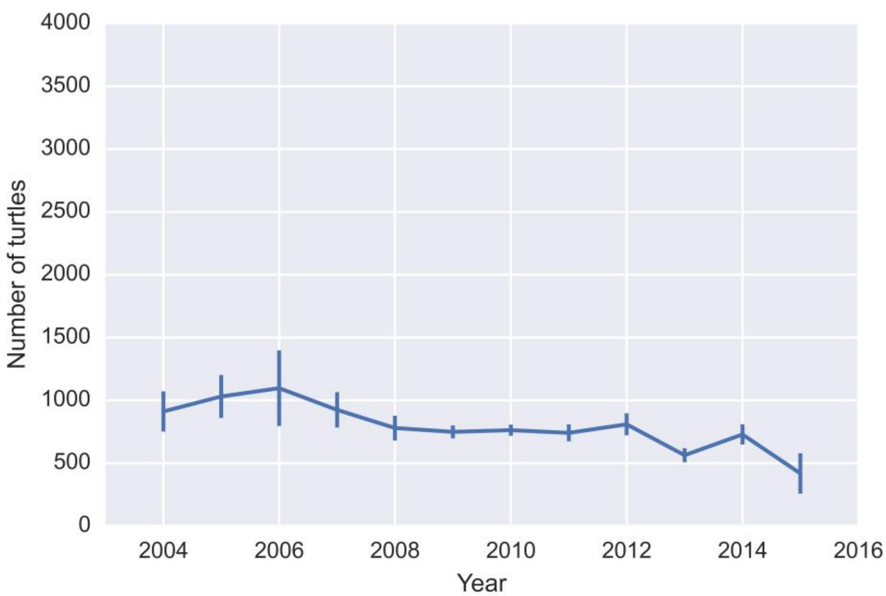



**Figure 35. In Jamaica Bay, New York, there is a visible and significant declining trend of the reproductively mature female terrapin population from 2004-2015 (r=-0.85, p=0.0005).**

### *Oceanside Marine Nature Study Area*

**Table 16. Annual numbers of recaptured and newly marked reproductively mature female terrapins as part of a mark-recapture study on M. terrapin of Oceanside Marine Nature Study Area, New York, 1999-2014.**

| YEAR | NEW | RECAPTURE | TOTAL | % RECAPTURE |
|---|---|---|---|---|
| **1999** | 4 | 0 | 4 | 0.00 |
| **2000** | 14 | 3 | 17 | 17.65 |
| **2001** | 6 | 2 | 8 | 25.00 |
| **2002** | 11 | 6 | 17 | 35.29 |
| **2003** | 2 | 7 | 9 | 77.78 |
| **2004** | 5 | 4 | 9 | 44.44 |
| **2005** | 2 | 9 | 11 | 81.82 |
| **2006** | 0 | 11 | 11 | 100.00 |
| **2007** | 1 | 3 | 4 | 75.00 |
| **2008** | 3 | 8 | 11 | 72.73 |
| **2009** | 4 | 7 | 11 | 63.64 |
| **2010** | 6 | 10 | 16 | 62.50 |
| **2011** | 3 | 10 | 13 | 76.92 |
| **2012** | 3 | 8 | 11 | 72.73 |
| **2013** | 0 | 10 | 10 | 100.00 |
| **2014** | 6 | 8 | 14 | 57.14 |

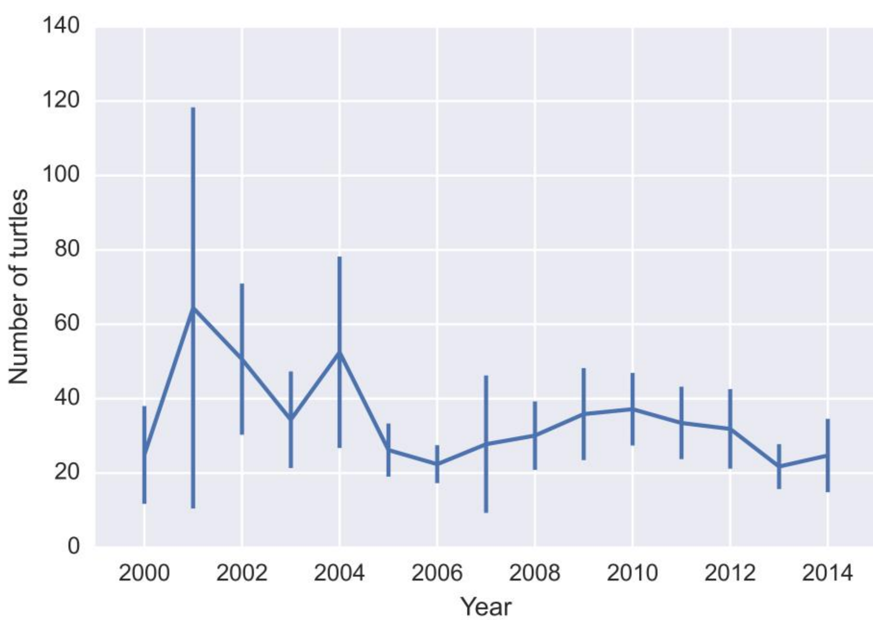



**Figure 36. At the Marine Nature Study Area in Oceanside, New York, we did not see a significant decline; however there appears to be a declining trend of the nesting female terrapin population from 2000-2014 (r= -0.48, p=0.068).**

## New Jersey – Hackensack Meadows and North Sedge Island

We analyzed 140 mark/recaptures records of reproductively mature females provided for the Hackensack Meadowlands from 2009 – 2013 (provided by B. Bragin) (Table 17) and 607 mark/recaptures records provided by MATES (J. Wnek) for North Sedge Island (Barnegat Bay) from 2004–2015 (Table 18). Using the CJS model, we did not find significant decreases in either the Hackensack Meadowlands or North Sedge Island; however, there does appear to be a declining trend occurring in both populations (Figure 37 and 38). Additional years of data are needed from the Hackensack Meadowlands in order to draw further conclusions.

The greatest concern on North Sedge Island is the decline in recruitment of new nesting females to the island (see previous Figure 32). North Sedge Island is within the Sedge Island Marine Conservation Zone preventing commercial harvests, crab potting, and other activities. The decline in nesting females may indicate that female terrapins travel greater distances than males and juveniles and may be subject to greater sources of mortality. It may also indicate that adult female terrapins may be undergoing mortality over the winter in their brumation areas. With a continued decline, the trend may become significant within the next few years.

### *Hackensack Meadowlands*

**Table 17. Annual numbers of recaptured and newly marked reproductively mature female terrapins as part of a mark-recapture study on M. terrapin of the Hackensack Meadowlands, New Jersey, 2009-2013.**

| YEAR | NEW | RECAPTURE | TOTAL | % RECAPTURE |
|---|---|---|---|---|
| **2009** | 14 | 0 | 14 | 0.00 |
| **2010** | 19 | 7 | 26 | 26.92 |
| **2011** | 24 | 19 | 43 | 44.19 |
| **2012** | 4 | 18 | 22 | 81.82 |
| **2013** | 2 | 13 | 15 | 86.67 |

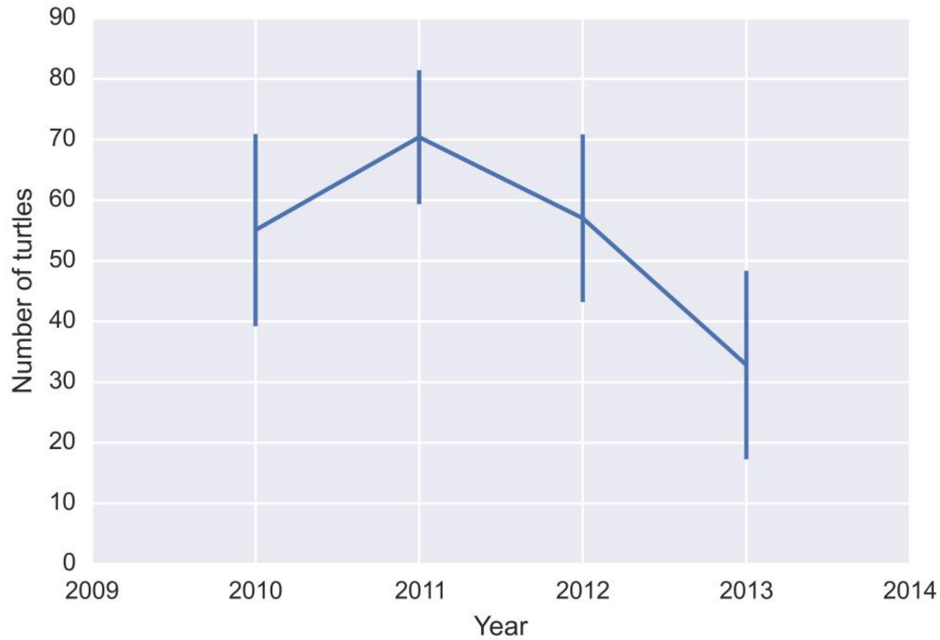



**Figure 37. In the Hackensack Meadowlands, New Jersey, we did not see a significant decline in the reproductively mature female terrapin population; however there appears to be a declining trend (r=-0.66, p=0.34).**

## *North Sedge Island – Barnegat Bay*

**Table 18. Annual numbers of recaptured and newly marked female terrapins as part of the mark-recapture study on M. terrapin of North Sedge Island, Barnegat Bay, New Jersey, 2004-2015.**

| YEAR | NEW | RECAPTURE | TOTAL | % RECAPTURE |
|---|---|---|---|---|
| **2004** | 57 | 0 | 57 | 0.00 |
| **2005** | 36 | 17 | 53 | 32.08 |
| **2006** | 21 | 9 | 30 | 30.00 |
| **2007** | 51 | 23 | 74 | 31.08 |
| **2008** | 5 | 15 | 20 | 75.00 |
| **2010** | 39 | 35 | 74 | 47.30 |
| **2011** | 40 | 44 | 84 | 52.38 |
| **2012** | 18 | 46 | 64 | 71.88 |
| **2013** | 16 | 48 | 64 | 75.00 |
| **2015** | 12 | 50 | 62 | 80.65 |

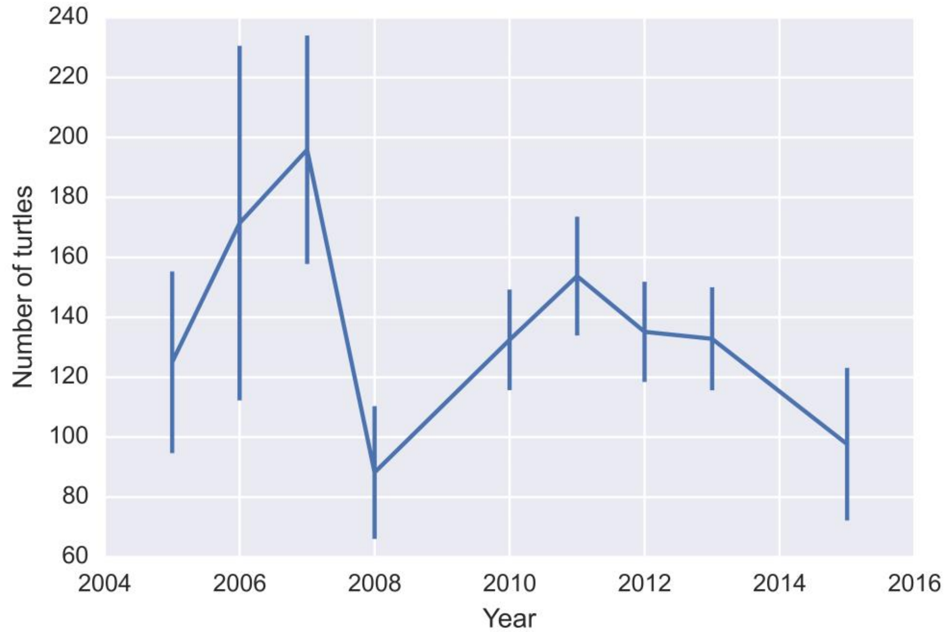



**Figure 38. At North Sedge Island, Barnegat Bay, New Jersey, we did not see a significant decline in the terrapin population; however, there appears to be a declining trend from 2005-2015 (r=-0.39, p=0.303).**

## LAW ENFORCEMENT CASES

Requests to federal and state law enforcement (LE) for cases on terrapin were made for a 15 year time period (2000-2014), but yielded few results overall for the NE region. Information was obtained for NY (7 cases), NJ (15 cases), MD (31 cases), and CT (one case is still pending). In RI, no cases have been prosecuted in relation to terrapins (Captain J. McIlmail, RI Department of Environmental Management, Division of LE pers. comm. 2015). In CT, a search of records revealed no enforcement cases involving terrapins. All CT turtle cases involved spotted, painted, or snapping turtles. However, there is an ongoing investigation of terrapins, but the information is unable to be released due to the active nature of the case (Colonel K. Overturf, CT DEEP, Director-State Environmental Conservation Police pers. comm. 2015).

### Federal Cases

The Freedom of Information Act request to the USFWS, Division of LE returned three closed investigations, all of which were related to the pet trade/and or exportation of terrapin; however, none of these occurred in the Northeast Region. We were made aware of a case that began in late 2014 and was still open at the time of the FOIA request (USFWS 2014). An aquaculture facility in MD (who was operating under an Aquaculture Permit with MD) sold 14,600 terrapin hatchlings to buyers in Louisiana. These hatchlings did come from the largest production facility for terrapins and is recognized as such by the USFWS. Terrapins are then to be sold to U.S. buyers who export the turtles. The USFWS CITES reviewed permit applications from a turtle farer/export in Louisiana for 7,000 and 7,600 terrapin hatchlings that were produced from the aquaculture facility. It was found that the hatchlings were produced by a purchase of 3,522 wild-caught terrapins from collectors in NJ (2013 and 2014) most of which were female and gravid. During the time of this case, NJ did have an open season on terrapins from November 1 to March 31 with an unlimited number allowed to be collected as long as they were taken by hand and with no reporting requirements. Expert opinion believes it would have been difficult for that many terrapins to be captured by hand during that time of the year (USFWS 2014).

### State Cases

#### *New York*

In NY, seven LE cases were provided - two in 2004 and 2005 for the sale of terrapins in Asian markets, a 2006 case for the possession of terrapins and other exotic species, a 2007 case for dead terrapins in a crab pot, a 2011 case for terrapin nest disturbance, and a 2012 and 2013 case of a terrapin being sold on the internet as a pet. The most recent case (2013) occurred in Richmond County (Staten Island). A terrapin and other exotic species were being sold over the internet as pets. The terrapin was retrieved and a summons was issued for "*Posses/Offer for sale of protected wildlife*." The 2006 case occurred in Suffolk County where a person had possession of several exotic species including seven terrapins and other exotic species (box turtle *spp*., snapping turtle, a tortoise, and other reptiles). The defendant was issued 10 NY

State ECATs (Environmental Conservation Appearance Tickets) for violations of possessing the above species under the following NY State Rules and Regulations:

***Environmental Concern Law - 11-0535 (2)***
*Endangered and threatened species, species of special concern*
*2. Notwithstanding any other provision of this chapter, the taking, importation, transportation, possession or sale of any endangered or threatened species of fish, shellfish, crustacea or wildlife, or hides or other parts thereof, or the sale or possession with intent to sell any article made in whole or in part from the skin, hide or other parts of any endangered or threatened species of fish, shellfish, crustacea or wildlife is prohibited, except under license or permit from the department.*

***Environmental Concern Law 11-0512 (1)***
*Possession, sale, barter, transfer, exchange and import of wild animals as pets prohibited*
*1. No person shall knowingly possess, harbor, sell, barter, transfer, exchange or import any wild animal for use as a pet in New York state, except as provided in subdivision three of this section.*

***Environmental Concern Law - 11-0107 (2)***
*Application of Fish and Wildlife Law*
*2. No person shall, at any time of the year, buy, sell, offer or expose for sale, transport, or have in his possession any fish protected by law, game, protected wildlife, shellfish, harbor seals, crustacea protected by law, or part thereof, or protected insect, whether taken within the state or coming from without the state, except as permitted by the Fish and Wildlife Law.*

***Department of Environmental Conservation - 6 NYCRR 182.5 (b)(1)***
*Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern; Incidental Take Permits*
*182.5 Endangered species, threatened species and species of special concern*
*(b) Threatened species. Those species that merit listing as threatened either based on the criteria for listing in sections 182.3(b) and (c) of this Part or because they are species listed as threatened by the United States Department of the Interior in 50 Code of Federal Regulations part 17 (see section 182.1 of this Part) and are native to New York State.*

The 2005 case occurred in Albany (NY) where 20 live terrapins were found at an Asian market for sale. Nine of the turtles were larger than the legal limit (greater than seven inches straight-line carapace) and were seized by LE. The seller was issued an ECAT for violating **6 NYCRR 3.1(c)(4)** which prohibits the purchase or sale of terrapins with a straight-line carapace length less than four inches or greater than seven inches.

***3.1 Diamondback terrapins***
*(c) Regulations.*
*(iv) purchase or sale of diamondback terrapin which has a straight line upper shell length less than four inches or greater than seven inches. As used in this section, sale means any delivery or transfer of a live diamondback terrapin or the flesh of a diamondback terrapin whether for a consideration or as a gift. As used in this section, sale includes offering for sale or possession with intent to sell.*

In 2004, in New York City, four live terrapins were found at an Asian market. Three of the four turtles were not of legal size and were also being sold between May 5th and July 31st which must be prepared for consumption if being sold during this time period. All four terrapins were seized by LE. The seller was issued an NYCUS for **6 NYCRR 3.1(c)(1)(iv)** for the sale of terrapins outside the legal limit and an NYCUS for **ECL 71-0924(1)** for illegal consumption of wildlife.

> ***3.1 Diamondback terrapins***
> *(c) Regulations.*
> *(iv) purchase or sale of diamondback terrapin which has a straight line upper shell length less than four inches or greater than seven inches. As used in this section, sale means any delivery or transfer of a live diamondback terrapin or the flesh of a diamondback terrapin whether for a consideration or as a gift. As used in this section, sale includes offering for sale or possession with intent to sell;*
> *(v) sale of diamondback terrapin from May 5th to July 31st inclusive except that diamondback terrapin legally taken during the open season may be sold throughout the year if they were killed and processed for consumption prior to May 5th;*
>
> ***NY Code - Section 71-0924****: Illegal commercialization of fish, shellfish, crustaceans, and wildlife - See more at: http://codes.lp.findlaw.com/nycode/ENV/71/9/71-0924#sthash.Qz9m8FRE.dpuf*

The three other cases provided by NY did not lead to any violations or citations issued. In 2012, an environmental conservation officer relayed information about a Craig's List ad for a terrapin being offered for sale. Unfortunately when an attempt was made to contact the individual they claimed the terrapin was no longer for sale. There was no other way to locate the seller so the case was closed. In 2011, a complaint was filed for a terrapin nest disturbance on West Meadow Beach, in the town of Brookhaven. There were no leads so the case was closed. In 2007, a complaint of a crab pot with dead terrapins was made. The crab pot was filled with 14 dead terrapins in the waters of Oyster Bay NWR (located across the dock off Creek Rd in Mill Neck Bay). The case was considered closed, as there were no leads, no tag on the crab pot and therefore noted as an abandoned crab pot.

### *New Jersey*

A search was conducted through the NJ Conservation Officer's website of the NJ Division of Fish and Wildlife Monthly Highlights Bureau of Law Enforcement Highlights (2014-2006) which yielded four summons cases. Chief Matt Brown further confirmed there were a total of 15 terrapin cases in NJ between 2000-2015 (Chief Matt Brown, NJDEP, pers. comm. 2016). Some highlights of cases are provided below. In January 2015, LE officers seized a total of 553 live terrapins from four men in two vessels who were unlawfully using blue claw crab dredges to harvest terrapins in a hibernacula located in a back bay area of Atlantic County. Summonses were issued to the harvesters for crab dredge violations, commercialization of unlawfully harvested species and taking terrapins by unlawful contrivance. In June 2015, LE officers seized 72 terrapins (2 adults and 70 hatchlings) from an individual on the Delaware Bayshore who claimed to be working with a college professor and a nonprofit conservation group under a scientific collecting permit. They issued the individual summonses for taking terrapin during the closed season and for possessing undersize terrapins. In July/August 2014, a man was charged for taking terrapins out of season, under-sized, and with the use of a net. He was also charged with possessing non-game/exotic species without a permit and attempting to sell a wild caught terrapin hatchling on the internet. In 2008, three individuals in the Reeds Beach area illegally took 30 terrapins for commercial harvesting. The individuals were issues summonses for harvesting diamondback terrapins during the closed season. In August 2007, a man was issued a summon(s) for selling exotic wildlife from him home including terrapins caught from the wild. In July 2006, a man was issued a summon(s) for an illegally caught terrapin at Great Bay Wildlife Management Area. In October 2006, a crabber was also issued summons for illegal crabbing on Cohansey River including: fishing more than two crab pots on a recreational license, no gear ID number and no biodegradable panels. Warnings were also issued for closed area, no terrapin excluders and failure to tend every 72 hours (NJ Division of Fish and Wildlife Monthly Highlights Bureau of Law Enforcement 2016).

### *Maryland*

In MD, warning and citations were issued under two violation categories - catching a terrapin commercially without a license (Violation category code 0605) and possession of an undersized terrapin (Violation category code 0628) (Capt. D.C. Larsen, Maryland Natural Resources Police, pers. comm. 2015). Twenty written warnings and zero citations were given for catching terrapins commercially without a license. Nine citations and two written warning were given for possession of an undersized terrapin under the following regulations:

> ***Maryland Natural Resources Section 4-602***
> *Regulation - 08.03.11.00. Title 08 The Department of Natural Resources Subtitle 03 WILDLIFE Chapter 11 Reptile and Amphibian Possession and Permits Authority.*
>
> ***MD Natural Resources Section 18222***
> *Regulation - 10.06.01.23. Sale and Distribution of Reptiles.*
> *A. Scope. (1) Pursuant to the authority conferred upon the Secretary by Health-General Article, §18-219, Annotated Code of Maryland, the Secretary has determined that reptiles and reptile eggs are dangerous to human health and safety in that human contact with reptiles and reptile eggs may spread disease to humans. With this regulation, the Secretary prohibits the sale or public distribution of turtles with a carapace length of less than 4 inches and viable reptile eggs.*
>
> ***Maryland Natural Resources Section 4-903***
> *§ 4-903.The Department shall adopt rules and regulations governing the catching of terrapin and conservation of terrapin resources, especially taking into consideration the establishment of a season and legal size.*

## CONSERVATION ACTIONS

Conservation actions often involve physical management of natural resources, but many other types of actions have been proposed in support of wildlife conservation such as property easements to influence land management, recreational use guidelines, education or outreach, and species reintroduction. In some cases, a lack of knowledge about species' requirements inhibits the planning of these more tangible actions, and research or survey actions are required to fill these knowledge gaps (Crisfield and the Northeast Fish and Wildlife Diversity Technical Committee [NEFWDTC] 2013).

Each proposed conservation action includes the objective and general and detailed strategies for each action, benefits to species, the implementing organization or potential partners striving to complete the conservation action and other action descriptors (Crisfield and NEFWDTC 2013). These descriptors are fully described in the Northeast Lexicon Conservation Synthesis for State Wildlife Action Plan Revisions (Reference documents for the Lexicon – Element 4) and in Appendix B. The strategic Conservation Actions developed for this Conservation Strategy mainly followed the format of the NE Lexicon. Revisions to the NE state SWAPS also used the format described in the NE Lexicon. Essentially for future revisions of the NE state SWAPS, this Conservation Strategy may be referenced for state proposed conservation actions in their respective SWAPs.

Participants were asked to develop strategic conservation actions based on their priority threats that were determined through the Threat Assessment exercises. Regional conservation actions were determined for both the NE states (MA, CT, RI, NY) and the Mid-Atlantic states (NJ, DE, MD, VA). Each of the eight states also conducted the Threat Assessment exercise and developed strategic conservation actions for their own respective state. The Conservation Actions listed below are completely contingent on funding unless otherwise specified. States (government, NGOs, and others) will use these Conservation Actions as guidance and will strive to complete these actions over the next five years (or otherwise designated time period) as possible. No state or organization is obligated to complete these actions unless otherwise specified (e.g. an organization currently has funding for a project listed below).

For the "Action Name," (the first row described in each of the conservation action table) we used the action classification system described in the NE Lexicon (Crisfield and the NEFWDTC 2013) and adopts the Wildlife TRACS action classification system. It is hierarchical, with three tiers. The official Wildlife TRACS resources and specifically the Wildlife TRACS Action Levels v20 with indicators spreadsheet can be found at https://tracs.fws.gov/learning/mod/folder/view.php?id=41.

Listed and described below are the strategic conservation actions developed in the following order: regional conservation actions for the NE (MA, RI, CT, NY) and the Mid-Atlantic (NJ, DE, MD, VA) followed by conservation actions for individual states, MA to VA.

## Northeast

**Table 19. ACTION 1: Northeast Conservation Action to Address Nesting Habitat Loss due to Development, Shoreline Hardening/Bulkheading, Natural Succession, and Climate Change.**

| | EXPLANATION |
|---|---|
| **Action Name** | **GIS Research Study for High-Density Terrapin Nesting Sites Within the Northeast States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Data Collection and Analysis<br>Action Level 2: Research, survey, or monitoring – habitat<br>Action Level 3: Baseline Inventory |
| **Objective** | By 2020, conduct a GIS research study to identify high-density terrapin nesting sites (or suitable nesting areas), with a focus on areas with adjacent salt marsh nursery habitat. |
| **General Strategy** | Use existing data and additional surveys to identify high terrapin nesting sites. Include sites in developed areas where bulkheading/shoreline hardening is already in place, permitted, or likely to occur in the future. Include nesting areas that are disappearing as a result of natural successional events, and coastal nesting areas that will be altered as a result of climate change.<br><br>Initiate and employ modeling techniques to identify nesting areas that may disappear or be altered as a result of sea level rise. |
| **Purpose** | Identifying high-density nesting sites and salt marsh nursery habitat will address the threats of Natural Systems Modification (Bulkheading), Climate Change and Severe Weather, and Residential and Commercial Development (Habitat Loss). Information on current and potential high density nesting sites is needed for planning and management purposes. Information on bulkheading and other hardening shoreline actions in relation to terrapin habitat is needed to better inform terrapin conservation actions that can serve as mitigation for permitted projects or living shorelines designs.<br><br>Identification of suitable nesting habitats will help prioritize habitat conservation and select locations for other conservation actions.<br><br>Such conservation strategies may replace bulkheading/hardening structures that may be modified or removed in the future. |
| **Benefits** | This action will benefit terrapins by identifying high priority habitat that should be focal areas of conservation in the coming years. This action will also benefit those interested in conserving high quality nesting habitat for diamondback terrapins and those interested in locating opportunities for habitat restoration. |
| **Estimated Cost** | $5K-10K per town. |
| **Urgency** | Immediate. The threat of habitat loss from development, shoreline hardening/bulkheading, natural succession and climate change is high. |
| **Likelihood of Success** | Feasibility = High<br>The Probability of Occurrence Model from this Conservation Strategy can be used to identify priority areas to survey for potential high-density nesting habitat that may not be well documented. Many high-density nesting habitats are known in MA, RI, and CT, but there are likely nesting areas that have not been well documented.<br>The cost may vary depending on the information that is already available, although with new information that is available the costs could be kept to the lower end of the estimated cost. Modeling for sea level rise as a result of climate change is being planned or has been completed in several coastal towns; so this type of modeling is useful for many planning purposes. There are already data layers available that can be used for climate change in the NE. Some states already have land use layers (e.g. bulkheading) that are available. There are no potential unintended consequences, risks, or constraints. |
| **Implementing Organization or Potential Partners** | MA - Massachusetts Audubon, MA Division of Fisheries and Wildlife (Natural Heritage and Endangered Species Program), others<br>RI - University of RI, RINHS, RIDEM<br>CT - CT DEEP Division of Wildlife, others<br>NY - NYSDEC, Hofstra University, Long Island Nature Organization (LINO) |
| **Affected Parties** | The surveys will have minimal impact on coastal landowners. |
| **Action Location** | Coastal NE States – MA, RI, CT, NY |
| **Detailed Strategy** | The Probability of Occurrence Model from this Conservation Strategy can be used to identify priority areas to survey for additional potential high-density nesting habitat that may not be well documented. Existing terrapin data is already available from the Terrapin Occurrence GIS layer produced for this Conservation Strategy. |

**Table 20. ACTION 2: Northeast Conservation Action to Address Nesting Habitat Loss due to Development, Shoreline Hardening/Bulkheading/ Natural Succession and Climate Change.**

| | EXPLANATION |
|---|---|
| Action Name | **Best Management Practices to Preserve and Protect Nesting Habitat Within the Northeast States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Governmental, 2) Non-governmental, and 3) Others<br><br>Action Level 1: Technical Assistance<br>Action Level 2's: 1) With individuals and groups involved in resource management decision making and 2) With private landowners |
| Objective | By 2020, identify and implement best management practices (BMPs) to prevent further loss of nesting habitat and to preserve, restore or augment existing nesting habitat. Inform and educate state agencies, local conservation commissions, and coastal homeowners by 2020. |
| General Strategy | Identify current and potential high-density terrapin nesting sites and work with local agencies to design strategies to protect and enhance terrapin nesting habitat. Provide information to agencies, NGOs, other conservation groups, and private landowners in the form of BMPs and technical assistance. Focus on areas with adjacent salt marsh nursery habitat. |
| Purpose | Identifying and implementing BMPs and restoration or augmentation of existing nesting habitat will address the threats of Residential and Commercial Development (Habitat Loss), Natural Systems Modification (Bulkheading), and Climate Change and Severe Weather. We will educate and work with partners and homeowners to develop strategies to preserve and enhance terrapin nesting habitat. This action will help interested parties to manage their lands for terrapins. This may prevent the destruction or degradation of existing habitat through poor management and improve degraded habitat. |
| Benefits | This action will benefit terrapins by preventing the destruction or degradation of habitat. This action will benefit land managers wishing to best manage their habitat for nesting terrapins. |
| Estimated Cost | Costs per area for planning would be low (<$10K). |
| Urgency | Action should be taken within 5 years. |
| Likelihood of Success | Feasibility = High<br>The protection and augmentation of terrapin nesting habitat is necessary for stabilizing terrapin populations throughout the NE. When stakeholders are informed of the conservation implications, they are often willing to work with towns and agencies to initiate and promote strategies to protect terrapin nesting habitat. Planning this type of conservation action may be tied to projects for protection and restoration of salt marshes. Some planning, as well as implementation, has already occurred. Turtle gardens for terrapins have been created in Wellfleet, Eastham and Orleans in MA and promoted to coastal homeowners in Barrington, RI. The Town of Eastham, MA, in partnership with Massachusetts Audubon Society purchased conservation land (Terrapin Cove), which is a high-density terrapin nesting site. There may be political or land use constraints depending on the site. |
| Implementing Organization or Potential Partners | MA – Massachusetts Audubon, Natural Heritage and Endangered Species Program.<br>RI – BLCT, University of RI, RINHS, others<br>CT - CT DEEP Division of Wildlife, others<br>NY- NYSDEC, Hofstra University, LINO |
| Affected Parties | Some actions will have impacts on coastal towns and property owners. |
| Action Location | Coastal NE States – MA, RI, CT, NY |
| Detailed Strategy | TBD |

**Table 21. ACTION 3: Northeast Conservation Action to Address Habitat loss due to Development, Shoreline Hardening/Bulkheading/Habitat Loss/Climate Change and Natural Succession.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Terrapin Habitat Creation and Augmentation Within the Northeast States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Land and Water Rights Acquisition and Protection (Potential High Level Purposes: Conservation/ Management, Recreation, Administration)<br>Action Level 2: Land acquisition<br><br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Living Shorelines - Physical manipulation in shoreline areas to maintain fish and wildlife habitats and/or restore ecological functions |
| **Objective** | By 2020-2025, create and augment habitat (e.g., beneficial use of dredge material). Conserve existing habitat within the years 2020-2025. |
| **General Strategy** | Initiate/approve projects that promote living shorelines and the creation of terrapin nesting habitat. Acquire and protect existing habitat. |
| **Purpose** | Habitat creation and augmentation will address the threat of Residential and Commercial development, Natural Systems Modification (Bulkheading) and Climate Change and Severe Weather. Terrapin nesting habitat is being lost as a result of anthropogenic alterations to the coastline as well as natural events such as sea level rise (climate change) and natural succession. To stabilize terrapin populations, suitable nesting habitat must be preserved and existing nesting habitat must be augmented. |
| **Benefits** | This action would benefit terrapin populations by conserving existing nesting habitat and improving the quantity and quality of habitat. This action would benefit other salt-marsh dependent species such as migratory birds, salt marsh birds. |
| **Estimated Cost** | There is a wide range of costs depending on whether a small turtle garden is created (<$1K) or if town or state-wide efforts are initiated to address habitat restoration as a consequence of shoreline hardening or sea level rise ($5K-$500K). In areas such as CT and NY, acquiring habitat could be prohibitively expensive. Improvements involving dredge spoils are likely to require intensive permitting and oversight and could be expensive as well. |
| **Urgency** | Action should be taken within 5-10 years. |
| **Likelihood of Success** | Feasibility = Moderate to High<br><br>Preservation and creation of nesting habitat in suitable locations is critical for stabilizing terrapin populations. In Eastham, MA, a turtle garden for terrapins on private property abutting a salt marsh became a high-density terrapin nesting area with the added benefit of preventing mortality on adjacent roads. This area, Terrapin Cove, was purchased by the Town and Massachusetts Audubon and is conserved as a terrapin nesting habitat. Landowners on other private properties on Cape Cod have created terrapin gardens, which have become productive nesting areas. There may be political or land use constraints depending on the site. Special application or permission by government agencies (political constraints) may be needed if work is proposed in a wetland area. Wetland regulations need to be strictly adhered to. If proposed in a designated upland area, fewer restrictions (if any) would likely be faced. Other potential unintended consequences may include a concentration of predators in certain areas that have turtle gardens. By adding predator excluder devices, it could reduce predators; however, it may also increase hatchling densities. In some areas this may stabilize terrapin populations and there can be an increase in terrapin populations in other areas. Vegetation structure within turtle gardens is necessary to provide cover. Open "sandy" areas tend to support higher incubation temperatures (Wnek 2010). As a result, there may be a gender bias for female development. |
| **Implementing Organization or Potential Partners** | MA - Local Towns, Conservation Commissions, Local Land Trusts, Massachusetts Audubon<br>CT - CT DEEP and others<br>RI - BLCT, The Nature Conservancy, Audubon Society of RI, local land trusts and conservation commissions<br>NY - NYSDEC, Hofstra University, LINO |
| **Affected Parties** | Coastal towns and landowners may be affected. |
| **Action Location** | Coastal NE States – MA, CT, RI, NY |

| | |
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| **Detailed Strategy** | Examples:<br>Instead of having homeowners place sand in front of bulkheads (because it washes away), they may either contribute to the protection of existing terrapin habitat or contribute to a fund to purchase land that would be managed and protected as terrapin habitat. Alternatively, homeowners may be able to create turtle gardens on their property. Use beneficial dredge material to create or enhance nesting habitat.<br><br>Purchase upland areas rather than barrier island sites to protect in perpetuity in response to sea level rise/climate change and in response to a shift in terrapin nesting habitat due to sea level rise/climate change. In addition, preserve existing terrapin habitat as mitigation for proposed/permitted bulkheading projects. Mitigation efforts need to be incorporated into permits by state or local conservation committee land managers. This will likely take some time/effort for permitting entities to agree to and incorporate these mitigation measures. |

**Table 22. ACTION 4: Northeast Conservation Action to Address Predation.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Research Study for Terrapin Nest Predator Excluders Within the Northeast States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Data Collection and Analysis<br>Action Level 2: Research, survey, or monitoring – fish and wildlife populations |
| **Objective** | By 2018/2019, implement a research study to evaluate nest cage (nest protector, predator excluder) design. Determine the most effective type(s) of nest protection structures for various locations. |
| **General Strategy** | Implement a research study on the effects of various types of predator excluders on hatchlings – fitness, sex determination, hatchling size, and survival during dry summers. This could potentially be conducted as a high school, college, or graduate student project. Some challenges to this study may be sex determination of hatchlings, which could be costly. It will be important to make sure that the nest protectors do not alter nest temperatures and affect the sex of hatchlings. However, temperature loggers in nests could be deployed to predict sex of hatchlings. |
| **Purpose** | Evaluating nest cage and nest protection will address the threat of Predation. The purpose is to design the most effective type of predator excluder for each terrapin nesting location. The design of the excluder must take into account whether the nests will be monitored on a daily basis or whether hatchlings will be able to emerge removal of the protector or if assistance is needed. |
| **Benefits** | This action will benefit by producing an increased number of hatchlings and increased recruitment into local populations. |
| **Estimated Cost** | Low, $10K per location, dependent on the type of predator excluder. The cost would be higher if increased staffing is necessary to build and monitor the predator excluders during the design and testing phase (this would likely be necessary). In NY, if a graduate student were hired at Hofstra University it would cost approximately $50K/year. The cost would increase if additional states were added (potentially MA) to $100,000 for a graduate student to do comparison study in two states. |
| **Urgency** | Immediate. The threat of predation is high.<br>In MA, researchers are seeing predation rates from subsidized predators of 85-93% in control areas where nests are not protected. Although we do not know the net effect on population demographics, we have seen the expansion of types of predators. Over the past decade, the increasing fox populations have been very effective in decreasing the numbers of eggs and hatchlings, even in nests protected with wire cages (B. Brennessel pers. comm. 2015). Without the use of predator excluders, most nests would be lost (C. Sornborger pers. comm. 2016). |
| **Likelihood of Success** | Feasibility = High<br>Protecting nests in suitable habitats will increase/stabilize terrapin populations. Predator excluders have been designed and used on Cape Cod (MA) and at Nockum Hill (RI). In addition to the type of predator excluder, vegetation type, olfactory, and visual cues can also influence depredation rates.<br>This action has been implemented on painted and snapping turtles in Canada (Riley and Litzgus 2013). Costs will be dependent on states conducting the work.<br>There could be potential risks to nest protection during the research study based on the success (or lack of) different types of nest protection structures.<br>Some individuals/groups may be resistant to the types of predator excluders depending on where they are implemented. There may be issues regarding esthetics or access to areas for monitoring purposes. Predator excluders in certain areas (on trails, for example) may interfere with access or may be subject to vandalism. |
| **Implementing Organization or Potential Partners** | MA – WBWS (Massachusetts Audubon), Wheaton College Terrapin Interns<br>RI - University of RI, Roger Williams University<br>NY - Hofstra University |
| **Affected Parties** | Homeowners may have a preference for the type of predator excluder/nest protector that is utilized on their property. |
| **Action Location** | Coastal NE states MA, RI, CT, NY / NY – Jamaica Bay (FOCAL AREA) |
| **Detailed Strategy** | Provided by R. Burke (Hofstra University, NY) - Turtle conservation projects routinely use predator excluders to reduce predation eggs and hatchlings. However, despite the likely impact of excluders on the nest microhabitat, little work has been done to test whether commonly used excluder designs affect nest temperatures, days until emergence, hatching success, hatchling morphometrics, and sex ratios. We propose to test three predator excluder designs commonly used for terrapins in the NE for their effects on terrapin eggs and hatchlings. We will place a temperature logger in each nest and simulated nest sites (90 total). We will protect 10 replicate nests for each of the three excluder designs; another logger will be buried in a nearby nest without an excluder to detect for a excluder temperature effect, and a logger will be buried in a randomly chosen spot near each test nest as a control for metabolic heat produced by incubating eggs. We will monitor nests daily until hatchling emergence, and record hatchling size, mass, and abnormalities along with days from oviposition to emergence. When the last hatchling emerges from each nest, the nests will be excavated and temperature loggers will be recovered. This project will determine whether nest protectors reduce hatchling fitness, thus lowering the conservation value of the protectors. If the nest protector designs have detrimental effects, it will be possible to minimize those effects and improving protector design. |

**Table 23. ACTION 5: Northeast Conservation Action to Address Predation.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Implementation of Terrapin Nest Predator Excluders Within the Northeast States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Wildlife damage management - nest exclusion devices |
| **Objective** | By 2017, employ predator excluders in key nesting areas to protect terrapin nests. |
| **General Strategy** | Monitor terrapin nesting sites to locate nests and use predator excluders. Depending on the type of predator excluder employed, daily monitoring programs may be needed and implemented to check for hatchlings. |
| **Purpose** | Employing predator excluders will address the threat of Predation and protect terrapin nests and stabilize terrapin populations. |
| **Benefits** | This action will benefit by the protection of nests, which will result in an increase in the number of hatchlings and will contribute to the recruitment necessary to help to stabilize terrapin populations. Typically, terrapin nests suffer from high depredation rates (80-95% in some areas). |
| **Estimated Cost** | Cost depends primarily on staffing. In areas where volunteers can do most of the monitoring, the cost will be minimal. In areas where professional staffing is needed in addition to volunteers, the cost estimate is $10-$50K (in each area). |
| **Urgency** | Immediate. The threat of predation is high.<br>In MA, researchers are seeing predation rates from subsidized predators of 85-93% in control areas where nests are not protected. Although we do not know the net effect on population demographics, we have seen the expansion of types of predators. Over the past decade, the increasing fox populations have been very effective in decreasing the numbers of eggs and hatchlings, even in nests protected with wire cages (B. Brennessel pers. comm. 2015). Without the use of predator excluders, most nests would be lost (C. Sornborger pers. comm. 2016). |
| **Likelihood of Success** | Feasibility = High<br><br>Protecting nests in suitable habitats will increase/stabilize terrapin populations. Nest protectors have been designed and are already in use on Cape Cod (MA) and at Nockum Hill (RI). Costs will be dependent on staff needed to conduct the monitoring. There may be issues regarding esthetics or access to areas for monitoring purposes. Nest protectors in certain areas (on trails, for example) may interfere with access or may be subject to vandalism. |
| **Implementing Organization or Potential Partners** | MA - Massachusetts Audubon Society, State agencies, local organizations<br>RI - BLCT, University of RI, USFWS Coastal Program (RI), Roger Williams Park Zoo, local organizations<br>NY - Potentially in Oceanside Marine Protected Area, not in Jamaica Bay |
| **Affected Parties** | Coastal towns and landowners may have predator excluders/nest protectors on their property. There may be issues regarding esthetics or access to areas for monitoring purposes. Nest protectors in certain areas (on trails, for example) may interfere with access or may be subject to vandalism. |
| **Action Location** | Coastal NE States – MA, CT, RI, NY<br>NY - Potentially in Oceanside Marine Protected Area (FOCAL AREA), not in Jamaica Bay |
| **Detailed Strategy** | TBD - will be implemented following BMPs as dictated by local field conditions and nest site selection by terrapins. |

## Mid-Atlantic

**Table 24. ACTION 1: Mid-Atlantic Conservation Action to Address Terrapin Mortality from Derelict Crab Pots/Other Fisheries Gear.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Derelict Crab Pot Retrieval Within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Hazard or infrastructure removal<br>Action Level 3: Derelict gear (net/pot) removal |
| **Objective** | Between 2016-2021, biennially survey a minimum of 80-100 mi² of estuary habitat (with a focus on shallow creeks 3 m depth or less) and retrieve 1,000+ abandoned crab pots total and other fisheries gear in VA, MD, DE, and NJ. |
| **General Strategy** | Partners from the Mid-Atlantic states will focus available resources or apply for grant funding in order to retrieve derelict crab pots and other fisheries gear biennially. Some grants have already been achieved to start this Conservation Action (e.g. CWNFJ and partners, NOAA Marine Debris Removal 2015 grant program, existing VIMS programs). |
| **Purpose** | The removal of abandoned crab pots will address the threat Biological Resource Use – Fisheries Issues. As crab pots and other fishing gear is lost or abandoned during the crabbing season, terrapins and other NOAA trust resources get caught and drown in these pots. Terrapins may also drown in other derelict gear such as eel pots or fyke nets. |
| **Benefits** | Direct biological benefits include: (1) a reduction of derelict pot-related mortality among terrapins and NOAA trust species such as American eels and blue crabs; (2) a reduction in local terrapin population declines and negative impacts on growth rates and changes in sex ratios; and (3) a reduction in derelict pot-related damage to sensitive estuary habitats such as submerged aquatic vegetation and oyster beds. This action will also provide economic benefits, as it will reduce the number of commercial blue crabs accidentally taken. A secondary benefit will be a reduction in navigational hazards in the form of derelict pots and other large gear in navigable waters. |
| **Estimated Cost** | Moderate to High, approximately $240,000 in total project costs for 1,000+ derelict crab pot removal project covering a minimum of 80 mi² of estuarine habitat over a 2-year time span (CWFNJ and partners - NOAA Marine Debris Removal 2015 grant program). However, this project also includes outreach and education components so the total cost could be lower. Small-scale projects are estimated at $10,000 for one month of work (~ 14 field days) to cover approximately 10 mi² and remove an average of 2 traps/day (TWI pers. comm. 2015). This short-term estimate includes total cost for personnel time, boat use, and equipment purchased for the work (side-scan sonar, etc.). |
| **Urgency** | Immediate action should be taken. The threat of derelict crab pots and other lost gear mortality is a priority threat and urgency is high. Terrapin population declines, reduced growth, and changes in sex ratios have been directly attributed to bycatch mortality in commercial crab pots (Roosenburg et al. 1997, Wood 1997, Hoyle and Gibbons 2000, Dorcas et al. 2007, Wolak et al. 2010). One study conducted in VA estimated that of the suitable terrapin habitat surveyed, 21% was considered vulnerable to crabbing pressures (Bilkovic et al. 2012). |
| **Likelihood of Success** | Feasibility = Moderate to High<br>Action has been implemented in VA and MD waters by VIMS 2008-2014 (VIMS 2008, 2009; Bilkovic et al. 2014, see also http://ccrm.vims.edu/marine_debris_removal/). Action has been taken in NJ by CWFNJ and partners http://www.conservewildlifenj.org/protecting/habitat/barnegatbay/, Stockton (S. Evert pers. comm. 2014), see also http://www.wecrabnj.org/) and TWI (2015). The number of pots retrieved may vary annually based on how many are subsequently abandoned each year. However, VIMS observed similar numbers are abandoned year to year. There may be derelict crab pot "hot spots" that are discovered and may be targeted more frequently than other estuaries or specific creeks. Cost will likely remain in the predicted range. Volunteers, students, and partners can keep the cost in that range by providing match. There are unlikely risks or unintended consequences by the action. Permits must be approved by each state (e.g. NJBMF) ahead of time in order to retrieve derelict pots. Some states may also require a species collection permit for handling terrapins or other organisms of concern that may be caught in the pots. Additionally, VA (VIMS) had to obtain special permission from their Governor to retrieve derelict pots as they are still considered private property there. |
| **Implementing Organization or Potential Partners** | VA - VIMS<br>MD -<br>DE – DE DNREC, The Center for Inland Bays (potential as they have retrieved crab pots in the past)<br>NJ - CWFNJ, MU, Stockton, MATES, TWI, Barnegat Bay Partnership |
| **Affected Parties** | Some actions will have impacts on stakeholders. Crab pots or other gear that may be identified to fishermen can be returned to those fishermen. This would have a positive, although minor, economic benefit on fishermen who had gear returned to them as the number of retrieved pots that are salvageable may be few in numbers. At the very least, it demonstrates that pulling derelict crab pots can be beneficial to terrapins and fishermen. |
| **Action Location** | VA - Chesapeake Bay "hot spots" as identified by VIMS (FOCAL AREA) |

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| | MD -<br>DE - Potentially Sussex County (FOCAL AREA)<br>NJ - Barnegat Bay, Great Bay, Southern NJ (Cape May and Atlantic Counties) (FOCAL AREAS) |
| **Detailed Strategy** | CWFNJ and partners have received funding through NOAA's Marine Debris Removal 2015 grant program. This 2-yr project anticipates removing 1,000+ derelict crab pots from December 2015 - March 2016 and December 2016 - March 2017 in Barnegat Bay-Little Egg Harbor estuary, a National Estuary Area. CWFNJ will provide management of the overall project with partners including MATES, MU, Stockton, Ocean County Vocational Technical School (OCVTS), ReClam the Bay (ReClam), Cattus Island and Trader's Cove County Parks, and local fishermen to conduct field work, manage volunteers, and provide logistical oversight. Additional coordination will occur with the National Fish and Wildlife Foundation (NFWF) and Covanta Energy Corporation for disposal and hauling. This project proposes to:<br><br>➢ Assess derelict crab pots and other derelict fishing gear (one week assessment time by each partner prior to retrieval).<br>➢ Retrieve derelict crab pots and other derelict fishing gear - Approximately 1,000+ derelict crab pots are estimated for removal.<br>➢ Inventory derelict crab pots and other derelict fishing gear - Inventory all marine debris including photographs, describe/catalog all bycatch, release live bycatch, and break down of pots for disposal.<br>➢ Refer to the CWFNJ Project Page - http://www.conservewildlifenj.org/blog/tag/barnegat-bay/<br>➢ *Stockton has received funding for an additional two years also through NOAA's Maine Debris Removal 2015 grant program. Refer to http://www.wecrabnj.org/<br>➢ VIMS – Refer to http://ccrm.vims.edu/marine_debris_removal/ |

*It should be noted that Stockton has received grant funding through NOAA not necessary in response to terrapin crab pot mortality but for a broader scope of the health of the bay(s) and NOAA trust resources.

**Table 25. ACTION 2: Mid-Atlantic Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Terrapin By-Catch and Derelict Crab Pot Reporting System Development within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3: Government agency |
| **Objective** | By 2018, include a stipulation in the Mid-Atlantic state commercial licensing/harvest reporting system (potentially working with the Mid-Atlantic Marine Fisheries Council and individual states agencies) to: (1) encourage commercial and recreational crab pot fishermen to report the number and location of terrapin bycatch and lost crab pots to the appropriate state agencies at the end of the blue crab harvest season, and (2) require all crab pot fishermen to mark their pots with a permanent identification tag fastened directly on their crab pots. |
| **General Strategy** | Work with each state's marine fisheries management agency (or other appropriate government agency) and local recreational and commercial fisheries associations and fishermen to develop a process that encourages fishermen to report lost crab pot and other fishing gear as well as terrapin bycatch at the end of the blue crab harvest season. Once the reporting system is established, ensure the numeric and spatial data are entered, proofed and available to lost gear retrieval/removal programs and fisheries and wildlife management agencies to direct lost gear retrieval/removal efforts and develop BMPs that reduce the amount of fishing gear lost annually. Work with each state's marine fisheries management agency (or other appropriate government agency) to develop and adopt regulations that require owner IDs to be fastened on the pots themselves (as opposed to buoys only). This regulation should include penalties when gear loss is attributed to blatant abandonment, careless deployment or other fishermen-induced loss in order to discourage this type of behavior. |
| **Purpose** | The reporting of derelict crab pots and other abandoned fishing gear will address the threat Biological Resource Use – Fisheries Issues. Currently there is no system to report gear lost by commercial or recreational fishermen or where fishermen in the Mid-Atlantic states secondarily observe lost gear. Secondly, lost gear that can be correctly assigned to the owner and potentially retrieved through derelict crab pot retrieval programs and can be returned to the owner if gear is still functional. |
| **Benefits** | Having a reporting system in place that will allow states to better document the number and location of fishing gear lost annually in the Mid-Atlantic crab pot fishery and in other fisheries operating in terrapin habitat. These data will help direct fishing gear retrieval/removal efforts and reduce search time and costs associated with finding lost gear. Enacting regulations that require fishermen to fasten ID tags on their gear will enable still functioning gear to be returned to the owner, if retrieved. In addition, when the loss of gear can be attributed to poor or unlawful fishing practices, the owner may be contacted by law enforcement and dealt with appropriately.<br><br>Direct biological benefits include: (1) a reduction of derelict pot-related mortality among terrapins and NOAA trust species such as American eels and blue crabs; (2) a reduction in local terrapin population declines and negative impacts on growth rates and changes in sex ratios; and (3) a reduction in derelict pot-related damage to sensitive estuary habitats. A secondary benefit will be a reduction in navigational hazards in the form of derelict pots and other large gear in navigable waters. |
| **Estimated Cost** | Moderate. |
| **Urgency** | Immediate action should be taken. The threat of derelict crab pots and other lost gear mortality is a priority threat and urgency is high. Terrapin population declines, reduced growth, and changes in sex ratios have been directly attributed to bycatch mortality in commercial crab pots (Roosenburg et al. 1997, Wood 1997, Hoyle and Gibbons 2000, Dorcas et al. 2007,Wolak et al. 2010). One study conducted in VA estimated that of the suitable terrapin habitat surveyed, 21% was considered vulnerable to crabbing pressures (Bilkovic et al. 2012). |
| **Likelihood of Success** | Feasibility = Moderate<br><br>It is unknown if this has been implemented in other settings and with what results. There are uncertainties in the results chain due to the contentious nature of the objectives. It is unknown whether there is uncertainty of the costs. There are risks or potential unintended consequences due to the contentious nature of the objectives. In NJ there may likely be under-reporting of terrapin bycatch due to fear of regulatory changes that would require excluders on all pots, not just in specific areas. There are political and possible legal constraints. |
| **Implementing Organization or Potential Partners** | VA - VIMS, VA Marine Resources Commission, VDGIF, commercial and recreational fishery associations.<br>MD - MD Dept. of Natural Resources, commercial and recreational fishery associations<br>DE – DNREC (currently there is requirement for identification on recreational crab pots. A commercial requirement may be an option).<br>NJ – CWFNJ, MATES, MU and Stockton, NJDFW, NJBMF, commercial and recreational fishery associations, NJ Marine Fisheries Council and TWI |
| **Affected Parties** | Some actions will have impacts on stakeholders. These objectives/actions will place additional regulatory burdens on commercial and recreational fishers as well as increase |

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| | the workload of local marine fisheries law enforcement staff. |
| **Action Location** | Coastal Mid-Atlantic states VA, MD, NJ, DE |
| **Detailed Strategy** | CWFNJ and partners have received funding through NOAA's Marine Debris Removal 2015 grant program (2-yr project) anticipates removing 1,000+ derelict crab pots and addressing other fisheries management concerns from December 2015 - March 2016 and December 2016 - March 2017 in Barnegat Bay-Little Egg Harbor estuary, a National Estuary Area. CWFNJ, MATES, MU and Stockton will work partner to:<br><br>➢ Work with the NJBMF in the development of a derelict crab pot (and other lost fishing gear) reporting system that would be a requirement of commercial fishermen.<br>➢ Work with the NJBMF for a similar reporting system and other prevention method educational efforts for recreational fishermen.<br>➢ Refer to the CWFNJ Project Page - http://www.conservewildlifenj.org/blog/tag/barnegat-bay/<br>➢ *Stockton has received funding for an additional two years also through NOAA's Maine Debris Removal 2015 grant program. Refer to http://www.wecrabnj.org/<br>➢ In addition, encourage BRD use and enforcement where required. |

*It should be noted that Stockton has received grant funding through NOAA, not necessarily in response to terrapin crab pot mortality but for a broader scope of the health of the bay(s) and NOAA trust resources.

**Table 26. ACTION 3: Mid-Atlantic Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Fisheries Matrix Development within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| **Objective** | By 2018, for each state, develop a matrix that lists every commercial and recreational fishery that operates in state waters and for each fishery, list fishing seasons, gear descriptions, locations and numbers of fishers. Use this matrix to identify those fisheries that pose the greatest threat to terrapins and develop observer programs to confirm/quantify the level of take. |
| **General Strategy** | Identify all state-managed recreational and commercial fisheries and characterize gear types, seasons, effort, and locations. Create a 2-year fishery observer program for state commercial fisheries using the commercial fisheries characterization/threat ranking matrix as well as input from the fishing community to determine which fisheries warrant initial observer coverage. |
| **Purpose** | The development of a Fisheries Matrix will address the threat Biological Resource Use – Fisheries Issues. |
| **Benefits** | The development of the fisheries threats matrix, the implementation of a 2-year observer program and the subsequent annual updating of the fisheries threats matrix can serve as a useful tool for tracking fisheries/terrapin interactions over time and help drive fishery management measures that are designed and implemented to minimize terrapin take. |
| **Estimated Cost** | Moderate to High. |
| **Urgency** | Immediate action should be taken. The threat of derelict crab pots and other lost gear mortality is a priority threat and urgency is high. Terrapin population declines, reduced growth, and changes in sex ratios have been directly attributed to bycatch mortality in commercial crab pots (Roosenburg et al. 1997, Wood 1997, Hoyle and Gibbons 2000, Dorcas et al. 2007, Wolak et al. 2010). One study conducted in VA estimated that of the suitable terrapin habitat surveyed, 21% was considered vulnerable to crabbing pressures (Bilkovic et al. 2012). |
| **Likelihood of Success** | Feasibility = Moderate<br><br>MD has developed a fisheries matrix for sea turtles, which can be adapted easily to terrapins, but the state has not yet established an observer program. There is uncertainty in the results chain. The establishment of a state observer program will likely be met with considerable resistance. There may be risks or potential unintended consequences. State fisheries management agencies may be hesitant to provide all the information necessary to develop an effective commercial and recreational fisheries characterization/threat-ranking matrix. Some fishermen may refuse observers onboard their vessels or have observers aboard alternative platforms accompany them. Strong political constraints are likely. |
| **Implementing Organization or Potential Partners** | VA - VA Aquarium and Marine Science Center, VA Marine Resources Commission, VDGIF, VA commercial and recreational fisheries associations.<br>MD - MD DNR<br>DE – DNREC (matrix, but unlikely the observer program)<br>NJ – CWFNJ, MATES, NJBMF, NJDFW, NJ Marine Fisheries Council (potential partner or could provide assistance), and TWI. |
| **Affected Parties** | Impacts on stakeholders can occur for commercial and recreational fishermen operating in terrapin habitats. |
| **Action Location** | Coastal Mid-Atlantic states VA, MD, NJ, DE |
| **Detailed Strategy** | Terrapins may be incidentally captured in other fishing gear such as derelict eel pots, fyke nets and purse seines. The development of commercial and recreational fisheries characterization/threat ranking matrix for Mid-Atlantic states can be used as a risk assessment tool for predicting terrapin/fishery interactions, and help direct initial observer effort by identifying those fisheries that pose the greatest threat to terrapins. Once an observer program is established, the data gathered will, in turn, confirm the risk levels of these fisheries. Under an existing NOAA Grant, CWFNJ and MATES will work with the NJBMF in the development of a derelict crab pot (and other lost fishing gear) reporting system that could be a condition of commercial fishermen permitting. We will also work with the NJBMF for a similar reporting system and other prevention method educational efforts for recreational fishermen. In NJ, we will meet with the Marine Fisheries Council, NJ Shellfish Association, and crabbers to get a better indication of the changes in effort per catch. Provide a plan for the idea of an observers program to shadow the crabbers to document catch, capture effort and bycatch as part of this effort. |

**Table 27. ACTION 4: Mid-Atlantic Conservation Action to Address Road Mortality.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Best Management Practices for Road Mortality of Terrapins within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| **Objective** | By 2018, develop BMPs for new roads and existing roads slated for future modifications designed to minimize road mortality in the short term (e.g. barriers) and long term (e.g. elevated roadways above the salt marsh). |
| **General Strategy** | Physical barriers, roadway elevation, and other measures can reduce roadkill and help preserve terrapin populations, although additional actions are needed. The development of BMPs, quantifying levels of terrapin mortality, and calculating a mortality threshold are conservation measures that need to be more fully developed for this conservation action. |
| **Purpose** | The development and implement of BMPs will address the threat of Transportation – Road Mortality. |
| **Benefits** | This action will reduce terrapin road mortality on roadways with historically high levels and will help identify new areas for mitigation/conservation action. This action develops criteria to serve as guidelines for BMP implementation on roadways. |
| **Estimated Cost** | Moderate to High. The cost of individual actions within this conservation action can range from relatively inexpensive (e.g. $500 for 15 cubic years of sand and delivery for a turtle garden) to highly expensive for the development of culverts (e.g. $116,175 for a turtle crossing project in NJ which consisted of 5 turtle tunnels and all other project related costs [B. Zarate, NJDFW pers. comm. 2015] and e.g. $221,641 for an amphibian crossing project in NJ for 1,200 ft. stretch of road, 4 tunnels, guide fencing and all other related costs [M. Hall, NJDFW pers. comm. 2015]). The cost of the development (not implementation) of this action may be moderately expensive. |
| **Urgency** | Immediate action should be taken. The threat of road mortality is moderate to high and a priority threat. |
| **Likelihood of Success** | Feasibility = Moderate to High<br><br>The Wetlands Institute and the Margate Terrapin Rescue Project have implemented short-term barrier fences for a number of years which has been effective at reducing terrapin morality in areas of continued fencing; however, it does not eliminate the problem as terrapins sometimes get under the fencing or find gaps in the fencing, and road mortality continues to occur. One uncertainty of the action is how quickly will creating alternate nesting habitat alone produce the desired effect of reducing terrapin crossings. It may take some time to become effective, especially due to terrapin site fidelity. Used in conjunction with other methods, it would likely be effective. Alternative nesting habitat (turtle gardens) has been created in the Northeast (MA). The CWFNJ and MATES are also currently working on turtle gardens and had successful nesting (and hatching) during the first season of the installment of a pilot turtle garden. Sea Isle Terrapin Rescue (NJ) is also experimenting with turtle gardens in cooperation with the municipality and TWI (an example of volunteer organizations increasing likelihood of success). There will be some uncertainty in the cost if implementing fencing is included in the cost; Weather and vehicles can damage fencing, which will need to be repaired or replaced. The cost of repair/maintenance, both in time and the money required to purchase supplies needed, can be significant. There may be risks or potential unintended consequences. Fencing that is installed with many gaps can create terrapin crossing/roadkill hotspots by funneling terrapins to the gaps. To avoid this, fencing should ideally be implemented in areas where it can be installed in long continuous strips. There may be some political constraints; some stakeholders are opposed to terrapin fencing for aesthetic reasons and can express this opposition to their government representatives. Working with town managers and other stakeholders, especially in an area(s) where fencing has never been implemented should be considered and be prepared for ahead of time.<br><br>The Probability of Occurrence Model GIS layer from this Conservation Strategy can be used to identify priority areas to high-density nesting habitat that may intersect with roads. |
| **Implementing Organization or Potential Partners** | VA - VDGIF, USFWS, VDOT and Chincoteague Bay Field Station<br>MD -<br>NJ - Road and Habitat Connectivity Working Group (this group currently works with NJ DOT), NJDFW, CWFNJ, MATES and TWI<br>DE - DNREC (via environmental reviews) |
| **Affected Parties** | Motorists using roadways to access coastal barrier islands or salt marsh areas may be affected by this action. |
| **Action Location** | VA, NJ and DE - Coastal roadways to barrier islands, salt marsh access roads. |

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| | DE – DE DNREC and DelDOT currently testing use of turtle tunnels as passageway through large riprap at Port Mahon Road in Little Creek.<br>MD - |
| **Detailed Strategy** | Large numbers of nesting female terrapins are killed on roadways throughout the coastal Mid-Atlantic (although may be more prevalent in states with more highly developed coastlines [e.g. NJ]). Adult female survival is particularly important to the survival of terrapin populations, due to their slow life history and low survivability of offspring. Although the impact of high annual roadkills has not been adequately addressed for terrapin populations in all areas, it is assumed to be of high conservation concern. We propose to work with state departments of transportation, terrapin biologists and other partners to complete the following:<br><br>➢ Develop and implement BMPs (e.g., physical barriers, terrapin sensors, elevated roadways, and create suitable nesting habitat in areas that terrapins can access without crossing roads that would be most effective in reducing mortality) for roadways that pose an immediate known threat to terrapins.<br>➢ Identify roads that bisect marshes or are adjacent to known nesting beaches for which no information exists on terrapin occurrences or mortality. The Probability of Occurrence Model GIS layer from this Conservation Strategy can be used to identify priority areas where there is high-density nesting or occurrence and interactions with roads.<br>➢ Quantify levels of terrapin mortality as well as vehicle use and traffic patterns along these roads to determine if, where and what type of BMPs would be most effective in reducing mortality.<br>➢ Identify and rank road locations based on relative potential threat.<br>➢ Identify and include protected areas (i.e. refuges, parks) as monitoring and data collecting for BMPs may be more efficacious relative to less protected areas.<br>➢ Calculate a threshold based on the number of terrapins crossing the road and vehicle use in a given period of time that would to trigger the implementation of BMPs.<br>➢ Have BMPs in place for any project DOT proposes (e.g. DelDOT) in terrapin (and other turtle species) zones.<br><br>New Jersey (CWFNJ, TWI and MATES) will work with the NJ Road and Habitat Connectivity Working Group as BMPs are currently being created and much of the background research has been done. Delaware will contribute time of year restrictions for mowing, or have someone present to watch for terrapins for temporary impacts if time restrictions are not possible. Recommend culverts under Route 1 in DE. In addition, DE Bayshore Initiative may consider turtle road crossing signs. Explore whether or not a program exists as a source for numbers of terrapin road mortality (e.g. humane officers who are assigned to pick up roadkill) that conservation groups are not aware of. |

**Table 28. ACTION 5: Mid-Atlantic Conservation Action to Address Bulkheading/Shoreline Hardening.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Best Management Practices for Bulkheading and Shoreline Hardening in Terrapin Habitat within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Governmental, 2) Non-governmental, and 3) Others<br><br>Action Level 1: Technical Assistance<br>Action Level 2's: 1) With individuals and groups involved in resource management decision making and 2) With private landowners |
| **Objective** | By 2018, develop BMPs for agencies and shoreline management guidance documents that minimize the potential impacts of bulkheading and shoreline hardening on terrapins. Also by 2018, include terrapin conservation actions in living shoreline BMPs and construction guidelines. |
| **General Strategy** | Using existing data, identify high terrapin nesting sites in developed areas where bulkheading/shoreline hardening is likely to occur and develop BMPs to reduce the impacts of shoreline hardening and encourage construction of living shorelines. These BMPs would be made to available to agencies responsible for proposed shoreline hardening projects. Aspects would include types and sizes of rock to use, best slope that would allow terrapins to scale. Establish protection of remaining beaches near bulkheading; determine ways terrapins can bypass bulkheading to access nesting habitat. |
| **Purpose** | The development of BMPs for bulkheading/shoreline hardening will address the threat of Natural Systems Modification (Bulkheading). Information on how living shorelines can benefit terrapins and the inclusion of terrapin conservation actions in existing living shorelines designs, BMPs, and guidance documents will greatly increase and protect suitable terrapin nesting and foraging habitats. |
| **Estimated Cost** | Moderate. |
| **Urgency** | Action should be taken within 1-5 years. |
| **Likelihood of Success** | Feasibility = Moderate to High<br><br>Protecting shorelines with alternative structures (e.g. living shorelines) vs. hardened structures is a very contentious issue especially in light of climate change. Local stakeholder and political constraints will likely occur in the implementation of the BMPs and not necessarily the development of BMPs. In NJ, living shorelines are the preferred method for shoreline stabilization over structural methods such as bulkheads (NJDEP 2009, Living Shoreline Creation Activities http://www.nj.gov/dep/landuse/activity/livingshore.html. Living shoreline projects may require multiple approvals from states (e.g. NJDFW) depending on special areas impacted. In NJ, the Coastal Zone Management rules at N.J.A.C. 7:7 outlines "special areas" found in the coastal zone that are regulated by the Department. Special areas are areas that are either so naturally valuable, important for human use, hazardous, sensitive to impact, or particular in their planning requirements, as to merit focused attention and special management rules. In VA, there are several resources for living shorelines at http://ccrm.vims.edu/livingshorelines/index.html and VIMS (2010). In 2011, VA SB964 established living shorelines as the preferred approach to shoreline erosion protection. Maryland has the Living Shoreline Protection Act (2008), which requires non-structural erosion protection unless the owner can demonstrate the need for the more traditional shoreline hardening approach (see also http://dnr2.maryland.gov/ccs/Pages/livingshorelines.aspx). Incorporating terrapin BMPs to existing documents may be a reasonable approach and there are likely no risks, unintended consequences, or cost in the development of BMPs; however, implementation of BMPs would require further efforts. |
| **Implementing Organization or Potential Partners** | VA – VDGIF, VIMS, VMRC, VDEQ Coastal Zone Management Program, Chesapeake Bay Foundation<br>MD -<br>NJ – CWFNJ, MATES, NJDFW, TWI, Barnegat Bay Partnership, others<br>DE - DNREC |
| **Affected Parties** | Homeowners or land managers may be impacted by the BMPs such as timing restrictions, building of "soft" shoreline protective measures such as living shorelines vs. hardened shorelines. |
| **Action Location** | Coastal Mid-Atlantic states VA, NJ, and DE, MD - |
| **Detailed Strategy** | Potential Strategy:<br>1. Shoreline hardening - with mapping data already available, identify a set of sites with specific shoreline structures in place and a set of site with no structures (possibly sites with pending permit requests?).<br>2. Mapping data can be obtained from State agencies. Match sites with any information of known terrapin presence/absence and any dates for those measures. Pull |

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| | up sites with active living shorelines as well and any information on how plantings used in the design were constructed.<br>3. Develop a set of criteria on which measures of success can be "quantified." The BMPs would then be built on those criteria. Any surveys, head counts or nest presence/absence could be directed to those sites initially for evaluating the value of criteria.<br><br>Protection of shorelines against erosion is becoming more necessary throughout the NE (e.g. Barnegat Bay, NJ). The Lighthouse Center in Waretown lost nearly 10 m of shoreline since 2008. Such erosion has encroached on salt marsh habitat. The area eroded serves as a nesting area for terrapins. Working with organizations like Barnegat Bay Partnership, the American Littoral Society, the Long Beach Island Foundation of the Arts and Sciences, the Academy of Natural Science of Drexel University, and Save Barnegat Bay, there is potential to implement living shoreline projects and to assess the projects for terrapin habitat potential. |

**Table 29. ACTION 6: Mid-Atlantic Conservation Action to Address Habitat Loss.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Land and Water Rights Acquisition and Protection within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Land and Water Rights Acquisition and Protection (Potential High Level Purposes: Conservation/ Management, Recreation, Administration)<br>Action Level 2: 1) Land acquisition, 2) Conservation Area Designation, 3) Private Land Agreements<br><br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Living Shorelines - Physical manipulation in shoreline areas to maintain fish and wildlife habitats and/or restore ecological functions (e.g. in the form of beach nourishment, sand dune restoration, dredge spoil or other restoration. |
| **Objective** | By 2018, create and/or enhance 5-10 acres of suitable terrapin nesting habitat. |
| **General Strategy** | Create and/or enhance terrapin habitat through habitat augmentation efforts (e.g., beneficial use of dredge material) at existing nesting areas; habitat protection through land acquisition or regulations; and address information gaps on the location of key nesting, developmental, over-wintering areas. |
| **Purpose** | The creation and/or enhancement of terrapin habitat (inclusive of habitat protection) would address the threat of Residential and Commercial Development (habitat loss). |
| **Benefits** | This action would benefit terrapin populations by conserving existing nesting habitat and improving the quantity and quality of habitat. This action would benefit other salt-marsh dependent species as well (e.g. salt marsh birds). |
| **Estimated Cost** | Low to High. There is a wide range of costs depending on whether a small turtle garden is created (<$1K) or if town or state-wide efforts are initiated to address habitat restoration as a consequence of shoreline hardening or sea level rise ($5K-$500K). In NJ, cost estimates from a small-scale turtle garden project constructed by MATES and CWFNJ on Long Beach Island, NJ are available. For a small turtle garden, approximately 15 cubic yards of sand was required and there are approximately 1.4 tons per cubic yard of sand. The cost per ton of the mixture was $22.75 (which may be reduced in cost with the amount ordered). A dump truck can carry 25-26 tons (or ~18.5 cubic yards). The cost of the delivery was $250 per dump truck. Therefore, the total cost of the small pilot turtle garden was $727.25. |
| **Urgency** | Immediate. The threat of habitat loss is high. |
| **Likelihood of Success** | Feasibility = Moderate to High<br><br>This action has been implemented in other settings with positive results. In Stone Harbor, NJ, a dredge spoil that was deposited for beach nesting bird nesting habitat was also used by terrapins with successful hatching and no predation noted (TWI pers. comm. 2015). In NJ, a pilot turtle garden was implemented with successful nesting and hatching and was relatively inexpensive for a small-scale project. There may be a small risk or potential unintended consequence of the terrapins not using the constructed site, but based on previous work this seems unlikely as long as it has been documented that there are nesting terrapins in the area. Dredging can be a very contentious issue, so there may be some political constraints. For turtle gardens, special application or permission by government agencies may be needed if work is proposed in a wetland area. If proposed in a designated upland area, fewer restrictions (if any) would likely be faced. Other potential unintended consequences for turtle may include a concentration of predators in certain areas that have turtle gardens. By adding predator excluder devices, it could reduce predators; however, it may also increase hatchling densities. In some areas this may stabilize terrapin populations and there can be an increase in terrapin populations in other areas. Vegetation structure within turtle gardens is necessary to provide cover. Open "sandy" areas tend to support higher incubation temperatures (Wnek 2010). As a result, there may be a gender bias for female development. |
| **Implementing Organization or Potential Partners** | VA - VDGIF, USACOE, VMRC, VDEQ Coastal Management Program, VIMS<br>NJ – NJDFW, CWFNJ, MATES, TWI<br>DE- Delaware Bay Shore Program has a Hurricane Sandy related project underway that terrapins may benefit from. It could provide more nesting habitat and protection for existing nesting habitat. The shorebird project (Mispillion Harbor) will increase horseshoe crab spawning and would likely benefit terrapins. |
| **Affected Parties** | These actions are likely to affect stakeholders that are interested in preserving terrapin habitat that also benefits other salt-marsh dependent species and beach-nesting birds. These actions may affect municipalities' access or land management. |
| **Action Location** | Coastal VA, MD, NJ, DE<br>NJ - Barnegat Bay (small scale turtle gardens FOCAL AREA), DE - Mispillion Harbor (FOCAL AREA), VA – Craney Island Dredge Material Management Area (FOCAL AREA) |
| **Detailed Strategy** | TBD for large scale dredge projects.<br>For smaller scale project such as a turtle garden, a detailed strategy by MATES and CWFNJ can be viewed at the Project Terrapin – Turtle Garden project page.<br>We recommend a high percentage sand (95 - 99%) with < 3% silt and clay (with < 0.5% being clay). |

**Table 30. ACTION 7: Mid-Atlantic Conservation Action to Address Predation.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Predator Management within the Mid-Atlantic States**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Wildlife damage management |
| **Objective** | By 2018, develop and implement predator management programs at key (or high-density) terrapin nesting sites where no predator management programs currently exist and where predator populations are at manageable levels. |
| **General Strategy** | ➢ Develop a list of predator management programs with the Mid-Atlantic states to facilitate coordination of predator management efforts with biologists/landowners managing beach nesting birds (e.g. piping plover, terns, American oystercatcher, black skimmers).<br>➢ Identify high-density terrapin nesting sites statewide and region wide.<br>➢ Secure funding, partners, volunteers, and appropriate guidance from predator researchers, if possible, to initiate predator management programs at high-density terrapin nesting sites where none currently exist. |
| **Purpose** | The development and implementation of predator management programs would address the threat Predation. |
| **Benefits** | This action will benefit by reducing the number of predators and increasing the protection of nests, which will result in an increase in the number of hatchlings and contribute to the recruitment necessary to help to stabilize terrapin populations. Typically, terrapin nests suffer from high depredation rates (80-95% in some areas). |
| **Estimated Cost** | Cost depends primarily on staffing. In areas where volunteers can do most of the monitoring, the cost will be minimal. In areas where professional staffing is needed in addition to volunteers, the cost estimate is $10-$50K (in each area). |
| **Urgency** | Moderate. Within 5 years for planning to 10 years for implementation. |
| **Likelihood of Success** | Feasibility = Moderate to High<br><br>Predator management has been implemented in other settings for beach nesting birds and has been highly successful. Some predator management programs for VA have already been developed in a spreadsheet for American oystercatchers, but could be used as a starting point to further develop a similar inventory for terrapins (see American Oystercatcher Working Group – predator management inventory). There are no risks or unintended consequences or uncertainty in the results chain or costs from developing a list of predator management programs. There would likely be constraints to predator management by animal advocacy groups especially if predator management implementation was occurring on public lands. |
| **Implementing Organization or Potential Partners** | VA - USFWS, TNC, VDGIF, USDA Wildlife Services, USACOE<br>MD - MD DNR, MD DTWG and Partners<br>DE - DNREC<br>NJ - NJ Endangered and Nongame Species Program |
| **Affected Parties** | Nest protection by predator management may affect landowner's/land user's activities in the nesting habitat temporarily. Animal advocacy groups would be affected by implementation. |
| **Action Location** | Coastal NJ, DE, MD, VA |
| **Detailed Strategy** | ➢ Develop a list of predator management programs with the Mid-Atlantic states to facilitate coordination of predator management efforts with biologists/landowners managing beach nesting birds (e.g. piping plover, terns, American oystercatcher, black skimmers).<br>➢ Identify high-density terrapin nesting sites statewide. Use the Probability of Occurrence and Terrapin Occurrence GIS layers that was developed as part of this Conservation Strategy as a starting point<br>➢ Secure funding, partners, volunteers, and appropriate guidance from predator researchers, if possible, to initiate predator management programs at high-density terrapin nesting sites where none currently exist.<br><br>Specific examples of strategy (provided by MD DTWG)<br>➢ Solutions on protected bay islands:<br>○ Predator control – hire nuisance wildlife cooperators/coon hunters<br>○ Predator proofing nesting beach (hot wire)<br>○ Individual nest protection (install metal mesh protectors) - 1) Jeff Popp will research groups to do predator control 2) DNR contacts Martin NWR |

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| | (USFWS)<br>➢ Solutions on protected mainland beaches<br>○ Predator control – hire nuisance wildlife cooperators/coon hunters<br>○ Predator proofing nest beach (shock wire)<br>○ Individual nest protection (metal mesh protectors)<br>➢ Solutions on privately owned nesting beaches<br>○ Provide information, techniques and equipment to property owners (individual nest protectors, shock wire, beach protection equipment)<br>○ Adopt-a-beach program |

## Massachusetts

**ACTION 1: Massachusetts Conservation Action to Address Predation** – *Refer to ACTION 4: Northeast Conservation Action to Address Predation*

**ACTION 2: Massachusetts Conservation Action to Address Predation** - *Refer to ACTION 5: Northeast Conservation Action to Address Predation*

**Table 31. ACTION 3: Massachusetts Conservation Action to Address Climate Change.**

| | Explanation |
|---|---|
| **Action Name** | **Terrapin Nesting Habitat to Determine Presence and Impacts of Climate Change**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Data Collection and Analysis<br>Action Level 2: Research, survey, or monitoring – habitat<br>Action Level 3: Baseline Inventory |
| **Objective** | By 2020, conduct surveys of potential nesting habitat and follow-up surveys to evaluate its continued suitability if impacted by erosion, flooding, and salt marsh die off. |
| **General Strategy** | Use the Probability of Occurrence Model GIS layer from this Conservation Strategy to identify priority areas to survey for potential high-density nesting habitat that may not be well documented. Also use this GIS layer and overlay predicted sea-level rise models to begin to evaluate continued suitability of these habitats. |
| **Purpose** | Conducting surveys of potential nesting habitat and monitoring for continued suitability would address the threat Climate Change/Severe Weather. This action would identify and preserve (if possible) nesting habitat throughout MA. |
| **Benefits** | This action would benefit terrapin populations by identifying and conserving existing nesting habitat (if possible) while evaluating the impact of climate change. This action would benefit other salt-marsh dependent species (e.g. salt marsh birds). |
| **Estimated Cost** | Moderate. Initial survey work conducted with the help of volunteers (citizen scientists) could assist with the overall budget for this action. |
| **Urgency** | Immediate. The threat of climate change is high.<br><br>Sea level rise is already having an effect on salt marshes. In some areas, "salt marsh die back" has been observed which is manifested by the decrease in *Spartina patens* and large, barren mud flats. This will likely have a dramatic affect on terrapin nursery and foraging habitat. Sea level rise will change the amount and distribution of terrapin nesting habitats (which are already decreasing due to development and natural succession). Climate change is likely to have an effect on the sex ratios of terrapins in our northern populations. (B. Brennessel pers. comm. 2015). |
| **Likelihood of Success** | Feasibility = Moderate<br><br>The Probability of Occurrence Model GIS layer from this Conservation Strategy can be used to identify priority areas to survey potential high-density nesting habitat that may not be well documented. There is no uncertainty in the results chain. There may be some uncertainty in the cost of conducting surveys if volunteers were not available for this action. There are no risks or potential unintended consequences from conducting surveys. There are likely no political or land use constraints in conducting surveys. |
| **Implementing Organization or Potential Partners** | Massachusetts Audubon, Cape Cod Consultants, Friends of Herring River, National Park Service |
| **Affected Parties** | With the current action, surveys would have no impact on stakeholders as it is information/baseline inventory collection. |
| **Action Location** | Coastal MA, Cape Cod Bay, Buzzards Bay, Nantucket Sound (FOCAL AREAS) |
| **Detailed Strategy** | TBD. |

**Table 32. ACTION 4: Massachusetts Conservation Action to Address Human Disturbance.**

| | Explanation |
|---|---|
| **Action Name** | **Outreach and Education Methods to Address Human Disturbance in Massachusetts**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| **Objective** | By 2020, develop outreach and education materials for the public on life history and threats to terrapins, incorporate human dimensions into education and outreach efforts and wildlife management. |
| **General Strategy** | Develop signage and short and long videos for education and outreach for terrapins addressing human disturbance and climate change. |
| **Purpose** | The creation of outreach materials will inform and educate the public and would address the threat of Human Intrusions and Disturbance. |
| **Benefits** | Raising awareness within the general public regarding threats to terrapins, specifically from human disturbances (e.g. nest site disturbances, recreational boat and and fishing practices, road mortality) and from climate change, may allow for management strategies to be considered more "acceptable." If human behavior is altered in the long-term this could result in less habitat destruction, more successful nesting, fewer boat and vehicle strikes, and fewer terrapins drowning in lost or abandoned fishing gear. Reducing the mortality of terrapins will help stabilize terrapin populations. In particular, minimizing the number of gravid females killed on roadways will have a large impact on the number of eggs produced. |
| **Estimated Cost** | Low to Moderate. $1K-$5K. Approximately 4-5 signs could be developed and produced for $1K. A professional film for a longer video (15 min) could be produced for approximately $5K. |
| **Urgency** | Moderate. Action should be taken within 1-5 years. |
| **Likelihood of Success** | Feasibility = High<br><br>There is no uncertainty in the results chain or the cost of developing outreach materials. There are no risks or potential unintended consequences from developing outreach materials. There are likely no political or land use constraints in developing outreach materials. There are many existing outreach material listed in this Conservation Strategy that ideas can be generated from. Although outside the NE, human dimensions in wildlife management of terrapins has been addressed with terrapin road management in Georgia (see Crawford et al. 2015) |
| **Implementing Organization or Potential Partners** | MA Audubon Society, National Park Service, local Homeowners Associations |
| **Affected Parties** | The public stakeholders that use coastal habitats for recreational purposes will be impacted in a positive manner with education and outreach. |
| **Action Location** | Coastal MA |
| **Detailed Strategy** | As noted from the Draft MA SWAP (Chapter 6, pg. 397) (MADFW 2015)<br><br>➢ Erect signage at sites with active habitat management activities, to explain to the public why changes are being made to familiar landscapes.<br>➢ Incorporate the human dimensions of wildlife management into effective and acceptable management approaches<br>➢ Develop short and long videos on topics ranging from the life history of charismatic SGCN, to the rationale behind specific habitat management activities, to the predicted effects of climate change on the state's biodiversity (A terrapin video could be made). |

## Connecticut

**Table 33. ACTION 1: Connecticut Conservation Action to Address Predation.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Predator Management within Connecticut**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Wildlife damage management |
| **Objective** | By 2020, develop a predator management plan for high-density terrapin nesting sites where no predator management plans currently exist. Determine, if possible, if predator populations are at manageable levels to employ nest protectors or predator excluders. Prepare implementation strategies and develop a program for implementation. |
| **General Strategy** | ➢ Develop a list of predator management programs in CT to facilitate coordination of predator management efforts with biologists/landowners managing beach nesting birds (e.g. piping plover, terns, American oystercatcher, black skimmers).<br>➢ Identify high-density terrapin nesting sites statewide. This ties into the Northeast Conservation Action #1.<br>➢ Secure funding, partners, volunteers, and appropriate guidance from predator researchers, if possible, to initiate predator management programs at high-density terrapin nesting sites where none currently exist. |
| **Purpose** | Development of a predator management plan would address the threat of Predation. This action will protect habitat and terrapin populations. |
| **Benefits** | If predator management is implement, this action will benefit terrapins by reducing the number of predators and increasing the protection of nests, which will result in an increase in the number of hatchlings and will contribute to the recruitment necessary to help to stabilize terrapin populations. Typically, terrapin nests suffer from high depredation rates (80-95% in some areas). |
| **Estimated Cost** | Cost depends primarily on staffing. In areas where volunteers can do most of the monitoring, the cost will be minimal. In areas where professional staffing is needed in addition to volunteers, the cost estimate is $10-$50K (in each area). |
| **Urgency** | Action should be taken within 5 for planning and within 10 years for implementation. |
| **Likelihood of Success** | Feasibility = Low to High<br><br>Predator management has been implemented in other settings for beach nesting birds and has been highly successful. Some predator management programs have already been developed in a spreadsheet for beach-nesting birds (e.g. American Oystercatchers), but could be used as a starting point to develop an inventory for terrapins (see American Oystercatcher Working Group – predator management inventory). There are no risks or unintended consequences or uncertainty in the results chain or cost from developing a list of predator management programs. There would likely be constraints (pushback) to predator management by animal advocacy groups and land managers especially if predator management implementation was occurring on public lands. The Probability of Occurrence Model GIS from this Conservation Strategy can be used to identify priority areas to survey potential high-density nesting habitat that may not be well documented. |
| **Implementing Organization or Potential Partners** | CT DEEP Wildlife Division and Partners |
| **Affected Parties** | Nest protection by predator management may affect landowners/land users activities in the nesting habitat temporarily. Animal advocacy groups likely would be affected by implementation. |
| **Action Location** | Coastal CT towns with nesting terrapins. |
| **Detailed Strategy** | TBD. Refer to ACTION 7: Mid-Atlantic Conservation Action to Address Predation as a suggested strategy.<br>Predation of nests and eggs also can include human disturbance (including dogs) on recreational beach areas. Humans and dogs can disturb nesting females and degrade nesting areas. Action is completely contingent on funding and personnel. Limiting human (and dog disturbance) of recreational beach areas bordering on salt marsh habitat may be concurrent with plover and tern monitoring. Demonstrating that these actions are reducing nest destruction may be difficult. |

**Table 34. ACTION 2: Connecticut Conservation Action to Address Habitat Loss.**

| | EXPLANATION |
|---|---|
| **Action Name** | **State Review of Proposed Development Projects and Impacts to Terrapins in Connecticut**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Technical Assistance<br>Action Level 2: Environmental Review<br>Action Level 3: Review of Proposed Projects |
| **Objective** | In 2016, begin to review proposed developments in high-density terrapin habitat so that minimal damage occurs. Terrapins have recently been listed as Species of Special Concern in CT. Development projects requiring a CT DEEP permit should come through the established permit review process for comments and recommendations. Actions to protect terrapins can be incorporated into the permit review process. |
| **General Strategy** | Through the CT DEEP permit review process:<br>➢ Make available mapped areas of high-density terrapin populations to prospective permit applicants.<br>➢ Avoid proposed alterations that destroy marsh and upland habitat or the dredging of estuaries where terrapin populations occur.<br>➢ Provide recommendations to restore nesting areas, protect shorelines and restore natural nutrient flow. |
| **Purpose** | Reviewing proposed development projects and providing appropriate recommendations to minimize the impact to terrapins from such projects would address the threat of Residential and Commercial Development (Habitat Loss) and Disturbance. |
| **Benefits** | The proposed recommendations should not only benefit terrapins through habitat protection, but coastal ecosystems as well (and coastal resiliency). This action will protect terrapin populations from habitat destruction and degradation. |
| **Estimated Cost** | Moderate.<br><br>The permit review process is already in place; however, the number of permits affecting terrapin populations is unknown and review must be ongoing. |
| **Urgency** | Immediate. The threat from development is high. |
| **Likelihood of Success** | Feasibility = High<br><br>The Probability of Occurrence Model GIS layer and the NE Regional Terrapin Occurrence GIS layer from this Conservation Strategy can be used to identify priority areas of high-density nesting habitat or potential high-density nesting habitat that may not be well documented. The Probability of Occurrence GIS layer can be overlaid with current development as well as proposed projects during the permit review process in an effort to minimize impacts to terrapins and their habitat. |
| **Implementing Organization or Potential Partners** | CT DEEP |
| **Affected Parties** | Developers, landowners, and marinas in areas with high-density terrapin populations may be affected by permit restrictions or recommendations. |
| **Action Location** | Coastal CT towns with terrapin populations and habitat. |
| **Detailed Strategy** | TBD, although a general strategy is well developed. Action is completely contingent on funding and personnel. Connecticut may use the Probability of Occurrence Model GIS layer from this Conservation Strategy to identify priority areas to survey for potential high-density nesting habitat that is know and areas that may not be well documented (may require ground-truthing). Using this GIS layer, CT DEEP can overlay current development and future proposed development projects to be evaluated during the permit review process to understand local and cumulative impacts to terrapins from proposed development. |

**Table 35. ACTION 3: Connecticut Conservation Action to Address Climate Change/Severe Weather.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Research Methods for Improving Coastal Resiliency in Connecticut**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Data Collection and Analysis<br>Action Level 2: Technique Developments<br>Action Level 3: Habitat Restoration Methods |
| **Objective** | By 2025-2035, examine the techniques for increasing salt marsh resiliency to sea level rise. Determine whether habitat modifications beneficially impact terrapin populations. (Will they use or are the successful in new or modified habitats?) |
| **General Strategy** | Work with local, state, federal partners, and climate change experts that are researching the feasibility of salt marsh migration and methods to protect fragile salt marsh areas and upland habitats. Determine the utility of salt marsh migration to terrapins. Research methods for improving coastal resiliency and enabling salt marsh migration. Research methods to test the effectiveness of these strategies and whether terrapins respond positively to habitat alterations. |
| **Purpose** | Reviewing coastal resiliency for climate change/sea-level rise and the effectiveness of potential modifications to terrapin habitat would address the threat Climate Change/Severe Weather. |
| **Benefits** | Increased habitat and increased coastal resiliency can potentially reduce the impact of storm surge events both to the fragile salt marsh and upland habitat and to the development surrounding the salt marsh and upland habitat. This action may mitigate the impact of sea level rise on terrapin habitats. |
| **Estimated Cost** | High |
| **Urgency** | Action should be taken within 10-20 years. |
| **Likelihood of Success** | Feasibility = Low. Salt marsh migration will require land acquisition and coastal land in CT is very expensive.<br>Threats to salt marshes vary depending on the frequency of storms and the degree of sea level rise. The height of sea level rise may be too great for even migrated salt marshes. |
| **Implementing Organization or Potential Partners** | Local, state and federal agencies. |
| **Affected Parties** | The affected stakeholders will be landowners adjacent to salt marshes. |
| **Action Location** | Coastal CT towns with terrapin populations and habitat. |
| **Detailed Strategy** | TBD. Action is completely contingent on funding and personnel. CT may use the Probability of Occurrence Model GIS layer from this Conservation Strategy to identify existing and potential high-density nesting habitat that may be impacted by sea level rise and habitat modifications. Using this GIS layer, CT DEEP can overlay projected sea level models to evaluate whether habitat modification may beneficially impact terrapin populations. Further field investigations would also be required. |

**Table 36. ACTION 4: Connecticut Conservation Action to Address Road Mortality and Boat Strikes.**

| | EXPLANATION |
|---|---|
| Action Name | **Public outreach to minimize mortality from cars, boats, and personal watercraft In Connecticut**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| Objective | By 2018, reduce direct mortality by vehicles when females are in route to nesting habitat. By 2018, reduce mortality by direct collision with boats and habitat disturbance from the wake of personal watercraft and boats. Jet ski wakes can cause erosion of nesting area habitat. |
| General Strategy | Produce signs and publicly available materials to warn motorists and boaters about the presence of vulnerable terrapins during the nesting season and how to modify their behavior to benefit terrapins. Provide training about terrapins and locations to avoid during personal watercraft licensing classes. |
| Purpose | Reducing road and boat mortality would address the threat of Transportation (Roads and Boats). This action would protect habitat and terrapin populations from mortality, injury and habitat degradation due to transportation threats. |
| Benefits | Reducing the mortality of terrapins will help stabilize terrapin populations. In particular, minimizing the number of gravid females killed on roadways will have a large impact on the number of eggs produced. |
| Estimated Cost | Low to Moderate |
| Urgency | Immediate. The threat of road and boat mortality is high. |
| Likelihood of Success | Feasibility = Low to Moderate<br>Volunteers may be recruited and trained to monitor roads when heavy terrapin/vehicle interact occurs.<br>There is no uncertainty in the results chain or the cost of developing outreach materials. There are no risks or potential unintended consequences from developing outreach materials. There are likely no political or land use constraints in developing outreach materials. There are many existing outreach material listed in this Conservation Strategy that ideas can be generated from. Although outside the NE, human dimensions in wildlife management of terrapins has been addressed with terrapin road management in Georgia and should be considered (see Crawford et al. 2015). |
| Implementing Organization or Potential Partners | CT DEEP Wildlife Division and Boating Safety Division and Partners. |
| Affected Parties | Affected stakeholders will be motorists on roads where heavy terrapin traffic occurs and watercraft users that are warned to avoid certain areas. |
| Action Location | Coastal CT, where terrapin habitat and populations occur. |
| Detailed Strategy | TBD. Action is completely contingent on funding and personnel. |

Table 37. ACTION 5: Connecticut Conservation Action to Address Pollution.

| | EXPLANATION |
|---|---|
| **Action Name** | **Guidance documents to minimize habitat degradation from pollutants in Connecticut.**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Governmental, 2) Non-governmental, and 3) Others<br><br>Action Level 1: Technical Assistance<br>Action Level 2's: 1) With individuals and groups involved in resource management decision making and 2) With private landowners |
| **Objective** | By 2020, produce guidance documents for towns that will enable wetland commissions and land planners to make land use decisions that will minimize habitat degradation through pollution in terrapin habitat. |
| **General Strategy** | Make available guidance documents and technical support for towns to minimize habitat degradation from the runoff of nutrients and pollutants into salt marsh habitats. |
| **Purpose** | To protect terrapin habitat and populations from point and non-point source pollution. |
| **Benefits** | The development of guidance documents to minimize habitat degradation would address the threat of Pollution. This action has the potential to engage and educate local leaders regarding the importance of salt marshes and the negative impacts of pollution in terrapin habitat to provide protection for terrapin populations. |
| **Estimated Cost** | Cost to develop the general guidance documentation would be low. Costs to implement the guidance and provide ongoing technical assistance is unknown and dependent on funding and personnel. |
| **Urgency** | Immediate. The threat of pollution is high. |
| **Likelihood of Success** | Feasibility = Low to High |
| **Implementing Organization or Potential Partners** | CT DEEP Wildlife Division and Office of Long Island Sound Programs and Partners |
| **Affected Parties** | Coastal CT towns with terrapin habitat and populations will be affected stakeholders. |
| **Action Location** | Coastal CT towns with terrapin habitat and populations. |
| **Detailed Strategy** | TBD. Action is completely contingent on funding and personnel.<br><br>Produce a guidance document that would provide technical assistance to municipalities to reduce nutrient and pollutant run-off in salt marsh habitats and prepare for a potential oil spill in terrapin habitat. |

## Rhode Island

**ACTION 1: Rhode Island Conservation Action to Address Predation** - *Refer to - ACTION 4: Northeast Conservation Action to Address Predation*

**ACTION 2: Rhode Island Conservation Action to Address Predation** - *Refer to - ACTION 5: Northeast Conservation Action to Address Predation*

**ACTION 3: Rhode Island Conservation Action to Address Habitat Loss due to Natural Succession and Climate Change** – *Refer to ACTION 1: Northeast Conservation Action to Address Nesting Habitat Loss due to Development, Shoreline Hardening/Bulkheading, Natural Succession, and Climate Change*

**ACTION 4: Rhode Island Conservation Action to Address Habitat Loss due to Natural Succession and Climate Change** – *Refer to ACTION 2: Northeast Conservation Action to Address Nesting Habitat Loss due to Development, Shoreline Hardening/Bulkheading, Natural Succession, and Climate Change*

**ACTION 5: Rhode Island Conservation Action to Address Habitat Loss due to Natural Succession and Climate Change** – *Refer to ACTION 3: Northeast Conservation Action to Address Nesting Habitat Loss due to Development, Shoreline Hardening/Bulkheading, Natural Succession, and Climate Change*

**ACTION 6: Rhode Island Conservation Action to Address Road Mortality** – *Refer to ACTION 4: Mid-Atlantic Conservation Action to Address Road Mortality and tailor strategies to Rhode Island*

## New York

**Table 38. ACTION 1: New York Conservation Action to Address Road Mortality.**

| | EXPLANATION |
|---|---|
| **Action Name** | **Assessment of the Impacts of Road Mortality in New York**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| **Objective** | By 2019, conduct GIS research/mapping to identify where terrapin road mortality is occurring. |
| **General Strategy** | Identify where terrapin populations may have been seriously depleted or extirpated due to road mortality.<br>Develop methods to reduce terrapin road mortality.<br>GIS mapping to identify where terrapin road mortality is occurring through Citizen Science<br>Develop methods to reduce terrapin road mortality through 1) Citizen Science 2) Public information campaign 3) Signage and 4) Fencing/barriers |
| **Purpose** | Identifying areas where terrapin road mortality is occurring would address the threat of Transportation (Roads). This action will help to determine where terrapin populations may have been seriously depleted or extirpated due to road mortality. |
| **Benefits** | Identification of these areas could allow proper precautions to be taken to reduce or eliminate these impacts. Raising awareness within the general public regarding threats to terrapins, specifically from road mortality may allow for management strategies to be considered more "acceptable." If human behavior is altered in the long-term this could result in more successful nesting and fewer vehicle strikes. Reducing the mortality of terrapins will help stabilize terrapin populations. In particular, minimizing the number of gravid females killed on roadways will have a large impact on the number of eggs produced. |
| **Estimated Cost** | Low – Less than $10K |
| **Urgency** | Action should be taken within 5 years.<br><br>This action could be ongoing in regards to collection of data via citizen science. Methods to reduce terrapin road mortality could be developed in 1-3 years following analysis of data, with implementation timeframe dependent on funding and staff time. |
| **Likelihood of Success** | Feasibility = Moderate<br><br>There is uncertainty where funding may be available, and what agency would be responsible for it. However, it but would be a relatively simple project to implement.<br>The Probability of Occurrence Model from this Conservation Strategy can be used to identify priority areas to survey potential high-density nesting habitat or habitat likely to be used during nesting excursions that may intersecting with roadways. There are existing methods to reduce road mortality that are already developed for either other species or in other states (e.g. NJ). The action has occurred in other states (NJ – TWI, CWFNJ, Margate Terrapin Rescue Project) with some success. Some uncertainty may occur as not able to detect where all the road mortalities are occurring, or knowing when those road mortalities are actually occurring, detection of the mortalities themselves. There may be uncertainties in the cost depending on what methods are used. There could be risks or potential unintended consequences from safety risks with surveyors on roadsides and for drivers. Further discussion is need with DOT and partners that have done similar road morality work (TWI – NJ). Although outside the NE, human dimensions in wildlife management of terrapins has been addressed with terrapin road management in Georgia and should be considered with this action (see Crawford et al. 2015). |
| **Implementing Organization or Potential Partners** | Hofstra University, DOT, NYSDEC |
| **Affected Parties** | DOT would be impacted, as they would need to install signage. |
| **Action Location** | Long Island, 5 Boroughs of New York City and Lower Hudson Valley (FOCAL AREAS) |
| **Detailed Strategy** | TBD. Refer to strategies occurring in NJ (TWI and Margate Terrapin Rescue Project). The Probability of Occurrence Model from this Conservation Strategy can be used to identify priority areas to survey for potential high-density nesting habitat or habitat likely to be used during nesting excursions that may intersect with roadways. |

**Table 39. ACTION 2: New York Conservation Action to Address Human Disturbance.**

| | Explanation |
|---|---|
| **Action Name** | **Minimizing Human Disturbance to Terrapins in New York**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| **Objective** | By 2020, work with public relations to develop educational materials, meet with landowners, and encourage closure of land during terrapin nesting. |
| **General Strategy** | ➢ Encourage June-July closure of public and private lands where risk of human disturbance of nesting terrapins is likely.<br>➢ Create public-friendly signage and education efforts to convey the message of human disturbance to nesting terrapins.<br>➢ Disturbance mitigation to protect beach dunes from off-road vehicles. |
| **Purpose** | Identifying areas where mortality is occurring from off-road vehicles would address the threat of Human Disturbance and Intrusion. To educate the public on the importance of terrapin conservation while allowing an additional level of protection during the nesting season. |
| **Benefits** | Landowners and municipalities will have a better understanding on the importance of terrapin conservation and perhaps become more willing to cooperate with proposed management methods. |
| **Estimated Cost** | Less than $5K (can modify existing materials from MA partners if applicable or other partners within the NE) |
| **Urgency** | Action should be taken within 5 years.<br>By 2020 develop educational materials, meet with public landowners, and develop a plan for minimizing human disturbance on terrapin occupied lands. |
| **Likelihood of Success** | Feasibility = Low<br><br>Beach driving is a popular activity on Long Island. Many areas are already protected due to conservation efforts of the endangered piping plover. However, due to the popularity of beach use during the summer months, municipalities are not likely to be open to the idea of additional closures for a species that is not categorized as threatened or endangered. Development of educational materials would be more of a possibility. |
| **Implementing Organization or Potential Parties** | Hofstra University, NYDSEC, NGO's |
| **Affected Parties** | NYSDEC, other municipalities, recreational beach users, private landowners |
| **Action Location** | Long Island (FOCAL AREA) |
| **Detailed Strategy** | TBD. TBD. Refer to strategies occurring in NY or in the NE for the protection of beach-nesting birds from off-road vehicles as this is likely to benefit terrapins (e.g. some recreational vehicle guidance may be derived from the USFWS's 1994 *GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES IN PIPING PLOVER BREEDING HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF THE ENDANGERED SPECIES ACT* [http://www.fws.gov/northeast/pipingplover/pdf/recguide.pdf]). The Probability of Occurrence Model from this Conservation Strategy can be used to identify priority areas to survey for potential high-density nesting habitat or habitat likely to be used during nesting excursions that may intersect with off-road vehicle user groups. |

**Table 40. ACTION 3: New York Conservation Action to Address Predation.**

| | Explanation |
|---|---|
| **Action Name** | **Implementation of Predator Management Programs in New York**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Wildlife damage management |
| **Objective** | By 2020-2025, develop and implement predator management programs at high-density terrapin nesting sites where no predator management programs currently exist and where predator populations are at manageable levels. |
| **General Strategy** | ➢ Develop a list of predator management programs in New York to facilitate coordination of predator control efforts with biologists managing beach-nesting birds (e.g. piping plover, terns, American oystercatcher, black skimmers).<br>➢ Secure funding and appropriate guidance from predator control professionals and shorebird biologists engaged in predator control to initiate predator control programs at key terrapin nesting sites where none currently exist. |
| **Purpose** | The development and implementation of predator management programs would address the threat of Predation. This action will minimize the negative impacts on terrapin nesting by predators. |
| **Benefits** | This action will benefit by decreasing the number of predators and increasing protection of nests, which will result in an increase in the number of hatchlings and will contribute to the recruitment necessary to help to stabilize terrapin populations. Typically, terrapin nests suffer from high depredation rates (80-95% in some areas). |
| **Estimated Cost** | Cost depends primarily on staffing. In areas where volunteers can do most of the monitoring, the cost will be minimal. In areas where professional staffing is needed in addition to volunteers, the cost estimate is $10-$50K (in each area). |
| **Urgency** | Action should be taken within 5-10 years.<br>By 2025, implement a predator management program that coincides with already existing predator management programs in areas with beach nesting birds. |
| **Likelihood of Success** | Feasibility = Moderate<br><br>Some areas on Long Island that are known to have predation issues in regards to beach nesting birds are also known terrapin nesting areas. Coordinating with the landowner or agency to come up with a program that is acceptable to the public while protecting multiple species is doable, but would be time consuming and costly.<br>A predator removal project occurred in Florida and a surge in terrapin nest success occurred (Munscher et al. 2012). Predator management has been implemented in other settings for beach nesting birds and has been highly successful. Some predator management programs have already been developed in a spreadsheet for beach-nesting birds (e.g. American Oystercatchers), but could be used as a starting point to develop an inventory for terrapins (see American Oystercatcher Working Group – predator management inventory). There are no risks or unintended consequences or uncertainty in the results chain or cost from developing a list of predator management programs. There would likely be constraints (pushback) to predator management by animal advocacy groups and land managers especially if predator management implementation was occurring on public lands. The Probability of Occurrence Model GIS from this Conservation Strategy can be used to identify priority areas to survey potential high-density nesting habitat that may not be well documented. |
| **Implementing Organization** | NYSDEC, other municipalities |
| **Affected Parties or Potential Partners** | NYSDEC, other municipalities, recreational beach users. |
| **Action Location** | Long Island, Jamaica Bay (FOCAL AREAS) |
| **Detailed Strategy** | TBD. *May Refer to ACTION 7: Mid-Atlantic Conservation Action to Address Predation* |

## New Jersey

**ACTION 1: New Jersey Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality** - *Refer to - ACTION 1: Mid-Atlantic Conservation Action to Address Terrapin Mortality from Derelict Crab Pots/Other Fisheries*

**ACTION 2: New Jersey Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality** - *Refer to ACTION 2: Mid-Atlantic Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality*

**ACTION 3: New Jersey Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality** - *Refer to ACTION 3: Mid-Atlantic Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality*

**ACTION 4: New Jersey Conservation Action to Address Bulkheading/Shoreline Hardening** – *Refer to ACTION 5: Mid-Atlantic Conservation Action to Address Bulkheading/Shoreline Hardening*

**Table 41. ACTION 5: New Jersey Conservation Action to Address Bulkheading/Shoreline Hardening.**

| | Explanation |
|---|---|
| **Action Name** | **Turtle Garden Development and Living Shoreline Education and Outreach in New Jersey**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Living Shorelines - Physical manipulation in shoreline areas to maintain fish and wildlife habitats and/or restore ecological functions (e.g. in the form of beach nourishment, sand dune restoration, dredge spoil or other restoration.<br><br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Government agency, 2) Non-governmental organization and 3) Others |
| **Objective** | By 2018, develop five turtle gardens that mitigate the potential impacts of bulkheading and shoreline hardening on terrapins. Develop and implement an educational initiative to promote terrapin nesting habitat enhancement, turtle gardens and awareness of the benefit of living shorelines to terrapins and other coastal wildlife as it relates to sea-level rise and coastal flooding. |
| **General Strategy** | Use existing data, identify high terrapin nesting sites in developed areas where bulk-heading/shoreline hardening is likely to occur and develop turtle gardens to reduce the impacts of shoreline hardening and encourage construction of living shorelines. Turtle gardens for terrapins are patches of sandy nesting habitat above the high water line that are less susceptible to flooding. |
| **Purpose** | Construction of turtle gardens would address the threat of Natural Systems Modification (Bulkheading/Shoreline hardening) and Climate Change/Severe Weather (sea-level rise). This also addresses Transportation (road mortality) - keeping terrapins from crossing roads by provide alternative nesting habitat closer to the marsh. We will implement an educational initiative to promote terrapin nesting habitat enhancement and awareness of the benefit of living shorelines to terrapins and other coastal wildlife as it relates to sea-level rise and coastal flooding within Barnegat Bay. |
| **Benefits** | There are many benefits to property owners and the coastal environment from living shorelines including, but not limited to, flood protection, aesthetic value, enhancement of habitat for aquatic organisms, and access for wildlife to the shoreline for nesting species of birds and terrapins (NJDEP Coastal Management Office November 2009; Partnership for the Delaware Estuary 2012). Terrapin nesting habitat has been lost due to shoreline hardening and flooding which poses a greater threat to these limited nesting areas. Loss of terrapin nesting habitats along marsh systems put terrapins at greater risk of mortality as a result of increased time searching for adequate nesting areas (Winters 2013). |

| | |
|---|---|
| **Estimated Cost** | Low to Moderate.<br><br>From the small-scale pilot turtle garden project constructed by MATES and CWFNJ on Long Beach Island, NJ approximately 15 cubic yards of sand were used and there are approximately 1.4 tons per cubic yard of sand. The cost per ton of the mixture was $22.75 (which may be reduced in cost with the amount ordered). A dump truck can carry 25-26 tons (or ~18.5 cubic yards). The cost of the delivery was $250 per dump truck. Therefore the total cost of the small plot was $727.25. |
| **Urgency** | Moderate to High |
| **Likelihood of Success** | Feasibility = Moderate to High<br><br>There have been actions implemented in other settings that would already contribute to this action. In NJ, a pilot turtle garden implemented with successful nesting and hatching and was relatively inexpensive for a small-scale project. There may be a small risk or potential unintended consequence of the terrapins not using the constructed site, but based on previous work this seems unlikely as long as it has been documented that there are nesting terrapins in the area. Other potential unintended consequences may include a concentration of predators in certain areas that have turtle gardens. By adding predator excluder devices, it could reduce predators; however, it may also increase hatchling densities. In some areas this may stabilize terrapin populations and there can be an increase in terrapin populations in other areas. Vegetation structure within turtle gardens is necessary to provide cover. Open "sandy" areas tend to support higher incubation temperatures (Wnek 2010). As a result, there may be a gender bias for female development. For turtle gardens, special application or permission by government agencies may be needed if work is proposed in a wetland area. If proposed in a designated upland area, fewer restrictions (if any) would likely be faced. There is a Barnegat Bay Partnership Citizen Science Project – to assess shorelines for better indication of shoreline structures along Barnegat Bay. There is an existing GIS layer on bulkheading on Seven Mile island as well other state layers available for shoreline structures. |
| **Implementing Organization or Potential Partner** | NJ – Barnegat Bay Partnership, CWFNJ, MATES, TWI and Sea Isle Terrapin Rescue |
| **Affected Parties** | Actions may have an impact of stakeholders those that use coastal habitats. Although these projects are smaller in scale, user restrictions from the turtle garden itself would be in place. However, there are many benefits to property owners and the coastal environment from living shorelines including, but not limited to, flood protection, aesthetic value, enhancement of habitat for aquatic organisms, and access for wildlife to the shoreline for nesting species of birds and terrapins (NJDEP Coastal Management Office November 2009; Partnership for the Delaware Estuary 2012). Protection of shoreline against erosion is becoming more necessary at Barnegat Bay. For example, the Lighthouse Center in Waretown lost nearly 10 meters of shoreline since 2008. Such erosion has encroached on salt marsh habitat. The area eroded serves as a nesting area for terrapins. Working with organizations like Barnegat Bay Partnership, the American Littoral Society, the Long Beach Island Foundation of the Arts and Sciences, the Academy of Natural Science of Drexel University, and Save Barnegat Bay, there is potential to implement living shoreline projects and to assess the projects for terrapin habitat potential. |
| **Action Location** | Barnegat Bay, New Jersey (or elsewhere in NJ if there is a need and an opportunity), Sea Isle City (FOCAL AREAS) |
| **Detailed Strategy** | ➢ Construct five turtle gardens within Barnegat Bay or where there is a need/opportunity.<br>➢ Conduct outreach programs/training sessions for the general public promoting terrapin nesting habitat enhancement and awareness of the benefit of living shorelines to terrapins and other coastal wildlife as it relates to sea-level rise and coastal flooding within the Barnegat Bay Watershed.<br>➢ Incorporate terrapin habitat development supporting living shorelines and address coastal flooding and sea-level rise in the public programs/training sessions. Work with local citizens (citizen scientists) for the development of a demonstration area(s), "Barnegat Bay Turtle Gardens."<br>➢ Incorporate Terrapin Education KITs (Kids Interact with Terrapins) into 10 schools (elementary and middle school grade levels) within Barnegat Bay as part of a school outreach program promoting the importance of living shorelines to terrapins and the connection to coastal flooding/sea-level rise and climate change in coastal communities.<br>➢ Develop and install signage to demonstrate project concept of turtle gardens.<br>➢ Develop additional outreach materials, some of which will be web-based (i.e. GIS Story Map on the proposed project). |

## Delaware

**ACTION 1: Delaware Conservation Action to Address Predation -** *Refer to ACTION 7: Mid-Atlantic Conservation Action to Address Predation*

**ACTION 2: Delaware Conservation Action to Address Bulkheading/Shoreline Hardening** – *Refer to ACTION 5: Mid-Atlantic Conservation Action to Address Bulkheading/Shoreline Hardening*

**ACTION 3: Delaware Conservation Action to Address** – *Refer to ACTION 4: Mid-Atlantic Conservation Action to Address Road Mortality*

**Table 42. ACTION 4: Delaware Conservation Action to Address Climate Change/Habitat Loss (also addresses Road Mortality).**

| | Explanation |
|---|---|
| **Action Name** | TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Land and Water Rights Acquisition and Protection (Potential High Level Purposes: Conservation/ Management, Recreation, Administration)<br>Action Level 2: 1) Land acquisition, 2) Conservation Area Designation, 3) Private Land Agreements<br><br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Living Shorelines - Physical manipulation in shoreline areas to maintain fish and wildlife habitats and/or restore ecological functions (e.g. in the form of beach nourishment, sand dune restoration, dredge spoil or other restoration. |
| **Objective** | By 2021, create nesting habitat in nearby areas in locations where development and sea level rise are depleting nesting beaches by 2021. Allow for methods of safe crossing for terrapins at roads to access this habitat. |
| **General Strategy** | Determine the highest use of terrapin areas and develop potential conservation actions for those beaches/bays. Work with DelDOT to develop standards for directional fencing and underpasses for new and existing roads to allow turtles to safely reach their nesting habitat. |
| **Purpose** | The creation of nesting habitat to mitigate for development and sea level rise would address the threat of Climate Change/Severe Weather, Recreational and Commercial Development (Habitat Loss), and Transportation (Roads). Terrapin nesting habitat is being lost as a result of development (inclusive of roads) to the coastline as well as natural events such as sea level rise (climate change) and natural succession. To stabilize terrapin populations, suitable nesting habitat must be preserved/augmented and new nesting habitat must be created to provide available nesting sites for terrapins. |
| **Benefits** | This action would benefit terrapin populations by creating nesting habitat and improving the quantity and quality of habitat. This action would benefit other salt-marsh dependent species. This action would also reduce road mortality of terrapins and provide safe passage to allow them to access their nesting habitat. |
| **Estimated Cost** | Low to High. There is a wide range of costs depending on whether a small turtle garden is created (<$1K) or if town or state-wide efforts are initiated to address habitat creation/restoration as a consequence of development and/or sea-level rise ($5/10K-$500K). Directional fencing along roads is generally inexpensive and may need volunteer monitoring to ensure they are in tact throughout the season depending on what type of fencing is used. In areas like CT, NY, and NJ acquiring habitat could be prohibitively expensive. Improvements involving dredge spoils are likely to require intensive permitting and oversight and could be expensive as well. |
| **Urgency** | Action should be taken within 5 years. |
| **Likelihood of Success** | Feasibility = Moderate to High<br>Preservation and creation of nesting habitat in suitable locations is critical for stabilizing terrapin populations. Similar actions have been implemented in other settings with positive results. In Stone Harbor, NJ, a dredge spoil that was deposited for beach nesting bird nesting habitat was also used by terrapins with successful hatching and no predation noted (TWI pers. comm. 2015). In NJ, a pilot turtle garden was implemented with successful nesting and hatching and was relatively inexpensive for a small-scale project. There may be a small risk or potential unintended consequence of the terrapins not using the constructed site, but based on previous work this seems unlikely as long as it has been documented that there are nesting terrapins in the area. Dredging can be a very contentious issue, so there may be some political constraints. For turtle gardens, special application or permission by government agencies may be needed if work is proposed in a wetland area. If proposed in a designated upland area, fewer restrictions (if any) would likely be faced. Other potential unintended consequences for turtle gardens may include a concentration of predators in certain areas that have turtle gardens. By adding predator excluder devices, it could reduce predators; however, it may also increase hatchling densities. In some areas this may stabilize terrapin populations and there can be an increase in terrapin populations in other areas. Vegetation structure within turtle gardens is necessary to provide cover. Open "sandy" areas tend to support higher incubation temperatures (Wnek 2010). As a result, there may be a gender bias for female development. |
| **Implementing Organization or Potential Partners** | DE DNREC, DelDOT |
| **Affected Parties** | DOT would be impacted as they would need to develop for methods of safe crossing for terrapins at roads to access habitat. Actions may have an impact of stakeholders those that use coastal habitats. |
| **Action Location** | Coastal DE |
| **Detailed Strategy** | TBD. The Probability of Occurrence Model from this Conservation Strategy can be used to identify priority areas to survey for potential high-density nesting habitat or habitat likely to be used during nesting excursions that may intersect with roadways. |

**Table 43. ACTION 5: Delaware Conservation Action to Address Habitat Loss (also addresses Bulkheading).**

| | Explanation |
|---|---|
| **Action Name** | **Citizen Science Terrapin Nesting Survey Project**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Data Collection and Analysis<br>Action Level 2: Research, survey, or monitoring – habitat<br>Action Level 3: Baseline Inventory<br><br>Action Level 1: Outreach<br>Action Level 2: Partner/stakeholder engagement<br>Action Level 3's: 1) Governmental, 2) Non-governmental, and 3) Others<br><br>Action Level 1: Technical Assistance<br>Action Level 2's: 1) With individuals and groups involved in resource management decision making and 2) With private landowners |
| **Objective** | By 2020, conduct a citizen survey followed by GIS research study to identify important terrapin nesting sites, with a focus on areas with adjacent salt marsh nursery habitat. |
| **General Strategy** | Use citizen surveys, existing data, and GIS research study to identify important terrapin nesting sites. Include sites in developed areas where bulkheading/shoreline hardening are likely to occur in the future and provide recommendations for protection of nesting areas and/or create turtle nesting and nursery areas. |
| **Purpose** | Identification of terrapin nesting and marsh habitat would address the threat of Recreational and Commercial Development (Habitat Loss) and Natural Systems Modifications (Bulkheading). Information on important nesting sites is needed for planning and management purposes. Information on sites where bulkheading and other hardening shoreline actions are in relation to terrapin habitat is needed to better inform terrapin conservation actions that can serve as mitigation for permitted projects or living shorelines designs. Identification of nesting habitats will help prioritize habitat conservation and select locations for other nest protection, creation of turtle nesting and nursery area, and other conservation actions. Such conservation strategies may replace bulkheading/hardening structures that may be modified or removed in the future. |
| **Benefits** | This action will benefit those interested in conserving high quality nesting habitat for diamondback terrapins. This action will benefit those interested in locating opportunities for habitat restoration. Development of recommendations for protection of nesting areas will help ensure nesting opportunities for terrapins. |
| **Estimated Cost** | $10K per town |
| **Urgency** | Action should be taken within 5 years. |
| **Likelihood of Success** | Feasibility = High<br><br>Some important nesting habitats are known in Delaware, but there are likely nesting areas that have not been well documented. The cost may vary depending on the information that is already available. Modeling for sea level rise as a result of climate change is being planned or has been completed in several coastal towns and for the NE; so this type of modeling is useful for many planning purposes. The Probability of Occurrence GIS Layer developed from this Conservation Strategy and the NE Terrapin Occurrence GIS layer can be used to identify current and potential important or high-density nesting sites. |
| **Implementing Organization or Potential Partners** | DE DNREC |
| **Affected Parties** | The surveys will have minimal to no impact on coastal landowners. |
| **Action Location** | Coastal DE, Bayshore beaches and waterways, Delaware Inland Bays (FOCAL AREAS) |
| **Detailed Strategy** | TBD. The Probability of Occurrence GIS Layer developed from this Conservation Strategy and the NE Terrapin Occurrence GIS layer can be used to identify current and potential important or high-density nesting sites. |

## Maryland

**ACTION 1: Maryland Conservation Action to Address Loss of Terrapin Eggs due to Subsidized Predators** – *Refer to ACTION 7: Mid-Atlantic Conservation Action to Address Predation*

**Table 44. ACTION 2: Maryland Conservation Action to Address Nesting Beach Habitat Loss (also addresses Bulkheading).**

| | Explanation |
|---|---|
| **Action Name** | **Addressing Nesting Beach Habitat Loss in Maryland (MD SWAP priority action- see 7-140) (MD DNR 2016)**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Land and Water Rights Acquisition and Protection (Potential High Level Purposes: Conservation/ Management, Recreation, Administration)<br>Action Level 2: 1) Land acquisition, 2) Conservation Area Designation, 3) Private Land Agreements<br><br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Living Shorelines - Physical manipulation in shoreline areas to maintain fish and wildlife habitats and/or restore ecological functions (e.g. in the form of beach nourishment, sand dune restoration, dredge spoil or other restoration. |
| **Objective** | By 2020, Protect terrapin nesting beach habitat by limiting rip rap and bulkheads along shorelines. |
| **General Strategy** | This is a regulatory issue. Include sites in developed areas where bulkheading/shoreline hardening are likely to occur in the future and provide recommendations for protection of nesting areas and/or create turtle nesting and nursery areas. |
| **Purpose** | Regulatory decision making regarding terrapin habitat and shoreline hardening would address the threat of Recreational and Commercial Development (Habitat Loss) and Natural Systems Modifications (Bulkheading). Information on important nesting sites is needed for planning and management purposes and regulatory review. Information on sites where bulkheading and other hardening shoreline actions are in relation to terrapin habitat is needed to better inform terrapin conservation actions that can serve as mitigation for permitted projects or living shorelines designs. Identification of nesting habitats will help prioritize habitat conservation and select locations for other nest protection, creation of turtle nesting and nursery area, and other conservation actions. Such conservation strategies may replace bulkheading/hardening structures that may be modified or removed in the future. |
| **Benefits** | This action is highly beneficial and will conserve high quality nesting habitat for diamondback terrapins and benefit other species (e.g. migratory birds). This action will benefit those interested in locating opportunities for habitat restoration. Development of recommendations for protection of nesting areas will help ensure nesting opportunities for terrapins. |
| **Estimated Cost** | Low (> $50K). |
| **Urgency** | Immediate (or within 2 years). The threat of nesting beach habitat loss is high. |
| **Likelihood of Success** | Feasibility = Medium to High<br><br>The action has a high priority in the state of MD and will address the threat of habitat loss, improve terrapin habitat and will benefit the MD terrapin population. The cost may vary depending on the specific site – if rip rap or bulkheading currently exists, is there terrapins nesting nearby, how will this area be affected by sea level rise. Modeling for sea level rise as a result of climate change is being planned or has been completed in coastal states; so this type of modeling is useful for many planning and regulatory purposes. This is a regulatory issue so there are likely to be political and land use constraints. The Probability of Occurrence GIS Layer developed from this Conservation Strategy and the NE Terrapin Occurrence GIS layer can be used to identify current and potential important or high-density nesting sites. |
| **Implementing Organization or Potential Partners** | MDE, MD DNR, MD DTWG, others |
| **Affected Parties** | Coastal homeowners and other coastal habitat business and recreational users may be impacted. |
| **Action Location** | Coastal MD |

| | |
|---|---|
| **Detailed Strategy** | The Probability of Occurrence GIS Layer developed from this Conservation Strategy and the NE Terrapin Occurrence GIS layer can be used to identify current and potential important or high-density nesting sites.<br><br>Provided by MD DTWG:<br><br>➢ MDTWG may prepare document/presentation that promotes innovative shoreline erosion control measures that are terrapin friendly (e.g. Jefferson Patterson Park)<br>➢ MD DNR (and partners) may meet with the USACOE (and USFWS: Pete McGawen) to present MDTWG recommendations for terrapin-friendly shoreline protection (Note: This may be urgent for upcoming and ongoing Bay Island protection/restoration projects e.g. Barren Island, Bodkin Island)<br>➢ Explore possibility of making existing rip-rap walls terrapin friendly – needs further exploration (see Mid-Atlantic Conservation Action #5)<br>➢ Incorporate nesting beaches into design<br>➢ Attend upcoming planning meeting with USACOE<br>➢ Attend and present (MD DNR & Partners) at Joint Evaluation (JE) meetings (joint fed/state regulators)<br>➢ Quantify “friendly” beach – how to minimize impact (P. Henry data) – data collected but not analyzed |

**Table 45. ACTION 3: Maryland Conservation Action to Address Nesting Beach Habitat Loss due to Development.**

| | Explanation |
|---|---|
| **Action Name** | **Addressing Nesting Beach Habitat Loss Due to Development in Maryland (MD SWAP priority action- see 7-140) (MD DNR 2016)**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Land and Water Rights Acquisition and Protection (Potential High Level Purposes: Conservation/ Management, Recreation, Administration)<br>Action Level 2: 1) Land acquisition, 2) Conservation Area Designation, 3) Private Land Agreements<br><br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Living Shorelines - Physical manipulation in shoreline areas to maintain fish and wildlife habitats and/or restore ecological functions (e.g. in the form of beach nourishment, sand dune restoration, dredge spoil or other restoration. |
| **Objective** | By 2018, protect and restore nesting and/or basking habitat and identify and document existing nesting beach habitat. |
| **General Strategy** | Protection of nesting areas and/or create turtle nesting and nursery areas. |
| **Purpose** | Identification and protection of terrapin nesting and marsh habitat would address the threat of Recreational and Commercial Development (Habitat Loss) and Natural Systems Modifications (Bulkheading). Information on important nesting sites is needed for planning and management purposes and regulatory review. Information on sites where bulkheading and other hardening shoreline actions are in relation to terrapin habitat is needed to better inform terrapin conservation actions that can serve as mitigation for permitted projects or living shorelines designs. Identification of nesting habitats will help prioritize habitat conservation and select locations for other nest protection, creation of turtle nesting and nursery area, and other conservation actions. Such conservation strategies may replace bulkheading/hardening structures that may be modified or removed in the future. |
| **Benefits** | This action is highly beneficial and will conserve high quality nesting habitat for diamondback terrapins and benefit other species (e.g. migratory birds). This action will benefit those interested in locating opportunities for habitat restoration. Development of recommendations for protection of nesting areas will help ensure nesting opportunities for terrapins. |
| **Estimated Cost** | Moderate ($50k-$500k). |
| **Urgency** | Immediate (or within 2 years). The threat of nesting beach habitat loss is high. |
| **Likelihood of Success** | Feasibility = High<br><br>The action has a high priority in the state of MD and will address the threat of habitat loss by development by improving terrapin habitat, identifying and documenting existing habitat, and will benefit the MD terrapin population. The cost may vary depending on the specific site – are terrapins currently using the site and/or there terrapins nesting nearby, how will this area be affect by sea-level rise. Modeling for sea level rise as a result of climate change is being planned or has been completed in coastal states; so this type of modeling is useful for many planning and regulatory purposes. There are likely to be political and land use constraints. |
| **Implementing Organization or Potential Partners** | Exelon, SHA, DNR, SWS, Towson University, MD DTWG |
| **Affected Parties** | Coastal homeowners and other coastal habitat business (developers) and recreational users may be impacted. |
| **Action Location** | Coastal MD |

| Detailed Strategy | Provided by MD DTWG:<br><br>➢ Solutions for protecting and restoring nesting and/or basking habitat<br>o Identify existing regulations that need better utilization to promote terrapin conservation (such as the Critical Areas law) (Need USGS data to screen projects)<br>o Amend "Living Shorelines" practices (educate) to promote terrapin friendly erosion control measures<br>o Develop incentives for the protection of terrapin nesting beaches on private property<br>o Determine if critical terrapin habitat can receive Wetlands of Special Concern designation<br>o Identify currently unoccupied areas that could be made terrapin friendly<br><br>➢ Solutions for identifying and documenting existing nesting beach habitat.<br>o Provide USGS nesting beach data of known terrapin nesting areas to regulatory agencies<br>o Similar effort in coastal bays & offshore islands in coastal bay– sensitive areas map<br>o GIS modeling for terrapin habitat using USGS data |
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**Table 46. ACTION 4: Maryland Conservation Action to Address Terrapin Bycatch from Fishing Activities.**

| | Explanation |
|---|---|
| Action Name | **Terrapin Bycatch from Fishing Activities in Maryland**<br>TRACS Project Level: Administration and/or Conservation / Management and/or Recreation<br>Action Level 1: Direct Management of Natural Resources<br>Action Level 2: Hazard or infrastructure removal<br>Action Level 3: Derelict gear (net/pot) removal |
| Objective | By 2018, implement strategies to reduce or eliminate terrapin bycatch from the fishing activities. |
| General Strategy | Implement strategies to reduce or eliminate terrapin bycatch from the fishing activities including recreational crab pots, commercial crab pots including derelict crab pots, commercial eel pots, commercial fyke nets, commercial pound nets, and commercial bank traps. |
| Purpose | Implementation of strategies to reduce bycatch would address the threat of Biological Resource Use (Fisheries). Additional requirements or changes in fisheries practices and regulations and the removal of derelict crab pots will address the threat Biological Resource Use – Fisheries Issues to minimize terrapin bycatch. |
| Benefits | Direct biological benefits include: (1) a reduction of derelict pot-related mortality among terrapins and NOAA trust species such as American eels and blue crabs; (2) a reduction in local terrapin population declines and negative impacts on growth rates and changes in sex ratios; and (3) a reduction in derelict pot-related damage to sensitive estuary habitats such as submerged aquatic vegetation and oyster beds. This action will also provide economic benefits as it will reduce the number of commercial blue crabs accidentally taken. A secondary benefit will be a reduction in navigational hazards in the form of derelict pots and other large gear in navigable waters. |
| Estimated Cost | For Practice and Regulation Changes cost can be low (<$50K)<br><br>For Derelict Crab Pot Removal cost can be High/Moderate - Approximately $240,000 project total for 1,000+ derelict crab pot removal covering a minimum of 80 $mi^2$ of estuarine habitat over a 2-year time span (CWFNJ - NOAA Marine Debris Removal 2015 grant program). However, this project also includes subcontracts to local fishermen, outreach and education components so the total cost could be slightly lower. Short-term projects are estimated at $10,000 for one month of work (~ 14 field days) to cover approximately 10 $mi^2$ remove an average of 2 traps/day (TWI pers. comm. 2015). This short-term estimate includes total cost for personnel time, boat use, and equipment purchased for the work (side-scan sonar, etc.) |
| Urgency | Immediate action (or within 2 years) should be taken. The threat of gear mortality and derelict crab pots and other lost gear is a priority threat and urgency is high. Terrapin population declines, reduced growth, and changes in sex ratios have been directly attributed to bycatch mortality in commercial crab pots (Roosenburg et al. 1997, Wood 1997, Hoyle and Gibbons 2000, Dorcas et al. 2007, Wolak et al. 2010). One study conducted in VA estimated that of the suitable terrapin habitat surveyed, 21% was considered vulnerable to crabbing pressures (Bilkovic et al. 2012). |
| Likelihood of Success | Feasibility = Moderate<br><br>There are ongoing efforts to increase BRD use and enforcement of existing regulations in MD.<br>Derelict crab pot removal action has been implemented in VA and MD waters by VIMS 2008-2014 (VIMS 2008, 2009; Bilkovic et al. 2014, see also http://ccrm.vims.edu/marine_debris_removal/). Action has been taken in NJ by CWFNJ, Stockton University (Steve Evert, Stockton, pers. comm. 2014, see also and http://www.conservewildlifenj.org/protecting/habitat/barnegatbay/ and http://www.wecrabnj.org/) and TWI (2015).<br>The number of pots retrieved may vary annually based on how many are subsequently abandoned each year. However, VIMS observed similar numbers are abandoned year to year. There may be derelict crab pot "hot spots" that are discovered and may be targeted more frequently than other estuaries or specific creeks.<br>Cost will likely remain in the predicted range. Volunteers, students, and partners can keep the cost in that range by providing match. There are unlikely risks or unintended consequences by the action. Permits must be approved by each State (e.g. NJ's Bureau of Marine Fisheries) ahead of time in order to retrieve derelict pots. Some states may also require a species collection permit for handling terrapins or other organisms of concern that may be caught in the pots. Additionally, VA (VIMS) had to obtain special permission from their Governor to retrieve derelict pots as they are still considered private property there. |
| Implementing Organization or Potential Partners | MCBP, MD DNR, MD DTWG and Partners |
| Affected Parties | Some actions will have impacts on stakeholders. Crab pots or other gear that may be identified to fishermen can be returned to those fishermen. This would have a positive, although minor, economic benefit on fishermen who had gear returned to them as the number of retrieved pots that are salvageable may be few in numbers. At |

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| | the very least, it demonstrates that pulling ghost crab pots can be beneficial to terrapins and fishermen. |
| **Action Location** | Coastal MD |
| **Detailed Strategy** | Specific examples of strategy (provided by MD DTWG):<br><br>➢ Solutions for Crab pots – Recreational Use<br>    ○ Ban the use of recreational crab pots<br>    ○ Enforce existing law requiring BRDs on all recreational crab pots<br>    ○ Require all recreational crab pots sold in Maryland to have BRDs (they all currently have escape rings per law)<br>    ○ Research the use of commercial crab pots in tributaries by landowners (W. Roosenburg has data)<br>    ○ How many of these have BRDs? (W. Roosenburg data: compliance <30%)<br>➢ Solutions for Crab pots – Commercial<br>    ○ Require BRDs in all commercial crab pots<br>    ○ Require BRDs in all commercial crab pots [?set in shallow waters (15' or less?) or x-distance from shorelines] – or identify areas where terrapin at most risk<br>    ○ Require BRDs at point-of-sale<br>    ○ Require BRDs at manufacture<br>➢ Solution Crab pots – Derelict crab pots (commercial)<br>    ○ Volunteer cleanups<br>    ○ Paid Derelict Crab Pot retrieval by watermen<br>    ○ Require individual IDs on all commercial crab pots<br>➢ Solutions for Eel Pots - Commercial<br>    ○ Require BRDs in all commercial eel pots (commercial pots are allowed in tributaries in shallow water/baited with clams – preferred terrapin food which leads to a disastrous situation for terrapins) - Action Item: Emergency regulatory change – MD DNR Fisheries<br>➢ Solutions for Fyke Nets – Commercial<br>    ○ Restrict season to cold months (1 November - 1 April)<br>    ○ Soak times (Oct. 16 to April 1: 48 hours; after April 1- Oct. 15: 24 hours. Define "soak time" = interval in which all organisms are removed from device).<br>    ○ If no soak times & in shallow water (water that is shallow enough that float provides air space at all times)-Require ***solid*** flotation devices in cod ends or cod ends secured above mean high tides (tied on stakes) for fyke nets set near shore<br>➢ Solutions for Pound Nets – Commercial<br>    ○ Soak times (72 hours up to a week)<br>    ○ Restrict areas of use (marine sanctuaries)<br>➢ Solutions for Bank Traps – Commercial<br>    ○ Soak times (48 hours)<br>    ○ Restrict areas of use (marine sanctuaries) |

## Virginia

**ACTION 1: Virginia Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality** - *Refer to - ACTION 1: Mid-Atlantic Conservation Action to Address Terrapin Mortality from Derelict Crab Pots/Other Fisheries*

**ACTION 2: Virginia Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality** - *Refer to ACTION 2: Mid-Atlantic Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality*

**ACTION 3: Virginia Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortality** - *Refer to ACTION 3: Mid-Atlantic Conservation Action to Address Terrapin Crab Pot/ Other Fisheries Gear Mortalit***y**

**ACTION 4: Virginia Conservation Action to Address Habitat Loss/Climate Change** - *Refer to ACTION 6: Mid-Atlantic Conservation Action to Address Habitat Loss*

**ACTION 5: Virginia Conservation Action to Address Predation** – *Refer to ACTION 7: Mid-Atlantic Conservation Action to Address Predation*

## ADDITIONAL CONSERVATION ACTIONS/RESEARCH NEEDED

Additional conservation actions or research needed that may not be fully developed by the NE states are included below. Some of the additional conservation actions are actions outlined in the NE state SWAPs. While there are conservation actions within updated NE state SWAPs that will likely benefit terrapins, only conservation actions that specifically included terrapins in their description/explanation are included below.

### Regional

***Regional Coordinated Survey***. See Maryland Coastal Bays – Terrapin Project for land and boat survey protocol and data sheets (Appendix C). The Maryland Coastal Bays Program aims to create a database on local terrapin habitats to aide scientists in the conservation of the terrapin using citizen scientists.

***Monitoring mud snails to assess diamondback terrapin populations***. See Jamaica Bay Terrapin Research Project - Surveying for Terrapins for survey methodology and data sheets (Appendix D). The trematode, *P. malaclemys* uses only terrapins as their adult hosts, and because this trematode is the only species that forms external cysts on eastern mud snails (a food source for terrapin), the number of cysts on mud snails can be used as an index of the number of terrapins locally (Byers et al. 2011).

***Hibernation/Hibernacula Study***. Determine important hibernacula for terrapins potentially through telemetry. The results could assist in determining species needs and providing recommendations during the environmental review process for winter dredging projects. It would also be beneficial for monitoring in response to illegal harvest. New Jersey and DE have expressed interest in a regional study.

### Connecticut

Connecticut SWAP Conservation Action Reptiles and Amphibians, Administration: Participate in regional conservation efforts, especially Regional Conservation Needs project for Regional Species of Greatest Conservation Need and CT SGCN herpetofauna such as diamond-back terrapin (see Chapter 4, 4-35, CT SWAP) (CT DEEP 2015).

### New York

New York SWAP Conservation Action (2015) Assess population status of Northern diamond-backed terrapins (see Chapter 8, pg. 67 NY SWAP) (NYSDEC 2015).

### New Jersey

***Identifying high risk areas for boat strikes***. Working with municipalities, marine police, conservation groups, and others to post no-wake or turtle warning signs. The signs would not likely be placed year round, but when terrapins are most vulnerable (e.g. at Oyster Creek, NJ during the July 4th weekend). This could be posted on the NJDFWS website as well as in the Marine Fisheries Digest.

***Headstarting***. Terrapin hatchlings are headstarted as part of several conservation programs in the region, including MD and NJ. Hatchlings are reared in captive conditions for a year or more to attain a larger size before being released to become part of the wild population. Schools may participate in the programs, giving students the opportunity to learn about terrapins, conservation issues, and animal care over the course of the school year. At TWI, viable eggs are collected from road-killed female terrapins during patrols of coastal roads and then incubated at temperatures to produce female hatchlings that enter a headstart program (Herlands et al. 2004). Headstarted terrapins are PIT tagged before release, and have been documented nesting on the property. Though criticized by some as an ineffective conservation approach that fails to address ultimate threats, when incorporated into more comprehensive conservation and education programs head-starting may confer benefits to the species. Additional research of marked populations, such as those at Poplar Island, MD, Stone Harbor, NJ, and North Sedge Island, NJ, is needed to better understand the effectiveness of headstarting on terrapin populations.

**Delaware**

Delaware SWAP Conservation Action Planning; Species and habitat management planning; Species management planning: Assess threats to terrapin and develop a conservation plan that focuses on protecting nesting areas (see Chapter 4, 4-14, DE SWAP) (DE DNREC 2015).

**Maryland**

Maryland SWAP Conservation Action (2015) Promote the use of cull rings and Turtle Exclusion Devices on all recreational pots to avoid bycatch (addresses IUCN Threat - Biological Resource Use) (see Chapter7, 7-140) (MD DNR 2016).

Maryland SWAP Conservation Action (2015) Determine efficacy of head-starting terrapins (addresses IUCN Threat Resource Management Needs) (see Chapter 7, 7-141) (MD DNR 2016).

Maryland SWAP Conservation Action (2015) Monitor spread of individuals affected by *Ranavirus*; determine impact of emerging pathogens (addresses IUCN Threat Resource Management Needs) (see Chapter 7, 7-141) (MD DNR 2016).

Maryland SWAP Conservation (2015) Continue to coordinate efforts of MD DTWG (addresses IUCN Threat Administrative Needs) (see Chapter 7, 7-141) (MD DNR 2016).

Maryland SWAP (2015) Continue working with other states on range-wide conservation projects (addresses IUCN Threat Administrative Needs) (see Chapter 7, -141) (MD DNR 2016).

## EDUCATION AND OUTREACH RESOURCES

### Terrapin Brochures, Fact Sheets, Field Guides, and Other Outreach Information

The Northern Diamondback Terrapin Habitat, Management and Conservation - for the Northeast Diamondback Terrapin Working Group with Support from Wheaton College and The Sounds Conservancy
http://www.dtwg.org/Bibliography/Gray/Brennessel%202007.pdf

Diamondback Terrapin factsheet - Natural Heritage & Endangered Species Program, MA Division of Fish and Wildlife
http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/malaclemys-terrapin.pdf

Diamondback Terrapin field guide – Buzzards Bay Coalition (MA)
http://www.savebuzzardsbay.org/DiscoverBay/AboutBuzzardsBay/FieldGuide/AnimalsPlants/DiamondbackTerrapin

Turtles in Rhode Island – RI Natural Heritage Program and the RI Endangered Species Program
http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/turtles.pdf

Rhode Island Diamondback Terrapin Project I.D. Card – RI Natural History Survey
http://rinhs.org/wp-content/uploads/2014/12/ID-card-singlesided.pdf

Northern Diamondback Terrapin, State Species of Special Concern factsheet - CT DEEP
http://www.ct.gov/deep/cwp/view.asp?a=2723&q=326000&pp=12&n=1

Diamondback Terrapin factsheet – NYSEC
http://www.dec.ny.gov/animals/59652.html

The Diamondback Terrapin – Gateway's Salt Marsh Turtle brochure (NY)
http://www.dtwg.org/Bibliography/Brochures/Gateway's salt marsh turtle.pdf
New Jersey's Diamondback Terrapins brochure/factsheet - TWI and NJDFW (NJ)
http://wetlandsinstitute.org/wp-content/uploads/2010/05/Terrapin-Brochure-publisher.pdf

Project Terrapin brochure – NJ
http://media.wix.com/ugd/a12dab_42b1d1baf519411682c7ece85491ce26.pdf

Terrapin Anatomy/Biology factsheet - Project Terrapin (NJ)
http://media.wix.com/ugd/a12dab_c3c5a771c4c847e0b0886fcb02f54201.pdf

Northern Diamondback Terrapin field guide – CWFNJ (NJ)
http://www.conservewildlifenj.org/species/fieldguide/view/Malaclemys%20terrapin%20terrapin/

About Diamondback Terrapins fact sheet - Center for the Inland Bays (DE)
http://www.inlandbays.org/wp-content/documents/Fact Sheet on Terps.pdf

Field guide to MD's turtles, Northern Diamondback Terrapin – MD DNR
http://dnr2.maryland.gov/wildlife/Pages/plants_wildlife/herps/Testudines.aspx?TurtlesName=Northern Diamond-backed Terrapin

Diamondback Terrain field guide – Chesapeake Bay Program (MD)
http://www.chesapeakebay.net/fieldguide/critter/diamondback_terrapin

Diamondback Terrapin fact sheet – MD Zoo
http://www.marylandzoo.org/assets/Terrapin-diamondback.01.27.15.pdf

Northern Diamondback Terrapin species booklet – VDGIF
http://www.vafwis.org/fwis/booklet.html?&bova=030067&Menu=_.Taxonomy

The Diamondback Terrapin: VA's Coastal Native brochure – VIMS
http://www.vims.edu/research/units/projects/terrapin_brds/_docs/terrapin_brochure.pdf

**Terrapins as Bycatch and BRD Information**

BRDs Bycatch Reduction Devices Terrapin Lifesavers! Brochure – Project Terrapin (NJ)
http://media.wix.com/ugd/a12dab_4c6cec46f50e49dbba7ae87ea27deebe.pdf

Terrapin BRD Instructions pamphlet – MD Department of Natural Resources
http://aqua.org/~/media/Files/blue-view/terrapinbrochure.pdf

Terrapin BRD Instructions pamphlet – VIMS (VA)
http://www.vims.edu/research/units/projects/terrapin_brds/_docs/terrapin_bdr_brochure.pdf

Terrapins and Traps educational article - TWI (NJ) http://wetlandsinstitute.org/conservation/terrapin-conservation/terrapins-and-traps/

Terrapins and BRD pamphlet - MD Coastal Bays Program
http://www.mdcoastalbays.org/content/docs/FinalTerrapin_brochure1.pdf

Aqua Kids 2015-07 Goodwin Islands – Marine Debris, Terrapins & Marine Life (RR) 01.18.16 EPISODE (VA)
http://www.aquakids.tv/project/aqua-kids-2015-07-goodwin-islands-marine-debris-terrapins-marine-life-01-18-15/

**Terrapin Habitat Guidance and Living Shoreline Resources**

Turtle Gardens guidance - Project Terrapin (NJ)
http://www.projectterrapin.org/#!turtle-gardens/vm8h9

Turtle Garden postcard - CWNFJ, MATES, and BBP (NJ)
http://media.wix.com/ugd/a12dab_f9133d3630934b339f39cef32de3cf5b.pdf

Turtle Garden brochure – Massachusetts Audubon and WBWS
http://www.turtlejournal.com/wp-content/uploads/2010/11/Turtle-garden-brochure-newest-edition.pdf

Northern Diamondback Terrapin Nesting Beach Restoration Project - DE DNREC
http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/DE Wetlands Conf 2014/Session IV Wetland Biology/Meadows_DE_Wetland_2014.pdf

StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage- Massachusetts Office of Coastal Management (CZM) and NOAA
http://www.mass.gov/eea/docs/czm/stormsmart/properties/ssp-factsheet-3-vegetation.pdf

Workshop: Living Shorelines for Coastal Erosion Protection in a Changing World
Marine Coastal Processes & Facilities / Marinas (includes slideshow presentations and video presentations) - NY Sea Grant
http://www.seagrant.sunysb.edu/articles/t/workshop-living-shorelines-for-coastal-erosion-protection-in-a-changing-world-marine-coastal-processes-facilities-marinas-news

MD's Living Shorelines Program Slideshow Presentation- MD Department of Natural Resources http://www.seagrant.sunysb.edu/Images/Uploads/PDFs/LivingShorelines0513-Presentations/5_NYSG_Living_Shorelines_Maryland.pdf

Living Shorelines: Plant Materials Applications Slideshow Presentation- USDA-NRCS, Cape May Plant Materials Center, NJ
http://www.seagrant.sunysb.edu/Images/Uploads/PDFs/LivingShorelines0513-Presentations/6_NYSG_Living_Shorelines_Plant_Materials.pdf

The Hudson River Sustainable Shorelines Project Slideshow Presentation- Cary Institute of Ecosystem Studies, Consensus Building Institute, Hudson River National Estuarine Research Reserve, NY State Department of Environmental Conservation, Stevens Institute of Technology, and other partners
http://www.seagrant.sunysb.edu/Images/Uploads/PDFs/LivingShorelines0513-Presentations/7_NYSG_Living_Shorelines_Hudson_River.pdf

"Living Shorelines" An Historical Perspective from Chesapeake Bay Slideshow Presentation - VIMS
http://www.seagrant.sunysb.edu/Images/Uploads/PDFs/LivingShorelines0513-Presentations/2_NYSG_Living_Shorelines_Chesapeake.pdf

Living Shorelines Online Resources/Publications
http://www.livingshorelinesacademy.org/images/resource-pdfs/LSOnlineResources.pdf

An Introduction to Living Shorelines (Video) - Restore America's Estuaries
https://vimeo.com/140113632

**Resources for Terrapin Threats and Protection**

Terrapins and Tires educational article – TWI (NJ)
http://wetlandsinstitute.org/conservation/terrapin-conservation/terrapins-and-tires/

Terrapins: What to do? educational article - TWI (NJ)
http://wetlandsinstitute.org/conservation/terrapin-conservation/terrapins-what-to-do/

A Guide for Building Terrapin Barriers and Fences – TWI (NJ)
http://wetlandsinstitute.org/conservation/terrapin-conservation/a-guide-for-building-terrapin-barriers-and-fences/
Be Terrapin Aware brochure – CWFNJ (NJ)

http://www.conservewildlifenj.org/downloads/cwnj_66.pdf

HEADSTARTING DIAMONDBACK TERRAPINS (article discussing terrapin road mortality issue)- The Richard Stockton College and the Wetlands Institute, NJ
http://loki.stockton.edu/~herlandr/terrapin/tcptext.html

**Lesson Plans, Classroom Educational Materials, and Programs**

Diamondback Terrapin lesson plans grades 3-6 (can be modified) - Disney Conservation Fund and TWI (NJ)
http://wetlandsinstitute.org/wp-content/uploads/2013/11/Lesson-plans-3-6_Jane_Maggie-Rev.pdf

Impact of Climate Change on Diamondback Terrapin lesson plan - NOAA
http://oceanservice.noaa.gov/education/pd/climate/activities/casestudies/eastern_coastline_activities_6_9_09.pdf

Terrapin Educational Presentation- Disney Conservation Fund and TWI (NJ)
http://wetlandsinstitute.org/video/Disney-Terrapin-PowerPoint.pdf

Terrapins in the Classroom, hatchling program – National Aquarium in Baltimore (MD)
http://www.aqua.org/learn/teacher-programs/terrapins-in-the-classroom

Aqua Kids 2015-07 Goodwin Islands – Marine Debris, Terrapins & Marine Life (RR) 01.18.16 EPISODE
http://www.aquakids.tv/project/aqua-kids-2015-07-goodwin-islands-marine-debris-terrapins-marine-life-01-18-15/

Terrapin Connection, supplemental classroom program - AACPS/ Arlington Echo's Chesapeake Connections program (Chesapeake Bay)
http://www.arlingtonecho.org/education/terrapin-connection.html

Diamondback Terrapins of Tampa Bay: an Educator's Guide (includes lessons and worksheets for children and had general info about terrapins in general and threats as well) - Heinrich Ecological Services and Tampa Bay Estuary Program (outside of the Northeast region, but still applicable as lesson plans)
http://www.tbep.org/pdfs/Diamondback_Terrapin_Educators_Guide.pdf

Diamondback Terrapin Board Game: “Living on the Edge”- Tampa Bay Estuary Program http://www.tbep.org/pdfs/Diamondback_Terrapin_Board_Game.pdf (outside of the Northeast region, but still applicable as lesson plans)

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Brennessel, B. Wheaton College. pers. comm. 2016

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**ADDITIONAL CONSERVATION ACTIONS/RESEARCH NEEDS**

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**Appendix A - Terrapin Occurrence Data Sources**
**Appendix B - Conservation Action Development**
**Appendix C - Land and Water Surveys Sheets**
**Appendix D - Mud Snail Protocol and Data Sheet**