

New Jersey Blue Crab Regulations and the Northern Diamond-backed Terrapin (*Malaclemys terrapin terrapin*): Terrapin Status, Biology, Threats, Regulations, and Recommendations

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Purpose and Scope

The two-fold purpose of this document is to: 1) support internal agency discussions regarding current threats to the Northern Diamond-backed Terrapin (*Malaclemys t. terrapin*) populations, and 2) support the recommendations of the Endangered and Nongame Species Program's (ENSP's) regarding potential conservation actions specific to blue crab regulations that could be implemented directly by NJ Fish and Wildlife (NJFW) and/or formally recommended to its applicable Councils for their consideration. Consequently, the scope of the threats and actions discussed herein is primarily focused upon fisheries management issues under the jurisdiction of the agency. A comprehensive range of threats and actions affecting Northern Diamond-backed Terrapins are identified in New Jersey's Wildlife Action Plan (2018).

Terrapin Status and Protection

Northern Diamond-backed Terrapins (terrapins) were once considered a "game" species in New Jersey and had an allowable hand-only harvest from November 1 through March 31. During 2015 and 2016, all terrapin harvest was halted via Administrative Orders (A.C. 2015-02, 2016-02). The executive orders were issued when the NJ Marine Fisheries Council (NJMFC) and the Endangered and Nongame Species Advisory Committee (ENSAC) raised concerns over excessive harvesting aimed at providing terrapins to out-of-state aquaculture operations and overseas markets (NJDEP 2016a). Excessive harvesting of terrapins was evidenced in 2014, when more than 3,500 terrapins were legally taken from two locations in southern NJ and transported to an out-of-state aquaculture facility that raises them for overseas markets. More than 14,000 offspring of the wild adult terrapins were then exported from the facility to Asia (NJDEP 2016a).

- In 2016, Governor Christie signed legislation (S-1625) designating terrapins as a "nongame" species, making them subject to the laws, rules and regulations of the Endangered and Nongame Species Conservation Act (N.J.S.A. 23:2A). This includes the statute's prohibitions on "take":

N.J.S.A. 23:2A-6: Prohibitions relative to certain species

Except as otherwise provided in P.L.1973, c. 309 (C.23:2A-1 et seq.) or the rules or regulations adopted thereunder, no person shall take, possess, transport, import, export, process, sell or offer for sale, or ship, and no common or contract carrier shall knowingly transport or receive for shipment, any species or subspecies of wildlife appearing on the following lists: (1) the list of wildlife determined to be endangered by the commissioner pursuant to P.L.1973, c. 309 (C.23:2A-1 et seq.); (2) the list of nongame species regulated pursuant to P.L.1973, c. 309 (C.23:2A-1 et seq.); [...].

- The 2016 legislation also added the following amendment:

N.J.S.A. 23:2A-4.1: Diamondback Terrapin [Diamond-backed Terrapin] designated nongame Indigenous species:

- a. Notwithstanding any law, rule, or regulation to the contrary, the diamondback terrapin shall be designated as a nongame indigenous species and shall be subject to the laws, rules, and regulations governing the importation, care, possession, and breeding of that type of animal in the State.
 - b. Any diamondback terrapin [Diamond-backed Terrapin], including any nest or egg thereof, shall be protected by the Department of Environmental Protection, any other State agency, and any local governmental entity in the same manner and to the same extent as any nongame species of reptile indigenous to the State that is protected by "The Endangered and Nongame Species Conservation Act," P.L.1973, Chapter 309 (C.23:2A-1 et seq.), any other applicable State law, or any rule or regulation adopted pursuant thereto.
 - c. The commissioner shall investigate populations, distribution, habitat needs, limiting factors, and other biological and ecological data concerning the State's diamondback terrapin population to determine management measures necessary for their continued ability to sustain themselves successfully. On the basis of such determinations, the commissioner shall develop management programs which shall be designed to insure the continued ability of the State's diamondback terrapin [Diamond-backed Terrapin] population to perpetuate themselves successfully.
- During the same year, the ENSAC recommended that terrapins be designated as a species of "Special Concern," based upon the results of a status review of NJ amphibians and reptiles (NJDEP 2016b). "Special Concern" is a term that applies to species that "warrant special attention because of some evidence of decline, inherent vulnerability to environmental deterioration, or habitat modification that would result in their becoming a Threatened species." The category is also applicable to species that meet the foregoing criteria and for which there is little understanding of their current population status in the state. The Special Concern status of terrapins in New Jersey is pending the state rulemaking process.
 - New Jersey designates the terrapin as a focal species of greatest conservation need (FSGCN) in New Jersey's Wildlife Action Plan (2018) and the Northeast Association of Fish and

Wildlife Agencies has recognized terrapins as a regional species of greatest conservation need (RSGCN) since 1999 (<https://www.northeastwildlifediversity.org/>).

- Current state listing and Species of Greatest Conservation Need (SGCN) status of terrapins in Northeast states is as follows:

State	State Listing	SGCN (Y/N)
Massachusetts	Threatened (S2)	Y
Rhode Island	Endangered (S1)	Y
Connecticut	Special Concern (S3)	Y
New York	Special Concern (S3)	Y
Delaware	Apparently Secure (S4)	Y
Maryland	Apparently Secure (S4)	Y
Virginia	Special Concern (S3)	Y

- The International Union for Conservation of Nature (IUCN) rank terrapins as Vulnerable with a decreasing population trend (Roosenburg et al. 2019 as cited on IUCN website, accessed 2019). Vulnerable is defined as a species that is likely to become Endangered unless the circumstances that are threatening its survival and reproduction improve.
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), a multilateral treaty to protect endangered plants and animals, added terrapins to Appendix II, effective 2013 (Egger 2016). Appendix II of the treaty applies to species that are not necessarily threatened with extinction but may become so unless trade in specimens is subject to strict regulation in order to avoid utilization incompatible with the survival of the species in the wild (CITES website, accessed 21 Feb 2020).

Distribution

There are seven recognized subspecies of Diamond-backed Terrapin, including the Northern Diamond-backed Terrapin (*Malaclemys terrapin terrapin*) which occurs from Massachusetts to the vicinity of Cape Hatteras, North Carolina (Ernst and Lovich 2009). Northern Diamond-backed Terrapins exclusively inhabit coastal salt marshes, estuaries, tidal creeks and ditches with brackish water, bordered by *Spartina* grass. In New Jersey, they occupy all coastal counties with estuarine habitat from Delaware Bay, the Atlantic Coast, tidal marshes of Raritan Bay, and Newark Bay, north to the lower Hackensack River and the NJ portion of the Hudson River. 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). In South Carolina, terrapins were recaptured in the same creek annually for almost twenty years (Brennessel 2006).

Biology and Reproduction

- Terrapins usually enter hibernation in November and December, buried in the mud substrate of tidal estuary creek bottoms 1.5 to 2.5 meters deep at low tides, ponds, or banksides (Coker 1906, Carr 1952, Ernst and Lovich 2009, Yearicks et al. 1981, and Seigel 1984 as cited in Outerbridge 2013). They remain there until February or March the following year (Yearicks et al. 1981 and Seigel 1984 as cited Outerbridge 2013). Terrapins may hibernate in large aggregations (Haramis et al. 2011), small groups, or singly (Yearicks et al. 1981).
- Like other turtles, terrapins grow and mature at a slow rate. Females generally reach sexual maturity around six years of age (between 13.2 cm and 17.6 cm) while males mature in 3-4 years or approximately 9 cm (Lovich and Gibbons 1990). However, Roosenburg (1991) noted that some terrapins mature later -- between 8 and 13 years for females (as cited in Szerlag 2006) and between four and seven year for males (Roosenburg 1996 as cited in Wnek 2014). The typical size for an egg laying female in New Jersey is between 13.2 cm and 18.4 cm (Straightline Plastron Length [SPL]) (Montevecchi and Burger 1975 as cited in Szerlag 2006).
- Mating occurs in the water in April into early May, with egg laying reported in New Jersey from mid-May to late July. Female turtles cross the intertidal zone to nest on flat locations in high dunes with varying cover densities and percentages (Burger and Montevecchi 1975). Terrapins favor nesting in areas with either little vegetation or very sparse vegetation (Williamson 2011), preferably in 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). According to Scholz (2006), females have been observed to prefer cleaner nesting areas to ones littered with debris or trash.
- Terrapins lay one to three clutches (Roosenburg 1991, Wnek 2014) of 4 to 18 eggs per year (Burger and Montevecchi 1975). Terrapins have been observed laying at least two clutches in New Jersey, New York, and Massachusetts (Auger and Giovannone 1979, Feinberg and Burke 2003, Szerlag 2006). Interval times between clutches may range between 13 and 35 days. In one New Jersey study, clutch sizes averaged 9.76 and ranged from 4 to 18 eggs (Burger and Montevecchi 1975). Another New Jersey study showed an average clutch of 12.7 eggs *in situ* (Wnek 2014). This is not markedly different from clutch sizes measured in nearby states: 10.9 in New York (Feinberg and Burke 2003) and 13.2 in Maryland (Roosenburg 1991). Eggs hatch in 60-120 days depending on a number of environmental factors, including temperature or precipitation, or from August through mid-September. Overwintering hatchlings (i.e., those that remain within the nest cavity during the winter months) may not emerge until April or May of the next year.
- Terrapin demography is characterized by very low natality and recruitment and high adult survival (Gibbons et al 2001; Harden et al. 2007; Tucker et al. 2001 as cited in Haramis et al.

2011). The survival rate of terrapin nests in Virginia has been estimated to be 10% (Ayers 2010). Feinberg and Burke (2003) documented a 92.2% nest mortality rate in New York (i.e. 7.8% survival) for terrapins. Nesting success rate can be low in any given year due to predation from raccoons, foxes, gulls and crows (Burger 1977). Environmental destruction, along with nesting in sites that are subject to repeated tidal inundation and infiltration from the roots of plants, also place egg nests in jeopardy.

- Limited information is available for hatchling or juvenile survival rate, but Draud et al. (2004) found a 67% predation rate from Norway Rats on hatchlings with fitted with transmitters and suggest less than 10% survivorship during the first year in New York. An indirect estimate of juvenile survival in Rhode Island was calculated at 56.5% (Mitro 2003), and adult survival rate was calculated for females at 94.4% to 95.9% (Mitro 2003). Using Mitro's (2003) adult survival estimates, Ayers (2010) projected adult survival under various levels of crab potting where females ranged between 74.8% and 97.1% (Ayers 2010) and males between 78.8% and 90.1% (Tucker et al. 2001 as cited in Ayers 2010).
- Modeling suggests that terrapin population growth depends mostly on the survival of adults and juveniles rather than survival of hatchlings (Mitro 2003, Ayers 2010) As a result, the elimination of egg-laying adult females in large quantities relative to their population size 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).
- Diamond-backed Terrapins are a slow-growing and late-maturing species that have a long lifespan. There have been marked recaptured terrapins with documented lifespans of 20 years, and some researchers believe that they can live for more than 40 years (Hildebrand 1932, Brennessel 2006).

Populations Trends/Ongoing Studies

- From the mid 1800's through the late 1920's, Diamond-backed Terrapin soup was considered a culinary delicacy, as the meat was thought to be superior to other species of turtle. The popularity of terrapin soup lead to heavy commercial exploitation of the species throughout the late 19th and early 20th centuries. Decimated supplies could not keep up with demand, causing the market to collapse, thereby ending one of the greatest food fads in American history (Carr 1952). The end of the terrapin "craze" permitted a rebound in terrapin populations in the 20th century, although at levels greatly reduced from their former abundance.
- No statewide or regional assessments that determine overall terrapin population size and trends have been completed. However, studies of local populations using mark/recapture techniques have been conducted in New Jersey for many years (Egger 2016).

- *North Sedge Island and Spizzle Creek, Barnegat Bay:* Project Terrapin 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, Marine Academy of Technology and Environmental Sciences (MATES), pers. comm. 2015). The decline in the nesting females coupled with the low recruitment of nesting females could foretell a decline in the overall population at North Sedge Island. The nesting site at North Sedge Island is within the Sedge Island Marine Conservation Zone (wherein motorized boat use is prohibited), yet 21% of the population has scars indicating boat injuries (J. Wnek, MATES, 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 having 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]).
- *Cape May:* Since 1997, The Wetlands Institute (TWI) has been conducting a long-term mark-recapture study of the terrapin population near Stone Harbor, New Jersey. Terrapins are captured by hand during nesting excursions or in traps placed in tidal creeks and marked with PIT tags. In addition, TWI staff head-start 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 headstarted terrapins 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.
- Other ongoing studies to determine terrapin population sizes and trends include Cedar Run Dock Run and Cedar Bonnet Island in Manahawkin (Project Terrapin), and in the Meadowlands (Hofstra University).

- Terrapins play an important role in the coastal marsh ecosystem by preying on periwinkle snails (*Littorina littorea*). Periwinkle snails, left unchecked, can graze a marsh down to mud, making it less effective at dampening waves and providing a buffer against storms that threaten coastal communities (Macdonald 2019, USFWS website). Declines in terrapin populations may therefore reduce ecosystem resiliency against stronger storms and future extreme weather events related to climate change. Further, the conversion of high vigor spartina marshes to denuded salt pans or mudflats would also curtail the coastal ecosystem's ability to sequester carbon.

Terrapin Threats Not Associated with Blue Crab Fishery

The Northern Diamond-backed Terrapin is challenged by a number of threats, primarily anthropogenic in origin. We describe below a subset of priority threats that are not directly associated with the blue crab fishery along with a brief description of how ENSP and conservation partners are taking conservation action to address the threat.

- Habitat Loss and Habitat Change
 - According to Ner and Burke (2008), available terrapin habitat has been severely impacted by the rapid urbanization of estuaries, which has reduced marsh habitat availability and quality. The installation of hard structures for stabilizing shorelines prevents terrapins from accessing nesting habitat (Wnek 2010, Roosenburg et al. 2014), causing individuals to travel farther distances in search of suitable locations from which to access land, potentially reducing fitness due to greater energy expenditure and increasing the risk of predation due to exposure (Winters et al. 2015). In addition, Wnek (2010) reports that human activities, such as vegetation mowing, cause soil compaction, which may cause hatchlings to die underground before emerging.
 - Impacts due to climate change such as sea level rise (including saltwater intrusion into brackish water marshes) and stronger storm surges exacerbate existing threats (Egger 2016). By using empirical nest survey data and regional Satellite Laser Range (SLR) modeling, Woodland et al. (2017) projected changes in terrapin nesting habitat availability in Chesapeake Bay in response to sea level rise. According to Woodland et al. (2017), rapid inundation of historically used terrapin nest locations will result in 25%-55% loss within ten years, and over 80% loss by the end of the century.
 - Conservation Action Example: As a candidate species of special concern, terrapins will be included in the next release of the Landscape Project, a tool for strategic wildlife habitat conservation (<https://www.state.nj.us/dep/fgw/ensp/landscape/>).
- Transportation
 - Motor vehicle collisions are a significant cause of terrapin mortality. As coastal development expands, 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 New Jersey, 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 2006, Szerlag and McRobert 2006). In 2016, of 1,082 terrapins recorded along Great Bay Boulevard in Tuckerton, New Jersey, 132 were found dead, with an average mortality rate of 12.2% throughout the survey area (Wurst, B. 2018, Conserve Wildlife Foundation Blog). Wurst (2018) found a nearly 100% mortality rate for terrapins attempting to cross Rt. 30 in Atlantic County.

- Recreational watercraft pose both a direct mortality threat, as well an indirect impact on terrapin habitat quality (Burger and Garber 1995, Gibbons et al. 2001). Even when mortality 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. Lester et al. (2013) report that in Barnegat Bay, New Jersey, 11% of terrapins (n = 2,644) had scars consistent with injuries from boats. According to Lester et al. (2013), *in situ* terrapins did not significantly change their behavior when exposed to playback recordings of boat engines of varying sizes. The lack of behavioral response of terrapins to boat sounds helps explain high rates of injury and mortality of terrapins and may threaten the viability of terrapin populations (Lester et al. 2013).
- Dredging operations can dislodge or kill terrapins in hibernacula (Brennessel 2006), while contaminated dredge material can lead to nest failure (Avery and Wnek 2011).
- Conservation Action Examples: 1) Connecting Habitat Across New Jersey (CHANJ) is an effort to make our landscape and roadways more permeable for terrestrial wildlife by identifying key areas and actions needed to achieve habitat connectivity across the state (<https://nj.gov/dep/fgw/ensp/chanj.htm>). 2) A number of permitted conservation partners monitor and rescue female terrapins from roadways during nesting season.

- Predators

- Human-subsidized predators, including raccoons, crows, and red foxes, prey heavily on eggs and hatchlings. Predation, particularly by raccoons, has been cited for up to 70% of nest mortality in the Patuxent River, Maryland (Roosenburg and Place 1994), and 92% in Jamaica Bay, New York (Feinberg 2004), with most depredations occurring within 48 hours of oviposition (Burger 1977, Butler et al. 2004). In New Jersey, crows have been observed in Galloway Township taking and devouring terrapin eggs before females have completed laying their clutch (R. Tilton, New Jersey Fish and Wildlife [retired], pers. comm. 2019).

- Conservation Action Example: A number of permitted conservation partners relocate vulnerable nests to securely fenced areas that are free from predators.
- Illegal Collection
 - Terrapins, along with a number of other SGCN turtle species, are illegally collected by members of the public unaware it is illegal to collect wildlife, and by commercial collectors as part of the illegal overseas markets and the pet trade industry. In 2019, a Pennsylvania resident was sentenced for his role in illegally collecting thousands of terrapins from New Jersey (see <https://www.justice.gov/usao-edpa/pr/levittown-man-sentenced-trafficking-protected-turtles>).
 - Conservation Action Example: NJFW staff are active members of Partners in Amphibian and Reptile Conservation's (PARC) Collaborative to Combat the Illegal Trade in Turtles (CCITT), a working with the mission of advancing efforts to better understand, prevent, and eliminate the illegal collection and trade of North America's native turtles (<https://parcplace.org/species/collaborative-to-combat-the-illegal-trade-in-turtles/>).

Terrapin Threats Associated with Blue Crab Fishery

According to Egger (2016), 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). The focus of the remainder of this paper will be on the anthropogenic threat of mortality due to drowning in actively fished and derelict commercial-style crab pots.

The current blue crab regulations are presented below, taken directly from the May 2022 New Jersey Marine Digest:

2022 New Jersey Blue Crab Regulations

(<https://nj.gov/dep/fgw/pdf/2022/digests/digmar22.pdf>)

1. Crabs may be taken recreationally with hand lines, manually operated collapsible traps or scoop nets without a license. A non-commercial crab pot license is required for the use of not more than two non-collapsible Chesapeake-style crab pots or two trot lines to harvest crabs.
2. It is illegal to harvest or possess more than one bushel of crabs per day per person or offer for sale any crabs without having in your possession a valid commercial crabbing license.
3. Minimum size for crabs that may be harvested (measured from point to point of shell) are as follows: a) Peeler or shedder crab: 3 inches b) Soft crab: 3½ inches c) Hard crab: 4½ inches

4. All female crabs with eggs attached and all undersized crabs shall be returned to the water immediately.
5. Recreational trot lines shall not exceed 150 feet in length with a maximum of 25 baits.
6. All pots and trot lines shall be marked with the identification number of the owner.
7. All crab pots must be tended at least once every 72 hours.
8. No floating line may be used on any crab pot or crab pot buoy.
9. No crab pot shall be placed in any area that would obstruct or impede navigation or in any creek less than 50 feet wide.
10. Only the owner or a law enforcement officer may raise or remove contents of a legally set fishing device.
11. Crabs taken with a bait seine may be retained for personal use only if the angler possesses a bait net license, and may not be bartered or sold unless the fisherman possesses a commercial crab license.
12. No crabs may be harvested from the Newark Bay Complex.
13. Crab Pot/Trot Line seasons: Delaware Bay and tributaries: April 6 – Dec. 4. All other waters: March 15 – Nov. 30. The following waters, and their tributaries, are closed to the use of crab pots and trot lines: Cumberland Co.: Cohansey River and creeks named Back, Cedar, Nantuxent, Fortescue, Oranoken and Dividing; Cape May Co.: West and Bidwell Creeks and the Cape May Canal; Atlantic Co.: Hammock Cove (Dry Bay); Ocean Co.: on east shore of Barnegat Bay, that area of Sedge Islands Wildlife Management Area enclosed by a line drawn from the northern bank of Fishing Creek on Island Beach State Park to the northern tip of the Sedge Islands (Hensler Island), then south from point to point along the western side of the Sedge Islands WMA and terminating on the most southwestern point of Island Beach State Park.
14. Crab Dredge Seasons: Delaware Bay and tributaries: Jan. 1 through April 15 and Nov. 15 through Dec. 31. All other waters: Jan. 1 through March 31, Dec. 1 through Dec. 31. Fish and Wildlife will issue a non-commercial crab dredge license for the harvest of not more than one bushel of crabs per day during the crab dredge season. Crabs so taken may not be sold or offered for barter. There is a fee of \$15 for this non-commercial crab dredge license.

Notice: All non-collapsible Chesapeake-style crab pots must be constructed to include a biodegradable panel designed to create an opening to allow crabs and other organisms to escape if the pot is lost or abandoned. All non-collapsible Chesapeake-style crab pots set in any manmade lagoon or any water body less than 150 feet wide must also include a turtle excluder device inside all pot entrance funnels.

- Terrapin Excluders and Biodegradable Panels Are Required on Chesapeake-Style Crab Pots
 - NOTE: It is illegal to catch or take diamondback terrapins in New Jersey.
 - Users of non-collapsible, Chesapeake-style crab pots note: all pots set in any body of water less than 150-feet wide at mean low tide or in any manmade lagoon MUST include diamondback terrapin excluder devices. Noncollapsible, Chesapeake-style crab pots set in any body of water MUST include biodegradable panels. These crab pot modifications will help reduce the unintentional drowning of terrapins allowing these and other species to escape in the event that pots are lost or abandoned. Terrapin excluder devices must be no larger than 2-inch high by 6-inch wide and securely fastened inside each funnel entrance. Biodegradable panels must measure at least 6½-inch wide by 5-inch high (5.1 × 15.2 cm) and be located in the upper section of the crab pot. The panel must be constructed of, or fastened to the pot with, wood lath, cotton, hemp, sisal or jute twine not greater than 3/16" diameter, or non-stainless steel, uncoated ferrous metal not greater than 3/32" diameter. The door or a side of the pot may serve as the biodegradable panel ONLY if it is fastened to the pot with any of the material specified above. Crabbers should note: ALL noncollapsible, Chesapeake-style crab pots MUST be licensed and marked with the gear identification number of the owner.

Terrapin Drownings Associated with Crab Pots

Terrapin population declines, growth, and changes in sex ratios have been directly attributed to by-catch 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), with local extirpations observed in some areas (Tucker et al. 2001). Terrapins are attracted to bait fish typically used in commercial-style crab pots and once through the entrance funnel, become entrapped and drown. Terrapins are also attracted to crab pots because they eat small crabs (Tucker et al. 1995). Commercial crab pots disproportionately kill small terrapins, particularly males that do not outgrow the opening size limits of commercial crab pots, and young females. Further, populations affected by crabbing may become increasingly older and increasingly female, with fewer young individuals surviving, due to selection pressures on smaller turtles (Dorcas et al. 2007, Grosse et al. 2011). Below are both general and specific accounts of terrapin mortality associated with drowning:

- Drowning in commercial-style crab traps represents a significant source of mortality for Diamond-backed Terrapins (Bishop 1983, Burger 1989, Roosenburg 1991, Roosenburg et al. 1997, Seigel and Gibbons 1995, Wood 1997). According to Gross et al. (2011), mortality due to drowning in commercial style crab pots is one of the species' chief conservation concerns. Further, using the Northeast Lexicon (Crisfield and NEFWDTC 2013), the Regional Conservation Strategy ranked "Fisheries" as a priority threat to terrapins in New Jersey and the Mid-Atlantic region (Egger 2016). Commercial style crab pots are set for the blue crab fishery and for recreational purposes in many areas also inhabited by the terrapin (Egger 2016).

- Reports of drownings are especially high in Delaware Bay, where commercial crabbers have been observed discarding terrapins from pots set in near-shore areas. These terrapins later wash ashore in high numbers. In 2017, Return The Favor (RTF) volunteers working with The Wetlands Institute (TWI) and ENSP, began tallying dead terrapins washed up on Delaware bayshore beaches. Volunteers estimated terrapin size, moved the carcass above the high tide line to avoid recount, and submitted photographs to TWI staff. In 2017, volunteers recorded 221 dead terrapins along thirteen beaches. In 2018, RTF volunteers counted 732 dead terrapins at 17 beaches. In 2019, RTF volunteers counted 907 dead terrapins at 16 beaches. Between 2017-2019, Thompson's and Moore's beaches had the most reports of dead terrapins (n=516, n=515 respectively). Although causes of death were unknown, drowned terrapins in nearby pots were observed. In addition, there were concentrations of crab pots directly set offshore of the beaches surveyed, and regular occurrences of fresh, intact, bloated individuals. The range of carcass conditions included decayed, shell only, missing limbs or injury. Condition of beach carcasses changed over time due to exposure and/or scavenging (L. Ferguson, TWI, 2019, unpublished data). In 2020 with the season still ongoing, preliminary data showed that from 15 May 2020 and 30 June 2020, 470 terrapin carcasses were counted by volunteers, with most occurring at Thompson's and Moore's beaches (L. Ferguson, TWI, 2020, unpublished data).
- To date, The Wetlands Institute studies provide the best evidence of large-scale terrapin loss in Delaware Bay. This information is further corroborated by NJDFW Marine Enforcement, whose officers have witnessed numerous occurrences of dead terrapins trapped in near-shore crab pots, including some instances when there were enough drowned terrapins (estimated n=40-50) to float the pot and ultimately cause them to wash up on oceanfront beaches (Snellbaker, J., 2020, NJDFW Marine Law Enforcement, pers. comm.). According to TWI, in 2019 commercial pots were observed to be set an average distance of 71.3 (+/- 12.5 SE) meters from the nearest shore or creek edge in Dennis Creek and at the mouth into Delaware Bay. With the number of basking terrapins observed on the creek's edge and the number of carcasses encountered on the bayshore beaches, the authors considered by-catch risk for terrapins in this area to be high (Williamson and Ferguson 2020).
- Due to budget constraints, resultant staff limitations, and competing priorities, Marine Enforcement cannot effectively patrol all fished areas and assess compliance with excluder regulations pertaining to recreational and/or commercial crabbing activity. In Maryland, where excluders are required on all recreational commercial-style pots, compliance with the regulation was less than 35% (Radzio et al. 2013). This suggest that education and/or enforcement are critical factors affecting the efficacy of existing or expanded use of excluders.
- Crab Pot Soak Times, the number of hours a set trap is submerged before being tended to:
 - According to the RCN Regional Conservation Strategy (Egger 2016), submergence information should be considered when regulations are determined regarding

soak times. Mortality may be reduced up to 90% with a specified and implemented shorter soak (Grosse et al. 2011). Currently, only NJ and DE have mandated maximum soak times (72 hours) (Egger 2016).

- Allowable 72-hour soak times do not prevent terrapins from drowning. Although terrapins can endure periods of submergence, they generally do not survive beyond 24-48 hours in submerged crab pots. Survival can depend on water temperature, activity level, and terrapin size (Baker et al. 2013). Even when excluders are affixed to crab pots, smaller males still become entrapped.
- Terrapins make quicker dives when water temperature is higher. In a laboratory study, mean voluntary dive times for males and juvenile females was 8.4 minutes; maximum dive time for adult females was 50 minutes (Baker et al. 2013). Drowning may occur in 2-4 hours at 20°C or greater. (Mann 1995; Roosenburg 2004 as cited in Baker et al. 2013), while current regulations only require crab pots to be tended once every 72 hours.
- Anecdotal information suggests that some recreational crabbers set commercial-style pots during weekends and sometimes allow them to sit unattended for days or weeks (D. Jenkins, ENSP, pers. comm. 2016).

Terrapin Threats Associated with Derelict/Ghost Crab Traps

Lost and abandoned commercial-style crab pots contribute to terrapin mortality, because individuals enter the pots and cannot escape. Crab pots may become lost due to storms, improper rigging to buoys, boat propellers that cut pots free from their buoys, and other factors. The longer a pot sits on the bottom, the more marine life becomes entrapped. Entrapped crabs, fish, turtles and other organisms in turn attract other marine life. The remains of captured animals serve as bait for additional by-catch, continuing the process of “ghost fishing” (Anderson and Alford 2014). It is estimated that derelict crab pots can fish for an additional 1-2 years, but possibly longer since they do not degrade quickly (Arthur et al. 2014). Unlike vehicular strikes, where females are more at risk, smaller males and juvenile females can enter traps more easily and are therefore disproportionately at risk from drowning (Bishop 1983, Wood 1997, Harden and Williard 2012).

- In Chesapeake Bay, it is estimated that up to 30% of 368,900 pots set annually are lost, adding more than 100,00 pots to the bay every year (Havens et al. 2008, Virginia Institute of Marine Science [VIMS] 2008). A study by VIMS funded through NOAA’s Marine Debris program estimated roughly 20% of all crab pots set in a year are lost (https://www.vims.edu/research/topics/fisheries/ts_archive/ghost_pot_2010.php). NJFW does not have a sound estimate on the number of crab pots used and/or information on derelict pots; however, anecdotal evidence from local fishermen suggests approximately 10% of pots are lost annually in New Jersey (Egger 2016). Pots can also be stolen and then moved into terrapin habitats (I. Jones, former New Jersey commercial crabber, pers. comm. 2018).

- According to Nemec (1995), ghost pots are frequently transported to shallow areas through tidal action and, in these locations, may account for substantial terrapin mortalities. Based on derelict crab pot research, Wnek et al. (2019) reported that pots tend to move as a result of strong currents produced by strong seasonal winds.
- Recreational pots tend to move more easily because they weigh less, but movement of both recreational pots and commercial style pots is dependent on the bottom composition (Wnek et al. 2019). According to Wnek et al. (2019), pots set in more silt/mud are more likely to settle into the substrate and are less likely to move. Pots set in sandier substrate, however, show greater movement. As a result, crab pots fished far from the shoreline may end up closer to shore after strong storms. In shallow water estuaries such as Barnegat Bay, pots can continue to move and capture species (Wnek et al. 2019). Crab pots, therefore, may be set in areas where excluders are not required, but could then be lost and displaced to areas with high terrapin concentrations.
- On Memorial Day, 2018, approximately 80 dead terrapins were found along the 11th Street beach in Sea Isle City, New Jersey. Groups of turtles were scattered within one block. In addition, a commercial crab pot was found in the immediate area. It was impossible to determine where the pot was set or whether it was in compliance with excluder area regulations (Reil 2018). According to B. Williamson (TWI, pers. comm. 2018), this event illustrates how one crab pot without an excluder can have a significant impact on a local population.
- In New Jersey, a number of organizations are working to remove ghost crab pots from the state's coastal waterways. In 2013, a Stockton University project resulted in >1,500 derelict crab pots located and 491 recovered in a 5 square mile radius of the Mullica River/Great Egg Harbor estuary. In 2015-2018, The Conserve Wildlife Foundation (CWF), Marine Academy of Technology and Environmental Science (MATES), Stockton and Monmouth universities removed >1,600 derelict pots in Barnegat Bay. During 2014-2018, TWI removed 81 derelict crab pots along the Atlantic Coast in Cape May County. In 2019, Patcong Creek Foundation was awarded a grant to remove ghost crab pots from the Great Egg Harbor watershed. These efforts document excluder compliance, by-catch contents, number of dead terrapins, and estimate minimum number of terrapin per trap.
- 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, Chelonian Research Institute, pers. Comm. 2015 in Egger 2016). Pots that have been pulled in these systems may not have been lost in terrapin habitat, but in deeper waters where terrapins and crab pot interactions are less likely to occur.

Biodegradable Panels and Crab Pots

Although biodegradable panels (BDP) are required on all commercial-style crab pots set in New Jersey waters, these do little to help turtles escape at the time traps are lost or shortly thereafter. It is unclear how long it takes for panels to degrade.

- Of 93 ghost pots retrieved by TWI and for which data on biodegradable panels exist, 73 (79%) of pots did not have any apparent BDP or breakaway panels (BAP). The remaining 20 traps had some form of identifiable BDP or BAP. Sixteen (80%) of these were intact, with 2 (10%) partially degraded and 1 (5%) fully degraded. Most traps retrieved by TWI have either had no discernable biodegradable panels, or the panels have been intact. However, there are many ways that crabbers can meet the current biodegradable panel criteria, some of which are hard to notice (ungalvanized hog rings on the trap door, or ungalvanized rings holding the trap together in other locations as opposed to a dedicated panel). It is possible, therefore, that panels could have been missed during processing (B. Williamson, TWI, pers. Comm. 2019).
- Pots that have some sort of degradable panel often are recovered with these panels intact and therefore don't appear to degrade much over the course of a few months (assuming traps retrieved in winter were lost the previous season and not lost several years prior). The possibility exists that panels last longer than a few months, but more data are needed to determine their longevity (B. Williamson, TWI, pers. Comm., 2020). It has also been reported that retrieved traps were found with panels degraded but facing the bottom, making it impossible for by-catch to escape.

Benefits of Terrapin Excluders on Chesapeake-Style Crab Pots

- There have been numerous studies indicating that the use of excluders, also known as bycatch reduction device (BRD), can reduce terrapin by-catch while maintaining or increasing blue crab catch when compared to crab pots without excluders (Wood 1997, Guillory and Prejean 1998, Roosenburg and Green 2000). Upperman et al. (2014) found no difference in the size and number of blue crabs captured in commercial style pots without excluders compared to those fitted with large (5 x 15 cm) and small (4.5 x 12 cm) excluders. Out of 69 terrapins that were captured as by-catch, 67 were found in the experimental pot without excluders and two in crab pots with large excluders (5 x 15 cm). Pots equipped with small excluders (4.5 x 12 cm) did not catch terrapins. According to Upperman et al. (2014), the potential mortality of terrapins in pots without excluders would have reduced the population in the tidal creek by 42% in just 24 days. Similarly, Chambers (2014) reported no difference in the size and numbers of blue crabs captured in commercial style pots without excluders compared to those fitted with large (5 x 15 cm) and small (4.5 x 12 cm) excluders.

- Excluders may reduce the rate of crab entry into traps, but also significantly decrease crab escape rate. According to Corso et al. (2017 in: Grubbs et al. 2017), the decreased escape rate then yields a high net rate of crab capture.
- In 1997, ENSP staff conducted experiments to evaluate the effects on blue crab catch by equipping commercial-style crab pots with excluder devices designed to reduce terrapin by-catch. The excluder devices were a 5 x 15 cm wire rectangle and 5 x 15 cm wire diamond. Equal numbers of each of three pot types (rectangle, diamond, no excluder) were deployed in Cedar Swamp Creek and the Mullica River for a total of 934 pot days. No evidence was found to show that either excluder affected the average size of crabs or the total number of crabs captured. The investigators concluded that the 5 x 15 cm rectangle excluder presented an economically efficient means of reducing an important source of adult mortality for terrapins without reducing crab catch for commercial crabbers (Jenkins et al. 1998). In addition, aquarium studies conducted by ENSP biologists to evaluate the effectiveness of four different excluder devices concluded that the 5 x 15 cm excluder was effective at keeping out female terrapins 116 mm carapace length and longer, and male terrapins longer than 132 mm carapace length while allowing 6.5" blue crabs through the funnel entrance (J. Bowers-Altman, 1997, unpublished data).

New Jersey Excluder Requirements on Actively Fished Crab Pots and Impact to Terrapin

Current NJFW regulations do not require the use of excluders within all waters that are also utilized by terrapins, such as Delaware and Barnegat Bays where terrapins are abundant. Also, excluders are not required in wide but shallow sounds in southern New Jersey marshes. Current regulations only require the use of excluders on commercial-style crab pots set in water bodies less than 150' wide and in man-made lagoons.

- Research by Wnek et al. (2019) suggests that the location of crab pots in proximity to shoreline areas, or even water body mean depth, may be more important than the width requirement of a waterbody, with regard to excluder use. New Jersey does not have an excluder requirement based on distance from shore or water body mean depth. According to Wnek et al. (2019), terrapins recovered during derelict/ghost pot removal efforts were most commonly encountered in pots located within 100 meters of the shoreline. In North Carolina, Hart and Crowder (2011) found that all terrapin captures in crab pots for their study were within 321.4 meters (1,054 feet) of the shoreline.

Terrapin Excluder Regulations in Other States

Below we summarize excluder regulations in Northeast states with terrapin populations:

- Massachusetts – No specific excluder regulations.
 - <https://www.mass.gov/service-details/recreational-saltwater-fishing-regulations>
 - In 2021 Massachusetts banned the use of six sided crab traps for blue crab.

- Rhode Island – No specific excluder regulations.
 - No person shall take blue crabs from the waters of the State between the hours of sunset and sunrise (R.I. Gen. Laws § 20-7-15).
- Connecticut – No specific excluder regulations.
 - Only manually-operated crab traps (no unattended pots) are permitted in CT: <https://portal.ct.gov/-/media/DEEP/fishing/saltwater/BLUECRABFACTSHEETpdf.pdf>
- New York – Excluders are required within bays, harbors, covers, rivers, tributaries and creeks that enter into Long Island Sound and other areas; 1 ¾" x 4 ¾" (4.5 x 12 cm)
 - <https://www.dec.ny.gov/outdoor/75333.html>
 - https://www.dec.ny.gov/docs/fish_marine_pdf/fishlimitscrabs.pdf
- Delaware – Excluders are required on recreational pots only; 1 ¾" x 4 ¾" (4.5 x 12 cm)
 - <https://regulations.delaware.gov/AdminCode/title7/3000/3700%20Shellfish/3715.shtml#TopOfPage>
- Maryland – Excluders are required on recreational pots only: 1 ¾" x 4 ¾" (4.5 x 12 cm)
 - <http://mdrules.elaws.us/comar/08.02.03.07>
 - In Maryland, compliance with excluder regulations was found to be less than 35% on recreational crab pots (Radzio et al. 2013).
- Virginia – Excluders are not required. However, the cost of a recreational license has been raised from \$36 to \$46 for those who choose not to use excluders. Their website doesn't specify excluder size, but states that "scientists have determined that the most effective size for a BRD (by-catch reduction device) is 1 ¾" x 4 ¾." (4.5 x 12 cm)

ENSP's Recommendations Pertaining to Reducing Terrapin and Crab Pot Interactions

- 1) Require the use of excluders on all commercial-style crab pots, both commercial and recreational, set in all areas. Requiring excluders on all commercial-style crab pots will 1) minimize terrapins from drowning in pots set close to shore, and 2) minimize terrapins from becoming entrapped in ghost pots that have been transported from deeper water into shallower terrapin areas.
 - a) If requiring excluders on all commercial-style crab pots (commercial and recreational) regardless of where they are set is not feasible, establish a distance from shoreline excluder requirement. Based on research by Hart and Chowder (2011) we recommend a distance of 1,000 feet, so that any crab pot set between the shoreline and 1,000 feet at mean low water will be required to be fitted with excluders; OR
 - b) If requiring excluders on all commercial-style pots set in all areas is not feasible, nor is a distance from shoreline requirement found reasonable, we recommend closing additional areas to crabbing by designating special "terrapin conservation areas." We recommend gathering information from terrapin partners and conservation officers to determine the areas where mortality from crabbing activity is especially high (e.g., nearshore areas of Delaware Bay).
- 2) Establish a soak time of no longer than 24-hours, or require that gear be checked "once daily," to drastically reduce the number of terrapins that drown in actively fished pots.

Although requiring excluders on all commercial-style pots will help reduce terrapin mortality, it will still be possible for smaller males and juveniles (including females) to become entrapped. According to the Monterey Bay Aquarium Seafood Watch (2019), an organization that evaluates the ecological sustainability of wildcaught and farmed seafood found in the US marketplace, terrapin by-catch may be limited by shortening crab pot soak times to under 24-hours.

- 3) Develop and implement a mandatory lost pot reporting system for commercial crabbers. Alerting Division staff, without repercussions to crabbers, where and when pots are lost will allow for a more immediate and successful retrieval effort. Provide outreach to commercial/recreational crabbers; outreach materials should include general information on terrapins, why excluders reduce mortality, tips on how to resuscitate terrapins if you find them in your pot. Terrapins may appear dead, but sometimes can be resuscitated. Immediately dumping them back into the water will kill them, since they do not have enough energy to swim to the surface. Outreach to commercial crabbers may also include providing crabbers with free excluders and inexpensive sonar or “pingers” for crab pots so that they may be found more easily. Distribute excluders and literature on terrapin protection to Division offices and at Division-sponsored events.
- 4) Investigate by-catch reduction technologies (BRTs) to increase crab catch in commercial style pots while excluding Diamond-backed Terrapins. For example, according to Corso et al. (2017), changing the color of excluders from orange to red has been demonstrated to attract the more profitable male blue crabs. In addition, placing LED lights in commercial traps with or without bait has been shown to increase snow crab catch (Nguyen 2017). According to Nguyen (2017), baited traps with white and purple LED lights had an increased catch per unit effort (CPUE) of 77% and 47%, respectively. Unbaited traps equipped with LED lights caught snow crabs in comparable amounts with baited traps. Further, LED lights have been shown to decrease by-catch of sea turtles and other organisms when affixed to gill nets. Nets illuminated with LED’s saw a 74% reduction in sea turtle catch compared to non-illuminated nets (Bielli 2020).
- 5) Investigate the feasibility of adopting the 4.5 x 12 cm excluder size that is currently used in NY, DE and MD. According to Wnek (2019), switching to this size excluder in New Jersey may make it easier for crab pot manufacturers to include a standard-sized excluder in all pots. And/or explore the adoption of the BRD design by South Carolina Department of Natural Resources (<http://sccoastalresources.com/home/2018/5/18/encouraging-results-for-turtle-saving-crab-trap-devices>), which Wnek (2019) has shown to capture more New Jersey legal-sized blue crabs than the current BRD design or those used in nearby states.
- 6) Identify areas that are highly utilized by terrapins (including sites where crab pots are frequently set) and work with authorities to implement seasonal speed restrictions for watercraft. Speeds in designated terrapin areas should be restricted to 5 mph and there should be no wake (Sornberger et al. 1994).

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