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Use of a Marked Population of Diamondback Terrapins (*Malaclemys terrapin*) to Determine Impacts of Recreational Crab Pots

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Diamondback terrapins (*Malaclemys terrapin*) are an important component of salt marsh ecosystems. Declines in population size have been reported from many areas throughout their range, from Massachusetts to Texas (Garber, 1990; Seigel, 1993; Seigel and Gibbons, 1995). Terrapin captures in commercial crab pots have been identified as contributing to the decline (Bishop, 1983; Roosenburg et al., 1997; Wood, 1997). Bishop (1983) estimated in South Carolina that there were 2835 terrapin captures in commercial pots per day in April and May with 10% mortality. Roosenburg et al. (1997) made population estimates for terrapins in Chesapeake Bay prior to conducting a study of mortality in crab pots. The study reported here for terrapins in the southern part of their range supports the finding that recreational crab pots are a potential conservation problem.

Methods. — A long-term mark-recapture study of diamondback terrapins in the Kiawah River, South Carolina, has resulted in the capture of more than 1200 adult terrapins since 1983 (Lovich and Gibbons, 1990; Tucker et al., 1995). Based on these data, population estimates were obtained for 1987–96 for a particular tidal creek, which allowed the number of terrapins captured in crab pots in this area in 1997–98 to be placed in a meaningful framework.

As Kiawah Island has developed, the number of recreational crabbers in the area has increased, while the commercial effort has remained constant (Joe Morris, commercial crabber, James Island, SC, *pers. comm.*). As the purpose of the current study was to assess the impact of recreational crab pots on terrapins, the locations and bait characteristic of recreational crabbing in South Carolina were utilized.

Fiddler Creek connects with the Kiawah River, which separates Kiawah Island from Johns Island, South Carolina, and is affected by tidal fluctuations of approximately 2 m. Depth in the study area at high tide ranges from 4 m at the mouth to 2.5 m in the upper reaches. Fiddler Creek is 21 m wide at the mouth, 8 m wide at the upper section, and is surrounded by marsh vegetation, primarily *Spartina alterniflora*.

Capture methods for the baseline long-term mark-recapture study from 1983–96 included trammel nets and seines during mid-ebb through mid-flood tides (Lovich and Gibbons, 1990; Tucker et. al., 1995). Carapace length, plastron length, body mass, and age were recorded on all captured terrapins, and each was uniquely marked by notching marginal scutes. Terrapins were returned to the same section of the creeks from which they were collected.

The present study was performed during two intervals, 1 May – 29 July 1997 and 1 April – 1 May 1998. Twenty recreational crab pots were set in Fiddler Creek. The pot entrances measured approximately 117 mm in width and 75 mm in height. Each pot was outfitted with a 13 mm diameter rebar weight along the bottom and was connected by 7 m of nylon rope to a 150 mm diameter styrofoam buoy. Pots were baited with raw chicken pieces (the bait most commonly used by recreational crabbers in the region) and set at approximately 33 m intervals along the center of the creek. Distance from shore ranged from 10 m near the mouth of the creek to 4 m at the upper section. The pots were monitored for 48 hrs each week and checked at 5-hr intervals during daylight hours to minimize the possibility of terrapin mortality. At the end of each 48-hr sampling period, the pot door was opened so terrapins would not be caught when the pots were not being monitored. All captured terrapins were identified, measured, and released at the capture site.

A Jolly-Seber population model (Pimentel, 1994), an open model designed for long-term studies, was used to estimate the terrapin population in Fiddler Creek based on the previously obtained baseline data. From 1987–96, 907 captures were made of 426 individuals. The data were analyzed by year.

Results. — During the 760 crab-pot-days in Fiddler Creek in 1997 and 1998, 21 captures were made of 19 individuals (= 0.027 terrapins per crab-pot-day). Two of the captures from 1998 were recaptures from the previous summer and were excluded from the analyses. Looking at the years separately, in summer 1997, 13 terrapins were captured during 600 crab-pot-days (Hoyle, 1997); in spring 1998, 8 terrapins were captured during 160 crab-pot-days. The sex ratio was 1 male to 1.4 females (8 males, 11 females). Nine individuals were unmarked. The mean plastron length was 109.3 mm for all terrapins captured (118.0 mm for females [range 96–152] and 99.6 mm for males [range 95–109]). All 8 males were sexually mature (> 90 mm plastron length; Lovich and Gibbons, 1990). Only 2 of the 11 females were above the estimated size for sexual maturity (138 mm; Lovich and Gibbons, 1990). Two pots became entangled during a high spring tide during the 1997 season when they were not being monitored. Four terrapins entered these pots and died.

The estimated population size of terrapins in Fiddler Creek ranged from 168 to 299 for the years 1988–95 (Table 1). Based on the model used, the estimated annual recruitment of terrapins in Fiddler Creek during the period ranged from 12 to 79 individuals (Pimentel, 1994; Table 1).

Discussion. — In a population of 168 to 299 terrapins, the potential removal of 19 individuals represents 6–11% of the population. Assuming a best-case scenario of 299 individuals, the first summer of the study (not including the 4 terrapins drowned in the entangled pot) caught 4% of the total population.

Table 1. Population estimates of *Malaclemys terrapin* in Fiddler Creek, Kiawah Island, South Carolina, based on a Jolly-Seber model.

Year	No. Captured	No. Recaptured	Population Size Estimate (N)	95% Confidence Limits	Estimated No. of Recruits (B)
1987	7	–			
1988	148	3	233	150–551	79
1989	68	30	257	163–273	62
1990	145	68	299	221–305	35
1991	148	92	241	194–243	49
1992	100	68	247	175–251	12
1993	81	62	235	152–261	30
1994	72	50	170	107–219	53
1995	22	12	168	66–346	
1996	36	22			

The funnel size of recreational crab pots combined with the demographics of the South Carolina terrapin populations results primarily in captures of mature males and immature females. Characterized by life history traits in which individuals are slow to mature and have extended longevity, terrapin populations cannot absorb chronic adult mortality (Congdon et al., 1994) caused by crab pots. In addition, in the Kiawah River populations, adult terrapins rarely move between creeks, thus reducing the likelihood of natural restocking of depleted areas (Gibbons et al., in prep.). Because of this strong site fidelity, anthropogenic mortality may have significant localized consequences on terrapin populations. In the Chesapeake Bay area, local terrapin populations can be extirpated in 3 to 4 years due to mortality in crab pots (Roosenburg et al., 1997).

Several differences in methodology between commercial and recreational crabbers suggest that recreational pots may be the greater threat to local terrapin populations. Recreational crabbers are able to access smaller creeks than commercial crabbers as they can wait for an appropriate tide to check their pots. Thus, recreational crabbers set their pots where terrapin populations are most concentrated. Commercial crabbers must be able to access their pots even at low tides because of the large number of pots they check in a day. In areas with high tidal amplitudes, as is characteristic of the Kiawah River, commercial crabbers cannot set their pots in the smaller creeks that are inaccessible at low tide. Additionally, recreational crabbers in South Carolina and Chesapeake Bay (Roosenburg, 1991) are more likely to leave their pots in the water for a longer period of time without checking them and may even unintentionally abandon them by placing them in areas where they can be washed away. The problem presented by lost pots was demonstrated by the two entangled pots in which four terrapins died. These pots were not being checked daily and represent the same threat as lost or ghost pots. In one year, two lost pots would account for more crab-pot-days than the 20 pots set during 1997.

In South Carolina, recreational crab pots presumably outnumber commercial pots. In 1997, the South Carolina Department of Natural Resources (SCDNR) licensed 277 commercial crabbers who set 20,552 pots. SCDNR estimates 25% of the 70,000 recreational fishermen licensed in 1997 set recreational crab pots. Two pots are allowed per person, resulting in a minimum estimate of 35,000 recreational crab pots in use in the state in 1997. This estimate does not account for recreational crabbers who do not fish and, therefore, do not require a license. The many tourists visiting Kiawah do not need licenses to set crab pots. Recreational crab pots may pose as big a threat to terrapin populations as commercial pots, because of the different methodology and higher number of pots used. Though recreational capture rates may not seem as high as the commercial rates reported by Bishop (1983), localized mortality from recreational pots can have a significant impact on a terrapin population.

In addition to local educational programs in coastal South Carolina where recreational crab trapping by inexperienced tourists is high, one solution for reducing mortality levels of diamondback terrapins is the use of some form of turtle excluder device, as recommended by Wood (1997). The use of a modified crab pot that is approximately 1.4 m taller than standard pots as recommended by Roosenburg et. al. (1997), would not be effective in South Carolina tidal creeks due to the high tide amplitudes and strong currents. Although as yet untested, a simple pot design suggested by a commercial crabber would make the pot entrance a rectangular opening that is oriented vertically. Crabs would turn vertically to enter, whereas terrapins might not (Sinkey Boone, commercial fisherman, Darien, GA, *pers. comm.*). Whatever approaches prove to be most effective, the initial step is to provide convincing documentation that the use of recreational crab pots are exacting a high toll on America's only exclusively estuarine turtle.

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Update on Permanent Residency, Persistence, and Longevity in a 35-Year Study of a Population of Three-Toed Box Turtles in Missouri

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In 1965, a study of a population of three-toed box turtles *(Terrapene carolina triunguis)* (Fig. 1) was initiated on a 22.2 ha area in Cole County, Missouri. For the next 25 years, 1743 individuals were collected, marked, and released at the point of capture (Schwartz and Schwartz, 1974, 1991; Kiester et al., 1982; Schwartz et al., 1984). Surveys through 1999 have now provided additional information on permanent residency, persistence, and longevity.

Permanent Residency. — Thirty-one turtles were collected over periods spanning 32 through 35 years; the number of captures for these individuals was 7 to 53 (mean 29.5). They included 17 males and 14 females with three age-classes (see below) represented. Based on the minimum rectangle method, all lived within a home range of 2.1 to 12.5 ha (mean 7.3).

Figure 1. *Terrapene carolina triunguis* (Turtle no. 514, male) was collected a total of 50 times over 35 years. This photograph was taken in 1978 when he was 20 years old. At his last collection in 1999 (age 41), he was still in excellent condition. Photo by Charles W. Schwartz.

It is apparent from these data that some turtles have a home area where they are permanent residents for up to 35 years, although wandering outside the area may not be documented. However, not all turtles are permanent residents in this study area because some are known to have moved through the environment as transients (Kiester et al., 1982; Schwartz et al., 1984). The ratio of permanent residents to transients in this study area is approximately 3:1 (Schwartz and Schwartz, 1991).

Persistence. — In 1989, 22 individuals of the original 1965 population of 366 were collected alive on the study area (Schwartz and Schwartz, 1991). Recent surveys found 13 turtles alive 35 years after marking, 9 alive 34 years after marking, and 7 alive 32 years after marking. Two additional turtles (Nos. 165 and 55, both females) were found freshly dead in their 34th and 35th years, respectively. Thus, 31 turtles lived 32–35 years after marking. This persistence is comparable to that of the subspecies *T. c. carolina*, for which Williams and Parker (1987) reported turtles in Indiana living at least 25 years after marking, and Stickel (1978) reported turtles in Maryland alive 30 years after marking. The most recent report of this latter turtle population (Hall et al., 1999) showed 7 turtles alive 50 years, 5 alive 40 years, and 6 alive 30 years after marking.

Longevity. — As a means of estimating a three-toed box turtle's age, three age-classes were established (Schwartz et al., 1984). These were based on a combination of characters (number and condition of scute rings, coloration, and total length of carapace): Age Class 1 (juveniles), actively growing, (from hatching through 9 years old); Age Class 2 (young adults), growing slowly or recently stopped growing (duration probably 23 years, from 10 through a projected 32 years old); and Age Class 3 (old adults) no longer growing (>33 years old). With additional data, the duration of these classes can be revised slightly, although the class-defining characteristics remain the same. The length of Age Class 1 is still 9 years.