

**A POPULATION STUDY OF DIAMONDBACK TERRAPINS OF
PIERMONT MARSH, HUDSON RIVER, NY**

A Final Report of the Tibor T. Polgar Fellowship Program

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ABSTRACT

The Hudson River Estuary is home to the diamondback terrapin (*Malaclemys terrapin*), a unique estuarine species of turtle harvested to very low numbers at the turn of the century. Although the turtle has slowly recovered from this decimation, loss of feeding and nesting habitats may impair the terrapin's ability to maintain healthy populations in the Hudson River. This research investigated the size and structure of the population of diamondback terrapins inhabiting Piermont Marsh in Rockland County, New York. From June 6 through August 24, 1997, thirty-nine surveys were made into the marsh, yielding information on terrapin population structure, feeding habitat and nesting potential. Trammel nets were set up in Crumkill and Sparkill Creeks and areas surrounding Piermont. Only eight terrapins were captured - six males and two females - suggesting that a relatively small population inhabits Piermont. All terrapins were trapped near sandy areas just north of the Piermont Marsh complex. Terrapins were neither trapped nor observed in the marsh creeks, indicating that terrapins are not using the marsh system for foraging or nesting during the summer months. Rather, terrapins are utilizing the open waters of the Hudson River, swimming and basking near the shores surrounding the Pier. Open sandy areas near Piermont Pier were the traditional nesting sites of the terrapins and may still be used, but recent development, soil subsidence, and *Phragmites australis* growth make these areas extremely poor nesting sites. In addition to the diamondback terrapin, the variety of estuarine species which inhabit the marsh complex make Piermont Marsh an important site for ongoing wildlife conservation.

TABLE OF CONTENTS

Abstract	I-3
List of Tables and Figures	I-6
Introduction	I-7
Methods	I-8
Results	I-13
Discussion	I-21
Acknowledgments	I-29
References	I-30

LIST OF FIGURES AND TABLES

Figure 1. Piermont Marsh, 1997, showing the Five Sampling Locations: Pier, North Sandbar, South Sandbar, Sparkill Creek and Crumkill Creek	I-9
Figure 2. Terrapin Field Form used in Piermont Marsh from June 6 to August 24, 1997	I-12
Figure 3. Terrapin Trapping Effort in Piermont Marsh from June 6 to August 24, 1997	I-16
Figure 4. Total By-catch Captured in Piermont Marsh from June 6 to August 24, 1997	I-20
Table 1. Descriptions of Terrapins Captured in Piermont Marsh from June 6 to August 24, 1997	I-14
Table 2. By-catch and Terrapins Captured in Piermont Marsh from June 6 to August 24, 1997	I-18

INTRODUCTION

Diamondback terrapin (*Malaclemys terrapin*) is a unique species of turtle that inhabits euryhaline coastal environments situated along the east coast from Cape Cod to the Gulf of Mexico. Large populations occur in the expansive barrier island marshes of southern New Jersey (Roger Wood, Stockton State College, pers. comm.), but smaller populations are more typical in the small isolated marshes of New York and coastal Connecticut (Victoria 1994). In New York and elsewhere along the eastern seaboard, diamondback terrapins are a species of management concern (Garber 1989; Roosenberg 1990; Seigel and Gibbons 1995), yet data on the population status of terrapins in different coastal environments is lacking. A survey of the terrapin populations of the State of New York has not been performed since 1991 (Seigel and Gibbons 1995).

Despite the wide spatial distribution and reduced size of the wetlands used by terrapins along the Lower Hudson River, a number of terrapins are known to inhabit the Piermont Marsh complex in Rockland County, New York (C. Nieder, HRNERR, pers. comm.; P. Warny, private herpetologist, pers. comm.). Terrapins have been observed swimming in Sparkill Creek, crawling up onto a small sand pit adjacent to the marsh and sunning on rocks along Piermont Pier, but the size, sex and age structure of this population is unknown. Informal surveys of the existing habitat surrounding the marsh indicate that the nesting habitat is poor, owing to ongoing development and a general lack of undisturbed and unvegetated sandy soils (C. Nieder, HRNERR, pers. comm.).

The main objective of this project was to complete a population study of the diamondback terrapins of Piermont Marsh during the summer of 1997. It was anticipated that a survey of the terrapins in this marsh would yield estimates of total population size,

terrapin age and size structure, terrapin sex ratios and terrapin nesting potential.

Ultimately, the results of this work were expected to assist the development of species management plans for the Piermont Marsh complex.

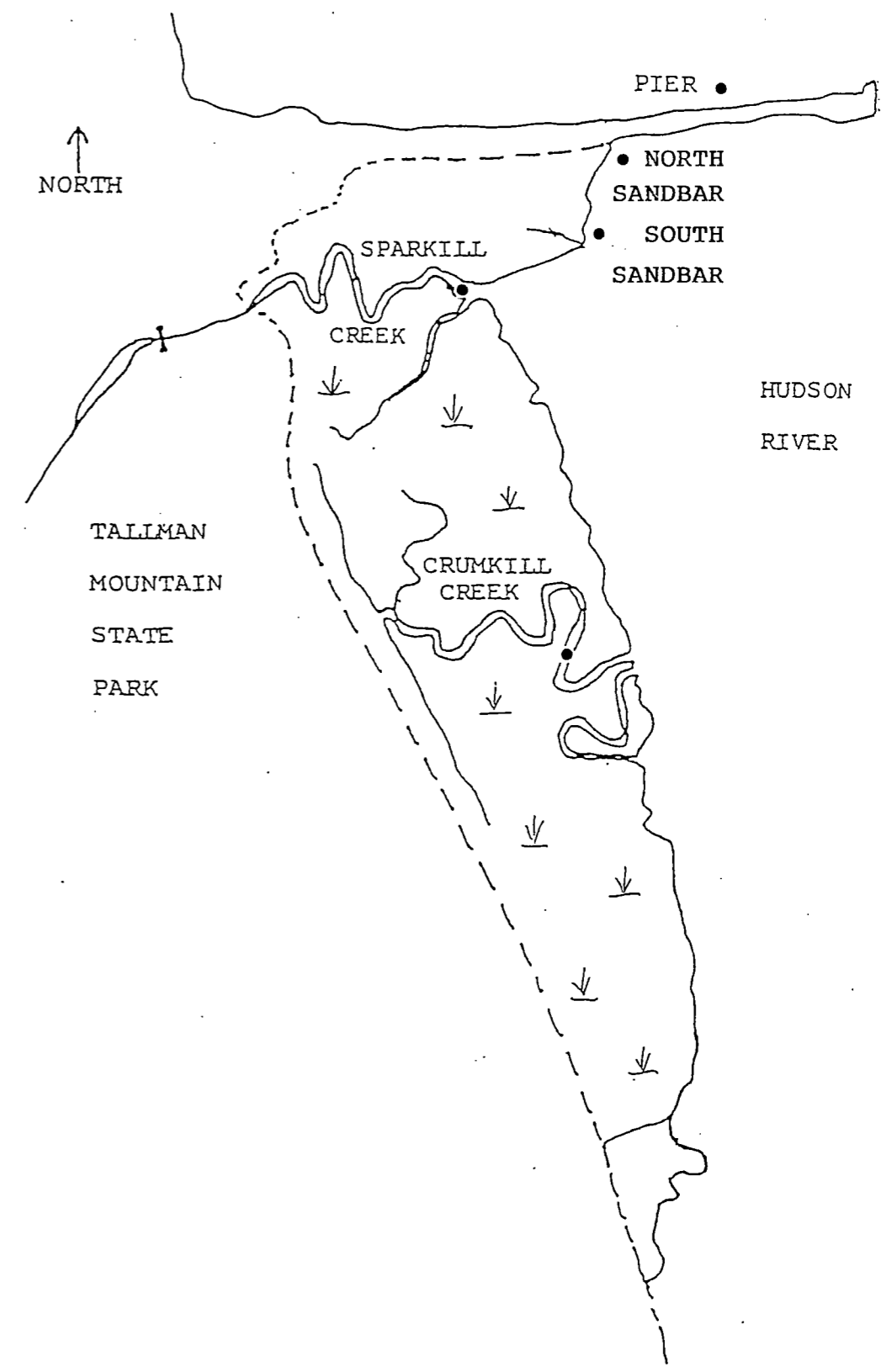
METHODS

Study Site

Piermont Marsh is located at approximately river mile twenty-three, on the western edge of the Hudson River just south of the Tappan Zee Bridge (Figure 1). The marsh is part of the Hudson River National Estuarine Research Reserve. The marsh is mesohaline with an average salinity of eight ppt during summer. This thousand-acre marsh is traversed by two major tidal creeks, the Crumkill and Sparkill. Crumkill Creek has slightly lower levels of dissolved oxygen than Sparkill Creek, with more silts than sand (Ramnarace et al. 1988). Salinity tends to be lower in Sparkill Creek due to greater freshwater runoff (Perrone and Knizeski 1988).

Areas surrounding the marsh are becoming increasingly urbanized. Upland areas adjacent to the marsh complex are part of Tallman Mountain State Park, managed by the Palisades Interstate Park Commission. However, the area just north of the marsh lies within the jurisdiction of the Town of Piermont and is undergoing intense development. Several condominiums are being constructed along and adjacent to the pier. The marsh creeks are regularly visited by jet skiers and fishermen, and the subtidal areas surrounding the marsh are used by local crab trappers.

Figure 1. Piermont Marsh, 1997, showing the Five Sampling Locations: Pier, North Sandbar, South Sandbar, Sparkill Creek and Crumkill Creek.



Despite the human disturbance, Piermont Marsh supports a variety of estuarine fauna. Between June and August 1997, avian species were observed utilizing the habitat in and around the marsh, including great blue herons, mallards, swans, Canada geese, marsh wrens, barn swallows, Baltimore orioles, and red-winged blackbirds. Deer and muskrat were spotted along the banks of the marsh and fiddler crabs could be seen among stalks of *Phragmites australis* (common reed). In sections of marsh, common reed almost completely covered the surface of the marsh, but *Sagittaria latifolia*, *Zizania aquatica*, and *Spartina alterniflora* were also found growing on the banks of the creeks.

Five sampling stations were identified and two potential nesting areas were investigated for this study (Figure 1). Turtle sampling was performed in Crumkill and Sparkill Creeks. In addition, terrapins were surveyed in the waters off two small sandy beaches located just south of Piermont Pier, named North Sandbar and South Sandbar. Diamondback terrapins frequently were observed swimming next to these potential nesting habitats. The fifth sampling area was located just north of the Pier next to rocks on which terrapins were seen basking. The upland areas adjacent to the marsh in Tallman Mountain State Park and the sandy areas just south of the pier were studied as potential nesting habitats. They were the only areas found in Piermont Marsh that could possibly have the open, sandy unvegetated environments in which terrapins prefer to nest (Burger and Montevicchi 1975; Roosenburg 1994).

Population Sampling

The primary method of sampling adult terrapins was via net capture using 50' and 75' trammel nets with four-inch outer mesh and two-inch inner mesh. These nets were strung across the five sampling locations in the Piermont Marsh complex during selected

strung across the five sampling locations in the Piermont Marsh complex during selected tidal periods between June 6 and August 24. This sampling strategy was chosen in order to yield adequate seasonal coverage both before, during and after the nesting season and to ensure that sampling was completed during different tidal stages. A trapping period consisted of setting a single net at a location over a complete flooding or ebbing tidal cycle. Nets were strung out across a location, then sampled by canoe every forty-five minutes for the duration of a six-hour tidal cycle. Terrapins and all other by-catch became entangled in the net and were removed long before experiencing hypoxic stress. The length and weight of all by-catch was recorded when possible and the organisms were subsequently freed. All collected terrapins were held in the canoe and released at the end of the sampling interval. Attempts to capture terrapins using baited hoop nets and crab pots were unsuccessful. Observations of terrapins swimming or basking were also noted.

At the end of each trapping period, a "Terrapin Field Form" was filled out for each captured terrapin (Figure 2). Weather conditions and air temperature were noted. Time, location and method of capture were also recorded. All adult terrapins were sexed, then weighed using a hanging tube scale. Tree calipers were used to measure the maximum length and width of the carapace and plastron of all turtles. Females were palpated for the presence of eggs. Terrapin age was estimated based on the number of annular growth rings on the plastron, a feature which was sometimes obscured on terrapins whose plastrons were excessively worn. Physical damage and unusual markings on the shell or skin were noted. Captured terrapins free of distinctive markings were marked before release using a file to notch the marginal scutes in unique "codes."

Figure 2. Terrapin Field Form used in Piermont Marsh from June 6 to August 24, 1997.

Terrapin ID Number: _____ Terrapin ID Code: _____

TERRAPIN FIELD FORM

Date: _____ Air Temp: _____

Weather: _____ Water Temp: _____

Location: Crumkill Sparkill Sandbar Pipe Describe: _____

Method of Capture: Trammel Net Hoop Net Scoop Net Hand _____

Time of Capture: _____ Recapture? Yes No Tides High: _____ Low: _____

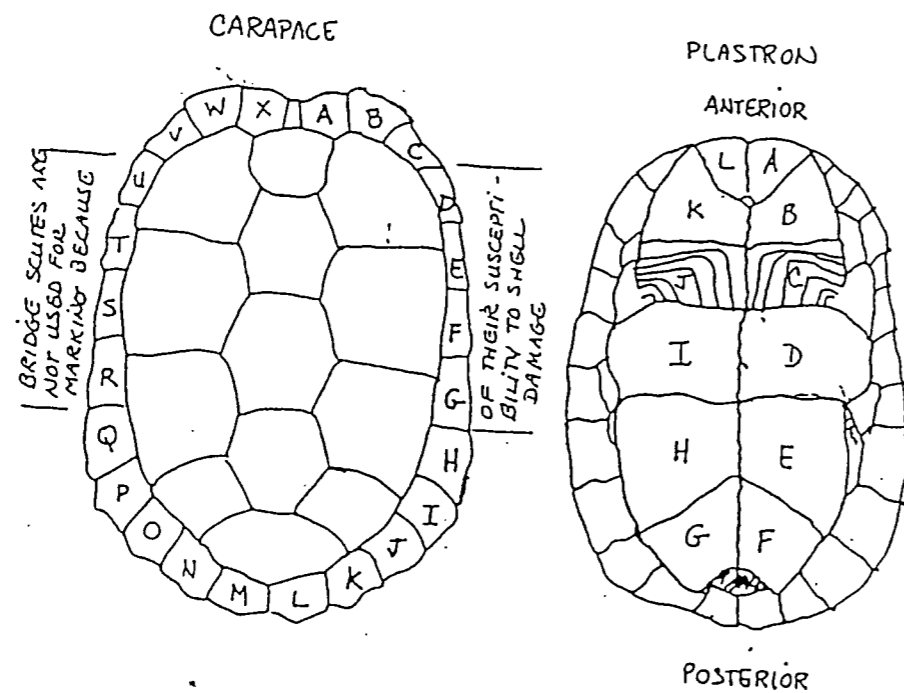
Carapace Length (mm): _____ Carapace Width (mm): _____

Plastron Length (mm): _____ Plastron Width (mm): _____

Weight (g): _____ Sex: Male Female Unknown Gravid? Yes No

Age: _____ Can't be determined Terrapin Activity: _____

Placement of ID Notches and Identifying Features:



A total of thirty-nine trapping periods were completed between June 6 and August 24. Every survey required two persons to paddle out to the designated sites at the beginning of a tidal cycle, set up the nets, check those nets every forty-five minutes, remove terrapins and by-catch, make the appropriate measurements, dismantle the nets at the end of the tidal cycle and travel back out of the marsh. This took approximately seven hours per trapping period. To sum, over five hundred man-hours were spent at the study site during the three months of the project.

RESULTS

Terrapins

Eight diamondback terrapins were captured with the trammel nets, two females and six males (Table 1). There were no recaptures. The males averaged 382 ± 68 g sd (standard deviation) and the females averaged $1,175 \pm 248$ g sd. The mean carapace length for male terrapins was 133 ± 9 mm sd and for female terrapins was 184 ± 13 mm sd, while carapace width averaged 104 ± 6 mm sd for males and 144 ± 9 mm sd for females. All but one male terrapins could not be aged because of obscured annular growth rings. The one male that was aged was five years old. The two females were ages six and seven years. Both were palpated for eggs but neither was found to be gravid.

Most of the terrapins caught had extremely worn shells. Six of the eight terrapins had chipped shells and circular blemishes. One female had extra segments on both her carapace and plastron. Three terrapins were caught with chips on their marginal scutes which resembled old notches. These notches were noted as part of the terrapin's ID code. Two captured terrapins had flesh wounds inflicted prior to capture. The seven-

year-old female had a cleft in her chin, and one male had a circular gash on his right hind leg. We were surprised to find a six-year-old female terrapin with no species-specific gray markings on her skin, and observed a completely white terrapin basking on the rocks at the North Sandbar location.

Table 1. Descriptions of Terrapins Captured in Piermont Marsh from June 6 to August 24, 1997.

Date	Location	Terrapin ID Code	Carapace (mm)	Plastron (mm)	Weight (grams)	Sex	Age (years)
8-Jun	S. Sandbar	C I/J M/N	124 x 97	102 x 63	275	male	CND
9-Jun	N. Sandbar	KM	131 x 101	109 x 67	400	male	CND
20-Jun	N. Sandbar	A I/J	136 x 101	420 x 67	420	male	CND
22-Jun	N. Sandbar	A M/N	131 x 102	112 x 66	350	male	CND
22-Jun	N. Sandbar	LM	175 x 137	161 x 92	1000	female	6
12-Jul	N. Sandbar	CJ	149 x 113	124 x 71	475	male	CND
27-Jul	S. Sandbar	J/K O	193 x 150	172 x 95	1350	female	7
24-Aug	S. Sandbar	BW	128 x 109	113 x 65	375	male	5

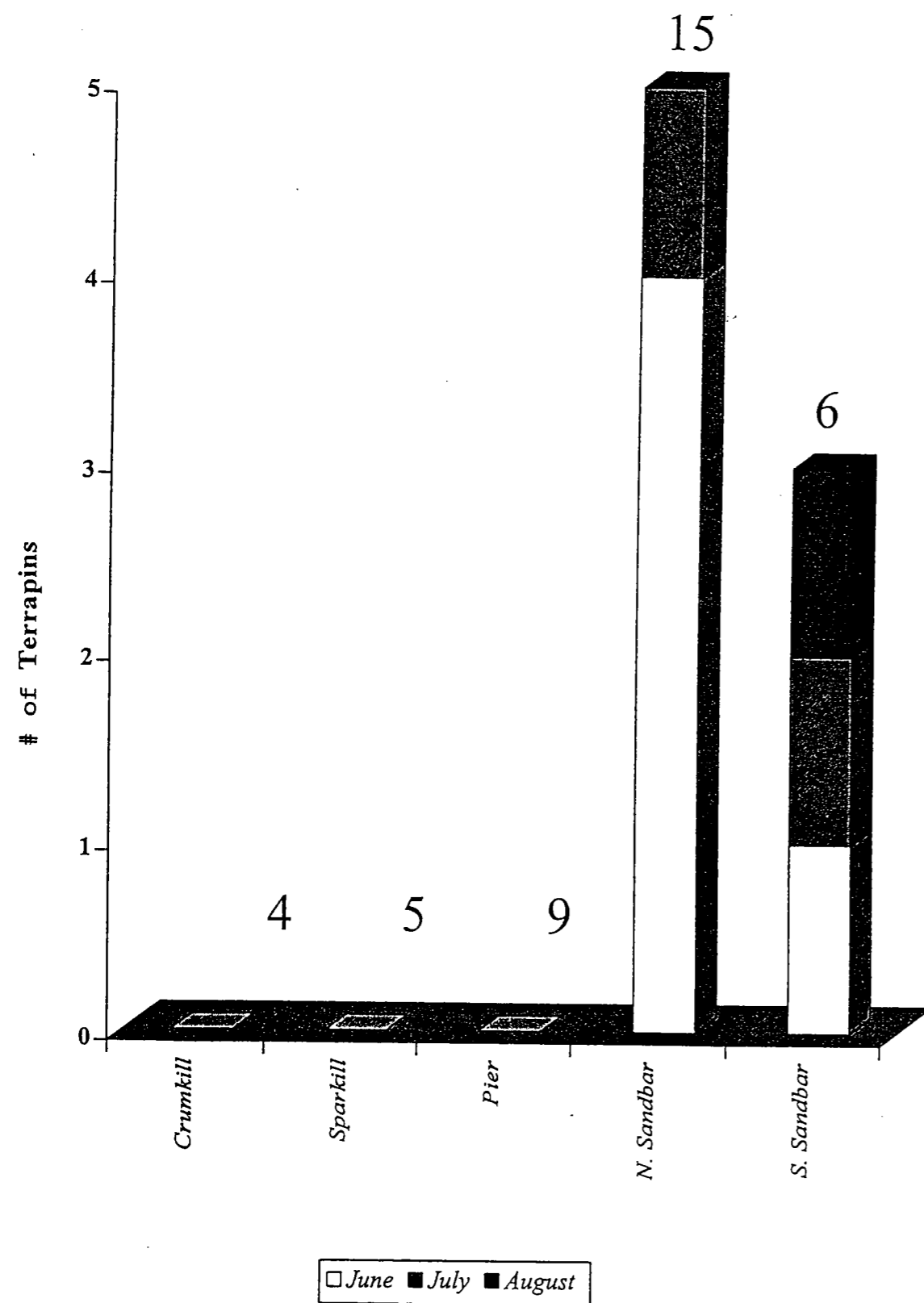
CND = Could Not be Determined

The small sample size precludes any definitive statements about terrapin activity. Half of the terrapins, however, were caught within seventy-five minutes of high tide, suggesting that terrapins may be foraging at this time. Terrapins were caught during both inclement and fair weather over a broad range of temperatures. The first diamondback was captured June 8, a partly cloudy day (70° F); two weeks later two terrapins were caught during a thunderstorm (95° F). Relative to temperature and tidal patterns, the seasonal pattern of terrapin captures was most pronounced, with five turtles caught in June, two in July and one caught on the last trapping day in August.

No terrapins were captured in Piermont Marsh (Figure 3). Despite nine trapping efforts in the marsh, trammel nets and hoop nets set up in Sparkill and Crumkill Creeks yielded no diamondback terrapins. Furthermore, no terrapins were spotted swimming in the creeks. Nine trapping efforts were also made at the Pier where up to six diamondback terrapins were spotted swimming and basking at one time. No terrapins were captured in either the crab pots or the trammel nets set up at this location. All terrapins surveyed were trapped off of the sandy spits just south of the pier. In fact, most of the terrapins spotted were seen basking and swimming near the North Sandbar station. Fifteen trapping efforts were completed in the North Sandbar location and five terrapins were caught, yielding a trapping efficiency of 33%. Despite observing only one terrapin swimming in the South Sandbar area, three terrapins were captured using only six trammel nets resulting in a trapping efficiency of 50%.

Investigations of potential nesting sites showed that Piermont Marsh has few suitable habitats for terrapin nesting i.e., open sandy uplands above the high tide level. Nesting suitability models indicate that an ideal nesting site should have between 25% and 75% canopy cover, grass cover between 5% and 25%, and a mean slope less than 25° (Palmer and Cordes 1988). The upland areas at the base of Tallman Mountain were rocky, highly vegetated and steep. Shrubs, vines and trees covered the land, and wild rice and *Phragmites australis* covered the marsh leading up to the banks. North and South Sandbar, however, had less vegetation. The soil was open and sandy, generally free from vegetation. However, during high tides both sites were almost completely submerged. *Phragmites australis* fringed both sand pits, possibly restricting terrapin access to more suitable uplands beyond the beaches.

Figure 3. Terrapin Trapping Effort in Piermont Marsh from June 6 to August 24, 1997. (Numbers refer to traps set)



By-catch

Crustaceans, chelicerates, reptiles, and fish were also captured in the study (Table 2). Generally, terrapin captures coincided with low by-catch captures. Since none of the by-catch was marked, it is not known whether the animals caught were initial captures or recaptures. A total of 105 blue crabs (*Callinectes sapidus*) were trapped during the study, along with 2 horseshoe crabs (*Limulus polyphemus*). In addition to diamondback terrapins, two other species of turtles were found inhabiting Piermont Marsh. Snapping turtles (*Chelydra s. serpentina*) were caught four times, and one softshell turtle (*Trionyx* spp.) was also captured. Several varieties of fish were removed from the nets. Species identification was confirmed by Robert Schmidt (Simons Rock College). Catfish (*Ictalurus catus*) were caught most often with a total of 37. Other species of fish included 8 carp (*Cyprinus carpio*), 1 flounder (*Paralichthys dentatus*), 1 goldfish (*Carassius auratus*), 9 gizzard shad (*Dorosoma cepedianum*), 16 white perch (*Morone americana*) and 4 striped bass (*Morone saxatilis*).

Capture of some species was distinctly seasonal (Figure 4). For example, all carp and 75% of perch were caught in June, whereas all shad were captured in August. By-catch also showed distinct spatial distributions. Almost 75% of the blue crabs were trapped around the area of the Pier including North and South Sandbar. However, 75% of the trapping effort was also at the Pier and Sandbar areas (Figure 3) indicating that the distribution of crabs was continuous throughout the study area. Gizzard shad and striped bass were only caught in the Sandbar locations. Although only a quarter of the trapping effort was in the marsh, two-thirds of all catfish were caught in marsh creeks. Other species occurred in all sampling locations or were too rare to discern a pattern.

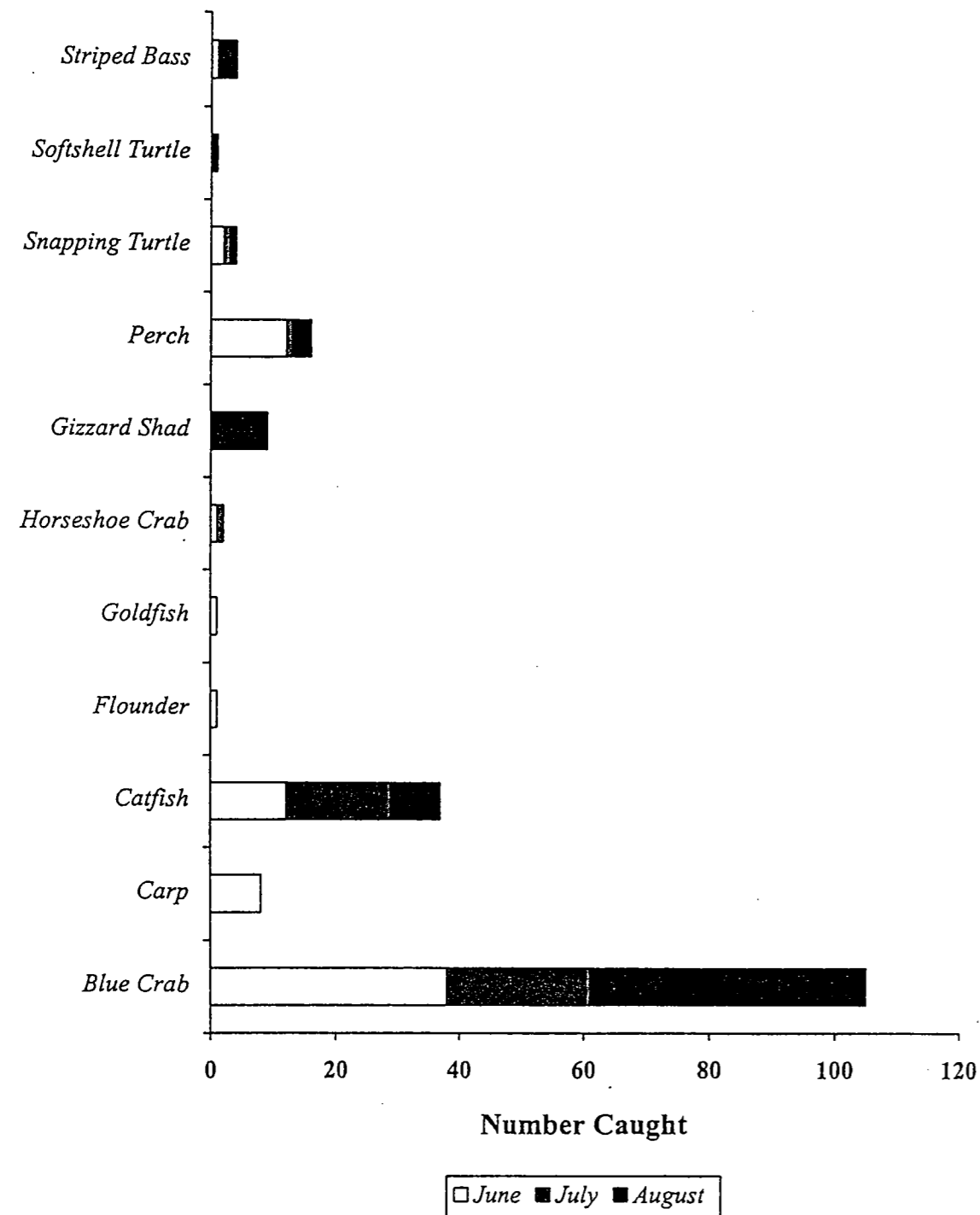
Table 2. By-catch and Terrapins Captured in Piermont Marsh from June 6 to August 24, 1997.

Trapping Period	Date	Location	Method of Capture	Terrapin Capture	By-catch
1	6-Jun	Crumkill	50 ft. net		3 catfish
2	7-Jun	Sparkill	50 ft. net		2 blue crabs; 1 perch
3	8-Jun	S. Sandbar	75 ft. net	male, 275g, 124mm x 97mm	1 catfish
4	8-Jun	N. Sandbar	50 ft. net		1 carp; 1 perch
5	9-Jun	S. Sandbar	75 ft. net		1 carp; 1 catfish
6	9-Jun	N. Sandbar	50 ft. net	male, 400g, 131mm x 101mm	1 striped bass
7	20-Jun	N. Sandbar	75 ft. net; 1 hoop net		3 carp; 1 perch
8	20-Jun	N. Sandbar	50 ft. net	male, 420g, 136mm x 101mm	1 blue crab
9	21-Jun	Sparkill	50 ft. net		2 perch; 1 catfish; 1 snapping turtle; 1 horseshoe crab; 3 blue crabs; 1 carp
10	22-Jun	N. Sandbar	75 ft. net	male, 350g, 131mm x 102mm; female, 1kg, 175mm x 137mm	2 blue crabs; 1 flounder
11	27-Jun	Crumkill	50 ft. net; 1 hoop net		5 catfish; 1 perch; 7 blue crabs
12	28-Jun	N. Sandbar	50 ft. net; 1 hoop net		2 perch; 5 blue crabs
13	28-Jun	N. Sandbar	75 ft. net		1 perch; 4 blue crabs
14	29-Jun	Sparkill	50 ft. net		2 perch; 1 carp 4 blue crabs; 1 snapping turtle
15	29-Jun	Sparkill	75 ft. net		1 carp; 1 catfish; 1 perch; 1 goldfish; 10 blue crabs
16	11-Jul	Pier	Hand net		
17	12-Jul	Pier	Hand nets; 2 crab pots		
18	12-Jul	N. Sandbar	50 ft. net; 1 crab pot	male, 475g 149mm x 113mm	3 blue crabs

Table 2. By-catch and Terrapins Captured in Piermont Marsh from June 6 to August 24, 1997. (continued)

Trapping Period	Date	Location	Method of Capture	Terrapin Capture	By-catch
19	13-Jul	Pier	75 ft. net		3 catfish; 3 blue crabs
20	13-Jul	Pier	50 ft. net		2 blue crabs
21	25-Jul	N. Sandbar	75 ft. net		1 perch; 3 blue crabs; 1 horseshoe crab
22	25-Jul	N. Sandbar	50 ft. net		7 blue crabs
23	26-Jul	Crumkill	50 ft. net		6 catfish; 1 blue crab
24	26-Jul	Crumkill	75 ft. net		7 catfish; 1 blue crab
25	27-Jul	S. Sandbar	75 ft. net	female, 1.35 kg, 193mm x 150mm	1 catfish; 2 blue crabs
26	27-Jul	N. Sandbar	50 ft. net; 1 hoop net		1 snapping turtle; 1 blue crab
27	28-Jul	Pier	50 ft. net; 2 hand nets		
28	1-Aug	Sparkill	50 ft. net		2 perch; 2 catfish; 1 snapping turtle; 3 blue crabs
29	1-Aug	S. Sandbar	75 ft. net		5 blue crabs
30	2-Aug	Pier	50 ft. net		1 blue crab
31	2-Aug	Pier	75 ft. net		4 catfish; 3 blue crabs
32	2-Aug	Pier	50 ft. net		4 blue crabs; 1 perch
33	2-Aug	Pier	75 ft. net		1 blue crab
34	11-Aug	N. Sandbar	50 ft. net		7 blue crabs; 1 striped bass; 3 gizzard shad;
35	11-Aug	N. Sandbar	75 ft. net		6 blue crabs; 1 striped bass; 1 gizzard shad;
36	24-Aug	N. Sandbar	75 ft. net		
37	24-Aug	S. Sandbar	50 ft. net	male, 375g, 128mm x 109mm	
38	24-Aug	N. Sandbar	75 ft. net		4 gizzard shad; 1 striped bass; 11 blue crabs; 1 catfish
39	24-Aug	S. Sandbar	50 ft. net		1 gizzard shad; 3 blue crabs; 1 catfish; 1 softshell turtle

Figure 4. Total By-catch Captured in Piermont Marsh from June 6 to August 24, 1997.



DISCUSSION

Terrapins

The low numbers of terrapin caught in this study (eight) are indicative of a small population; the low numbers of turtles marked and the absence of recaptures precludes the use of any statistically reliable estimates of population size. Small populations of terrapin are common in northern latitudes. Unlike the expansive barrier island marshes of New Jersey and further south, the brackish estuarine environments of New York and Connecticut are generally small and isolated from each other and do not support large populations (Victoria 1994; Roger Wood, Stockton State College, pers. comm.).

In addition to small population size, one potential reason for the low trapping efficiency of the trammel nets was the location of nets in the marsh complex. Setting up nets in the open waters of the Hudson (near the Pier and Sandbar sites) may have allowed terrapins to avoid the nets. The trapping efficiency of the nets is higher when they are set in tidal creeks such as Crumkill and Sparkill. As a test, two trammel nets were set up in Crumkill Creek during a rising tide, one at the mouth and one as far upstream as possible. Six catfish were caught in the net at the mouth. After being released, the same six catfish were caught an hour later in the net upstream. We also set up trammel nets in a tidal creek in Milford, Connecticut, where terrapins had been observed swimming. Within two hours we had captured six diamondback terrapins.

Trammel nets were set at the Pier and Sandbar sites because nets set in Crumkill and Sparkill Creeks did not capture any terrapins. Terrapins typically forage in tidal marsh creeks. In this study, however, terrapins were neither seen nor captured in marsh creeks. Rather, all terrapin captures and sightings occurred near the Sandbar area. This

suggests that the terrapins are finding a greater abundance of the crustaceans, mollusks and other invertebrates that they consume (Carr 1952; Ernst and Barbour 1972; Spagnoli and Margonoff 1975) in the Sandbar locations. Terrapins might also be using other locations for foraging such as the Pier, where the largest number of terrapins were observed basking and swimming, and could utilize the Sandbar area as a nesting site.

Terrapin nesting sites in areas subject to tidal influence are constructed in flat sand substrates above the levels of normal high tides, with shrub canopy ranging between 25% to 75% (Palmer and Cordes 1988). Although North and South Sandbar are not ideal nesting sites due to their low elevation and granular, muddy soil, the sites historically were prime nesting habitats (A. Ciganek, private herpetologist, pers. comm.). Terrapins usually nested in the fine silty dredge that the Town of Piermont deposited at South Sandbar. During the past few years, the Town has not dredged and as a result South Sandbar has subsided and become overgrown with *Phragmites australis*. Despite having deteriorated as a nesting site, terrapins may still be returning to South Sandbar to nest because of nest site philopatry (Roosenberg 1994).

A terrapin's choice of nesting site is a major determinant of sex ratios. In this study adult males outnumbered females three to one. Although the current sample size was small, sex ratios which depart from one to one are not uncommon in terrapin populations, owing to environmental sex determination (Jeyasuria et al. 1994; Roosenberg and Place 1994). Environmental sex determination is such that terrapins must nest on sandy uplands with a restricted range of thermal conditions to ensure appropriate sex ratios. Nests placed in cooler microhabitats generally produce an abundance of male hatchlings. The potential nesting habitats investigated in this study

were low elevation, sandy spits oriented toward the east. Although east facing beaches are exposed to direct morning sunlight, the angle of incoming solar radiation does not warm the sand as much as on beaches facing south. Nesting areas close to mean high tide are also generally cooler. Terrapin nesting in the Sandbar locations could have produced the sex ratios that were observed.

Terrapins are most active during the nesting season. The exact duration of the nesting season in Piermont is unknown. However, up to twenty terrapins have been observed swimming in the South Sandbar area in late May in previous years, and it is possible that terrapin nesting begins at that time (C. Nieder, HRNERR, pers. comm.). In May 1997, terrapins were not observed during preliminary surveys in and around the marsh complex. Colder temperatures this year may have delayed the terrapin nesting season (B. Hergreuth, Paradise Boat Rentals, NY, pers. comm.). In New Jersey, oviposition in terrapins has been reported from June 9 to July 23 (Burger and Montevicchi 1975; Burger 1977), and in Massachusetts, from June 10 to July 20 (Lazell and Auger 1981). Seven terrapins in the current study were caught between June 8 and July 27. One female was caught June 22 and the other was captured on July 27. Neither was found to be gravid, however, indicating that they had already deposited their eggs for the season.

Daily terrapin activities tend to increase during the nesting season. Nesting is typically observed in the daytime during high tides (Palmer and Cordes 1988) and most terrapins in Piermont were captured near high tide. Daily terrapin activity is determined for the most part by tidal variations. The diamondback terrapins in Piermont exhibited typical terrapin activity. Swimming activity, and therefore trapping frequency, was strongly

associated with high tide while inactivity or basking activity on the Pier was observed at lower tides (Muehlbauer 1987). Terrapins may swim more during high tides because of increased food availability. At high tides, more snails are available and marsh-dwelling crabs are more active with the rising tides (Teal 1985; Tucker et al. 1995). Terrapins bask at low tides because more choice upland areas and rocky intertidal areas around the pier become exposed.

The average weight of the male terrapins captured in this study, 382 g, was well within the typical range of terrapin weights, 350 g to 400 g (P. Warny, private herpetologist, pers. comm.). In a study on the foraging ecology of the diamondback terrapin in South Carolina, the average length of male terrapins was 12 mm smaller than the terrapins in this study; likewise, females were larger in Piermont relative to South Carolina (Tucker et al. 1995). This difference indicates that resources are allocated sooner to reproduction in the southern populations and thus the turtles are smaller upon reaching maturation. However, average carapace lengths for the males captured in this study were also higher than the average range of lengths measured in a study conducted in Connecticut (Wood 1992). Piermont's population of terrapins may be reaching sexual maturity at a later time in their development than other northern populations due to environmental stresses such as decreased food quality.

Age could not be determined for five male terrapins because of worn shells. This phenomenon is typical of most terrapin studies. Over half of the 2,800 terrapins captured in a study on the Patuxent River could not be aged (Roosenberg 1990). Sloughing of scutes over time removes the annuli on the shell. As a result, individuals greater than ten years cannot be aged by examining the scutes. Because male terrapins do not increase

significantly in size after reaching sexual maturation, their ages can not be determined from size. The five terrapins almost certainly were older individuals whose scutes were worn with time.

The shell and skin features observed in this study are consistent with the characteristic markings seen on terrapins in other studies. Worn spirals, chips and extra segmentation are common. Terrapins often scrape their shells on river bottoms. Nicks and extra segmentation are caused by propellers and animal bites. Skin color also varies from terrapin to terrapin. A completely black skinned female was captured and a white skinned terrapin was observed in this study; terrapin studies in Connecticut indicate that "skin color can be pure white, cream, dusky, gray, or black, marked with black stripes, blotches, freckles or a combination of all three" (Wood 1992).

By-catch

A significant portion of this study was spent handling a variety of species other than diamondback terrapins. Two species of particular note were the horseshoe crab and softshell turtle. Two horseshoe crabs were captured during this study, one at the end of June, the other at the end of July. Horseshoe crabs are usually found in ocean waters, but they have been known to migrate into rivers as salt wedges from the ocean proceed up stream. However, horseshoe crabs are seldom observed in locations as far north as Piermont Marsh (T. Lake, SUNY-New Paltz, pers. comm.). Both chelicerates were caught when salinity was low during June and July, relative to August. Stranger still was the unexpected capture of a softshell turtle. Softshell turtles have a home range that extends from Florida up to the Great Lakes and Lake Champlain. Softshells are not

typically found in the Hudson River. This particular softshell may have migrated down from Lake Champlain or been released by someone, as softshell turtles are frequently sold as pets and as food.

Besides the terrapin, several species of animal observed in this study are of management concern. The thousand-acre marsh still supports a wide variety of estuarine species. For example, estuarine birds such as herons, mallards and marsh wrens utilize the marsh extensively for feeding and/or nesting. Likewise, the presence of blue crabs, catfish, perch, gizzard shad and carp is an indicator that Piermont Marsh is still a viable resource for recreational fishing and commercial trapping. As a habitat for several species of commercial, recreational and environmental concern, Piermont Marsh has great management potential.

Recommendations

Based on the results of this study and observations from others, the population of terrapins inhabiting Piermont Marsh is small. Small populations are particularly vulnerable to even the smallest change in their environment (Roosenberg 1990). In terrapins, recruitment is low, replacement rates are unknown, and the generation time is long. It is unlikely that terrapin populations can adapt to rapidly changing environmental pressures. There are several environmental pressures in Piermont which threaten the viability of the terrapin population.

The decreasing quality of the nesting sites in Piermont Marsh is particularly detrimental to maintaining healthy populations. North and South Sandbar, the nesting habitat of the terrapins, has been subject to significant disturbance in the past few decades

decades (A. Ciganek, private herpetologist, pers. comm.). North and South Sandbar are located right along a road with car and foot traffic. The town has stopped dredging a small creek near the pier which provided fine silty soil as a nesting site for gravid turtles in the South Sandbar area. In addition, the coverage of marsh by *Phragmites australis* has doubled in the past thirty years (Winograd and Kiviat 1997), choking off potential nesting areas and creating a hazard for turtles searching for upland areas to lay their eggs. Furthermore, development along the edge of the marsh has claimed more potential nesting habitat. Construction crews have limited access to sandy uplands by erecting chain link fences around their sites. Despite the deterioration of the North and South Sandbar sites, terrapins continue to use these habitats, often to their disadvantage, due to nest site philopatry.

Healthy terrapin populations are also threatened by human predation. Crab pots, fishing nets and fishing lines increase terrapin mortality. I observed several crab traps and fishing nets submerged for over eight hours around the pier. Terrapins caught in these devices suffer from hypoxic stress and eventually die. Juvenile and male terrapins are more frequently caught in crab traps; adult females are too large to fit in these traps. However, fishing nets and lines do not discriminate between organisms. Terrapins of both sexes and all sizes become entangled in nets or hooked on broken fishing lines. Terrapins are also threatened by raccoon predation on small terrapins, hatchlings and eggs. As nesting sites deteriorate, nesting densities increase, allowing raccoons to increase predation rates on these concentrated food sources (Roosenberg 1990).

Specific recommendations can be made to protect the diamondback terrapin of Piermont Marsh. Nesting habitat must be protected and isolated from human

disturbance. Maintaining a sandy shore is integral to providing terrapins with suitable nesting habitat. This can be done in a variety of ways. A few truck loads of sand could be deposited in the Sandbar areas and *Phragmites australis* could be aggressively controlled through physical mowing and/or removal. A more cost-effective alternative would be to have the construction company or the Town of Piermont dredge the small creek near the sandbar. The dredge spoils could be piled on the North and South Sandbar area to increase the sites' elevation, and dumped on some of the *Phragmites australis* that surround the sites so to increase the overall area of the nesting habitat. Dredge spoils should be piled on this area each year or as needed, after hatchlings emerge from their nests in the late fall. Furthermore, dredging the creek will increase tidal flushing, opening up more area for access by Hudson River estuarine species.

The most effective way of preventing terrapin drowning is to require crab trappers and fishermen to check their pots and nets periodically, every three to four hours, and remove any terrapins that get captured. Another solution is for crab trappers to use "turtle excluder devices," or TEDs, developed by Dr. Roger C. Wood at the Stone Harbor Wetlands Institute, N.J. (Campbell 1997). Crab pots can be designed so that portions remain above water to give turtles access to air, or pots can be set in shallow water. Lastly, educational programs can be implemented to educate local high school students on the significance of the wetlands and the diamondback terrapin and the need to protect these valuable natural resources.

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REFERENCES

- Burger, J. 1977. Determinants of hatching success in diamondback terrapin, *Malaclemys terrapin*. *Am. Midl. Nat.* 97:444-464.
- Burger, J., and W.A. Montevicchi. 1975. Nest site selection in the terrapin *Malaclemys terrapin*. *Copeia* 1975:133-119.
- Campbell, D.A. 1997. A wary reception for new crab traps. *The Philadelphia Inquirer*. 8 Sept., Section B-1.
- Carr, A. F., Jr. 1952. Handbook of turtles. The turtles of the United States, Canada, and Baja California. Cornell University Press, Ithaca, N.Y. 552 pp.
- Ernst, C. H., and R.W. Barbour. 1972. Turtles of the United States. University of Kentucky Press, Lexington 347 pp.
- Garber, D. 1989. Status of the diamondback terrapin. In Uricheck, M.J. (Ed.) Proceedings 13th International Herpetological Symposium, Phoenix, AZ, pp. 151-158.
- Jeyasuria, P., W. M. Roosenburg and A. R. Place. 1994. Role of P-450 Aromatase in sex determination of the diamondback terrapin, *Malaclemys Terrapin*. *Journal of Experimental Zoology* 270:95-111.
- Lazell, J. D., Jr., and P.J. Auger. 1981. Predation on diamondback terrapin (*Malaclemys terrapin*) eggs by dune grass (*Ammophila breviligulata*). *Copeia* 1981:732-724.
- Muehlbauer, E. I. 1987. Field and Laboratory Studies of Tidal Activity in the Turtle *Malaclemys terrapin terrapin*. Ph.D. Dissertation, New York University, New York, New York.
- Palmer, W.M., and C.L. Cordes. 1988. Habitat suitability index models: diamondback terrapin (nesting)--Atlantic coast. *U.S. Fish Wildl. Serv. Biol. Rep.* 82(10.151). 18 pp.
- Roosenburg, W.M. 1990. The diamondback terrapin: population dynamics, habitat requirements, and opportunities for conservation. In *New Perspectives in the Chesapeake System: A Research and Management Partnership. Conference Proceedings*. Baltimore: Chesapeake Research Consortium Publ. No. 137:227-234.
- Roosenburg, W.M. 1994. Nesting habitat requirements of the diamondback terrapin: a geographic comparison. *Wetland Journal (Environmental Concern, Inc.)* 6:8-11.
- Roosenburg, W. M. and A. R. Place. 1994. Nest predations and hatchling sex ratio in the diamondback terrapin: implications for management and conservation. pp. 65-70, In *Tortoise Sustainable Coastal Watershed: The Chesapeake Experiment*. Chesapeake Research Consortium, Publication no. 149.
- Seigel, R.A. and J.W. Gibbons. 1995. Workshop on the ecology, status, and management of the diamondback terrapin (*Malaclemys terrapin*), Savannah River Ecology Laboratory, 2 August 1994: Final Results and Recommendations. *Chelonian Conservation and Biology* 1:240-243.
- Spagnoli, J.J., and B.I. Marganoff. 1975. New York's marine turtle. *Conservationist (New York)* 29:17-19.
- Teal, J. M. 1958. Distribution of fiddler crabs in Georgia salt marshes. *Ecology* 39:185-193.
- Tucker, A. D., N. N. FitzSimmons, and J. W. Gibbons. 1995. Resource partitioning by the estuarine turtle *Malaclemys terrapin*: trophic, spatial, and temporal foraging constraints. *Herpetologica* 51:167-181.
- Victoria, J. 1994. Diamondback terrapin inventory. Annual performance report, CT Department of Environmental Protection, Project No. E-02-08., 2 pp.
- Winogron, H.G. and E. Kiviat. 1997. Invasion of *Phragmites australis* in the tidal marshes of the Hudson River. Section VI: 29 pp. In W.C. Nieder and J.R. Waldman (eds.), *Final Report of the Tibor T. Polgar Fellowship Program, 1996*. Hudson River Foundation, NY.
- Wood, Constance. 1992. Close encounters with a gentle reptile...the diamondback terrapin. *Connecticut Naturalist* 21:1-3.