

In Stream, Streamside, and Under Stream Bank Movements of a Bog Turtle, *Glyptemys muhlenbergii*

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ABSTRACT. – Movements of a bog turtle, *Glyptemys muhlenbergii*, outside of characteristic wetland habitat were recorded using radiotelemetry. Data suggest that permit reviewers and park managers should consider the conservation implications of stream use, undercut banks, and streamside habitat in formulating mitigation and management plans within the range of this federally protected species.

Bog turtle (*Glyptemys muhlenbergii*, formerly *Clemmys muhlenbergii*) habitat is typically characterized as spring-fed wetlands with little canopy, flowing water, and soft, mucky substrates (Lee and Norden 1996; Buhlmann et. al 1997; Herman and Tryon 1997; Somers et. al 2000). A number of authors have reported long-distance movements of bog turtles outside of characteristic wetlands and into a variety of other habitats both wet and dry (Ernst 1977; Herman and Tryon 1997; Carter et al. 2000; Somers et al. 2000). Noncharacteristic wet habitats utilized include first- and second-order streams, seepages, and restored wetlands. Dry habitats where turtles have been radio-tracked or found include forested uplands, lowland valleys, cultivated areas, roads, and ridges far from known wetlands (Herman 2003; Tryon 2004). The rarity of such reports and the absence of in-stream, streamside, and under stream banks reports makes any new accounts of these movements important in establishing permit review protocols, conservation plans, and management practices for this federally protected species.

In June 2000, a fisherman in a state park in the western Piedmont of North Carolina found a female bog turtle in a rhododendron thicket adjacent to a stream. The age of the animal was estimated at 13 years by counting annuli on the carapace and plastron. Sections of the stream within the park were classified using the Rosgen System as types B4c and C4 moving toward D4 (North Carolina Stream Restoration Institute 2000). In 1977, a bog turtle was also found on a road within the same park, but no

characteristic bog turtle wetlands are known within the park. An area of hydric soils, downstream from where the turtle was last seen, may have once been a functioning mountain bog but is now too dry to support a diverse bog community (North Carolina Stream Restoration Institute 2000). The initial capture was intermediate between the closest known confirmed bog turtle wetlands, which are estimated to be at straight-line distances of 3.6 km south, 5.3 km southwest, and 4.9 km northeast.

A transmitter was attached to the turtle (as in Eckler et al. 1990) prior to release at the point of capture. The turtle was radio-tracked 43 days, from 24 June 2000 to 14 August 2000, when the signal was lost. An intensive effort by 8 researchers searching in the vicinity of the last recorded transmission failed to locate the bog turtle.

Tracking occurred during trout season when the park was experiencing periods of high visitor activity in and around the stream. The turtle moved over 800 m downstream using a variety of stream and streamside habitats. Upstream movements to 150 m were recorded within this period of downstream movement. The turtle's activities included swimming along the water's edge, basking on and around small to large-sized rocks and rootstocks, and frequent use of undercut banks covered with root wads (Fig. 1). Movements away from the stream were correlated with periods of heavy rains and evening thunderstorms. While away from the stream the turtle rested under pine debris and in thick vegetation. On one occasion the radio signal was detected coming from the root cavity of a large tulip polar (*Liriodendron tulipifera*) 3.5 m from the stream where the turtle was resting underground. She was also observed several times in very conspicuous locations and could have easily been seen by any fisherman or hiker in the area.

Safeguarding turtles in public areas is a resource-protection problem. Throughout this study there were concerns for the turtle's safety because of heavy visitor activity. The fate of the turtle is unknown, and the possibility that a park visitor removed her cannot be ruled out. Garber and Burger (1995) demonstrated that public access to protected areas could result in turtle population declines. Population losses related to human activity include removal and handling of turtles by visitors, turtle mortality on roads, and increased predation resulting from rising predator populations subsidized by human trash and waste. They recommended that public parks take stronger measures to deter the public from disturbing turtle populations. Widner and Roggenback (2000) found that park visitors were less likely to take park relics when informed about park regulations by volunteers in uniform and when parks displayed explicit signs that detailed the park's rules and the legal consequences of breaking them. We support their recommendations that appropriate literature, signage, and programs be developed to educate park visitors about the importance of leaving resources undisturbed.



Figure 1. A transient bog turtle utilized this and other streambank undercut and root wads.

Bog turtle populations are often small (Buhlmann et al. 1997; Herman and Tryon 1997) and hence are vulnerable to demographic stochasticity and extinction. The characteristic wetlands of bog turtles are essentially habitat islands; movements between sites likely assist in maintaining genetic variation in the populations and support colonization or recolonization of suitable sites. The probability of population extinction may increase if movement between sites is restricted (Gibbs 1993; Semlitsch and Bodie 1998; Carter et al. 2000). Genetic similarity is greater between bog turtles in the same drainage than between adjoining watersheds (King, in Herman 2003), consistent with extensive use of wet corridors. Although the turtle movement reported here was along a stream corridor, bog turtles clearly use upland routes for dispersal (Herman 2003; Tryon 2004). The diversity of pathways used suggests that landscape-level protection would offer the best opportunity for gene flow between populations.

We are unaware of any reports of bog turtles utilizing undercut banks in streams prior to this account. Permit reviewers should recognize this potential when environmental impact is expected from projects in streams within the range of the bog turtle.

Johnson and Gaines (1990) suggested that studying dispersal and patterns of movement is important in understanding distribution, social behavior, genetic structure, and persistence of populations. Information regarding distance, timing, and proximate cues for movement is essential to further understanding the behavior and ecology of turtles. Bog turtles may make large-scale movements more frequently than suggested by Carter et al. (2000) because their tracking studies averaged only 2 years in duration. Long-term radio-tracking studies, such as those being conducted by Tryon (2004), may reveal that bog turtles move more frequently than previously thought and depend on a diversity of habitats. Knowledge of what motivates turtles to move outside of wetland patches, distances traveled, and how dispersals affect turtle population genetics and demographics will require additional study, as the conservation implications of movement restriction are not well understood at this time.

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Traumatic Injuries in Eastern Spiny Softshell Turtles (*Apalone spinifera*) Due to Recreational Activities in the Northern Lake Champlain Basin

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ABSTRACT. — We report several boat propeller- and fishing-related injuries sustained by eastern spiny softshell turtles (*Apalone spinifera*) from the northern Lake Champlain basin of Québec and Vermont. These

incidents may have negative impacts at the population level when added to habitat alterations and other mortality factors challenging this threatened and isolated northern population.

Decline in reptile populations is a growing concern, and the impact of human activities on turtle population health is becoming a prevalent issue in conservation (Gibbons et al. 2000; Klemens 2000; Galois and Ouellet 2007). Freshwater turtles can be affected by modification and loss of habitat (Dodd 1983, 1990; Burke and Gibbons 1995; Reese and Welsh 1998), road and agricultural machinery accidents (Ashley and Robinson 1996; Saumure and Bider 1998; Haxton 2000), commercial and recreational fishing (Bishop 1983; Borkowski 1997; Brown and Sleeman 2002), chemical contamination (Meyers-Schöne and Walton 1994; Sparling et al. 2000), personal and pet-trade collecting (Cagle 1950; Garber and Burger 1995), and increased predator populations (Congdon et al. 1993). Little quantitative information is available on the impact of aquatic recreational activities on turtles (Burger and Garber 1995; Roosenburg et al. 1997; Gibbons et al. 2001).

Except for a few documented cases of shell abnormalities (Smith 1947; White and Murphy 1972; Burke 1994; Stuart 1996), parasite presence (Webb 1962; Acholonu 1970; Ernst and Ernst 1977, 1979; Wacha and Christiansen 1977), and anecdotal reports of fishing incidents (Conant 1961; Webb 1962; Cochran and McConville 1983), the health of spiny softshell turtle (*Apalone spinifera*) populations and the impacts of human activities are not well documented. The species is highly aquatic and secretive (Webb 1962; Ernst et al. 1994), making adequate documentation of the frequency and severity of injuries from human origin difficult.

An isolated population of eastern spiny softshell turtles occurs at the northern limit of the species' range in Québec, Canada, and adjacent Vermont, US (Ernst et al. 1994; Galois et al. 2002). Based on archeological remains and more recent records, the species had a larger distribution in Québec in the past (Bonin 1997). It is now observed only in the Lake Champlain basin with the population size believed to be only a few hundred individuals. Consequently, a recovery plan has been established in Québec and collaboration initiated with the Vermont Fish and Wildlife Department. The species is listed as threatened in Québec (Gazette Officielle du Québec 1999), Canada (COSEWIC 2007), and Vermont (Vermont Statutes Annotated 2005).

We have been conducting a health-related study of this population of spiny softshell turtles as part of a radiotelemetry and nest monitoring study (Galois et al. 2002). Herein, we report observations of traumatic injuries in this population. We also discuss the impact of recreational activities on the health of this turtle population

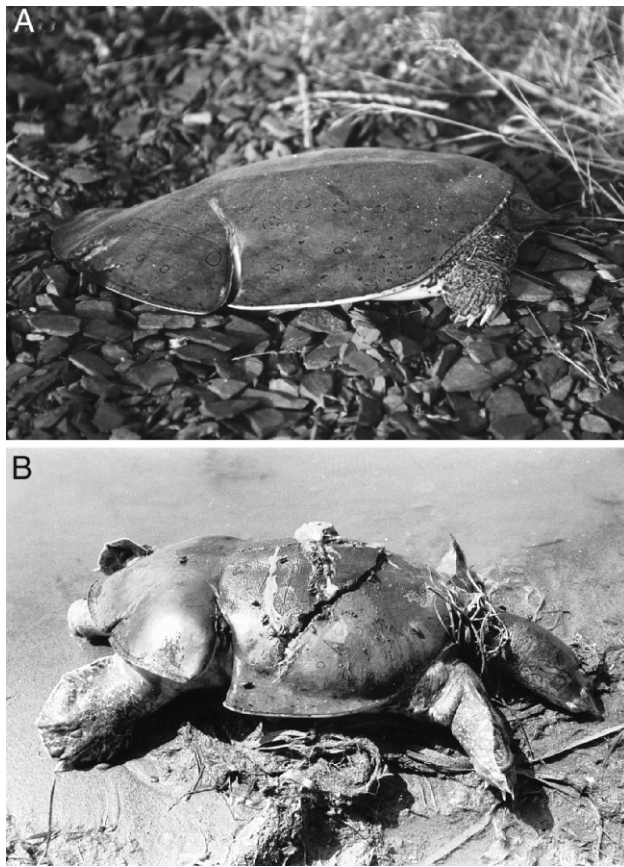


Figure 1. A: Adult female eastern spiny softshell turtle (*Apalone spinifera*) in June 1995 with a fresh traumatic laceration on the posterior right side of the shell. B: The same female found dead in August 1999 with new deep lacerations and fractures of the carapace in addition to the healed previous injuries.

and propose management recommendations to prevent any further decline.

Methods. — The study took place from 1995 to 2004 in northern Lake Champlain, Québec and Vermont, and its tributaries, including the Rivière aux Brochets (Pike River) and the Missisquoi River (Galois et al. 2002). Capture effort was concentrated between May and September. Turtles were captured either with hoop traps or by swimming with a floating blind and a dip net (Bider and Hoek 1971). The turtles were examined on site for any sign of injuries, diseases, or abnormalities. General health condition was assessed through external physical examination, and a standardized health form was completed. Pictures of the ventral and dorsal sides were taken as well as close-ups of any particular abnormality or trauma. For each individual, we measured carapace length (CL) with calipers (± 0.5 mm) and body mass with a spring balance (± 25 g). Each animal was marked with a PIT tag (Passive Transponder System ID-100; Datamars, Lugano, Switzerland) injected in the left abdominal cavity before release. Necropsies of dead turtles were performed in appropriate facilities. Reports of turtles hooked on fishing line were obtained through opportunistic discussions with riverine landowners and anglers. Difference in the rate of injuries

between male and female was tested using a Fisher's exact test (SYSTAT, version 10; SPSS, Chicago, IL) with significance determined as $p < 0.05$ (Zar 1999).

Results. — Overall, 72 eastern spiny softshell turtles were captured and examined during this study. Four adult females out of 50 (8.0% of females or 5.5% of the total sample size) had major traumatic injuries, while none of the 22 males were injured. There was no significant difference between female and male injury rates ($p = 0.306$). Minor injuries or scars were not taken into account since their impact was not significant and their etiology was unclear. Over the study period, 10 other observations were documented, and these injuries were assigned to 2 categories: boat-related injuries (propeller lacerations and collisions) and fishing-related incidents.

In the boat-related injury category, 3 females were captured, including 2 equipped with a radiotransmitter. One of them was observed on the Pointe de la Province, Québec (lat 45°00'N, long 73°11'W) on 29 June 1995 and noted to have a laceration on the right rear side of the shell (Fig. 1A). The laceration was 68 mm deep and penetrated the dorsal part of the shell from its edge toward the midbody axis for 61 mm. The margins of the wound were red, and internal organs were visible. Another smaller laceration, 23 mm in length, on the caudal right side of the shell was observed. The same female was recaptured 2 years later in June 1997, 11 km north of the original site (lat 45°04'N, long 73°05'W). The lacerations through the shell were still visible, but the margins had healed. At that time the female had a CL = 359 mm and a body mass of 3725 g and was in good general condition. She was monitored for 16 months until the transmitter stopped in October 1998 at the hibernation site, located 16 km south of the capture point in Lake Champlain near East Alburg, Vermont. During the 1997–1998 period, this individual made 2 winter and 1 spring migrations between the river and the East Alburg hibernaculum. She was found dead in August 1999 on the Rivière aux Brochets shoreline, Québec (lat 45°06'N, long 73°04'W). At that time she had a CL = 368 mm, and multiple lacerations and fractures of the carapace were observed in addition to the previous injuries (Fig. 1B). The new lesions were the presumed cause of death.

On 14 June 2004, a second adult female with a deep healed laceration was captured on the Rivière aux Brochets, Québec (lat 45°05'N, long 73°04'W). The laceration penetrated the dorsal part of the shell from its edge toward the midbody axis for 106 mm on the left side of the carapace. The female had a CL = 370 mm and a body mass of 4100 g and was in good general condition. In the following months, she was observed nesting and traveled south to overwinter near East Alburg.

A third adult female with a recent head injury was captured on 15 September 2004 at the East Alburg Bridge, Vermont (lat 44°58'N, long 73°13'W). The right eye was swollen and shut, the left side of the lower jaw was torn away from the skull, and the jaw was hanging from the

skin on the right side with much of the bone visible; skin had fallen away from the leading edge of the carapace. The cause of injury may have been due to a boat strike. She had a CL = 345 mm and a body mass of 3175 g. She was kept in captivity for surgery and medical treatment and released a month later.

The fishing-related injury category involved 1 adult female captured on 18 July 1998 on the Missisquoi River, Vermont (lat 44°59'N, long 73°08'W). She had a deep but healed laceration through the superior left lip, premaxilla/maxilla, and nostril. She had a CL = 397 mm and a body mass of 4600 g and was in good general condition. The female was fitted with a transmitter and monitored until December 1999. During this period, she completed 2 winter and 1 spring migration movements between the Missisquoi River and the East Alburg hibernaculum.

Two other boat propeller lacerations were also reported to us. One adult female was also observed with a fishing line hanging from the mouth on 3 July 2001 on the Missisquoi River, Vermont (lat 44°57'N, long 73°09'W). Finally, the severity of the injuries from 7 other fishing hook events is difficult to assess precisely since reports were simply obtained from anglers who declared that the turtles managed to free themselves from the hook or were released without or after removal of the hook.

Discussion. — Spiny softshell turtles bury in and wander on the bottom in shallow water (Lagler 1943; Graham and Graham 1991, 1997). In northern Lake Champlain, this habit could make them vulnerable to boat propeller injuries, especially as they tend to be in less than 1.5-m mean water depth from May to August (Galois et al. 2002). Two females survived propeller lacerations and seemed to regain normal movements despite the severity of the injuries. The morphometric data collected during the present study are insufficient to assess the potential effect of these injuries on growth or to make comparisons with other studies conducted in more southerly areas (Dunson 1967). However, it has been shown that injuries can impede turtle growth (Congdon et al. 1993; McLeod 1994; Saumure and Bider 1998) and affect the survival of individuals (Harding 1985). Female eastern spiny softshell turtles might be more at risk from such accidents than males. Males tend to bury themselves at the water's edge, whereas females are more likely to bury themselves in deeper water (Plummer et al. 1997). Females are associated more often with open water than males (Williams and Christiansen 1981) and use different microhabitats based on intersexual differences in diet (Cochran and McConville 1983). In Lake Champlain, females travel more than males during the year, in particular to reach nesting sites (Daigle et al. 2002; Galois et al. 2002). These observations suggest that females would spend more time than males moving, foraging, and resting where they are likely more vulnerable to boat accidents, either collisions or propeller lacerations. A similar trend was observed in diamondback terrapins

(*Malaclemys terrapin*) damaged by boat propellers (Gibbons et al. 2001).

Spiny softshell turtles are active bottom foragers (Ernst et al. 1994) and are known to be hooked by anglers (Thompson 1853; Evermann and Clark 1920; Babbitt 1936; Conant 1961; Webb 1962; Painter 1993). Hooked turtles are sometimes released by cutting the fishing line, leaving the turtle with the hook (Hartup 1996; Borkowski 1997; Galois and Ouellet 2007), which may inflict further injuries to the mouth and throat, induce infection, and impede feeding. Ingestion of the monofilament line by turtles may cause perforations and necrosis in the digestive tract (Borkowski 1997) and lead to mortality (M.O., *pers. obs.*). Indirect effects of fishing line ingestion may include lead poisoning from lead sinkers, which may induce depression and general muscle weakness (Borkowski 1997).

In our study, the frequency of trauma reported is low but may underrepresent turtle injuries because people may be reluctant to report cutting a fishing line or sacrificing the turtle, especially a threatened species. Even if our data indicate a low rate of trauma and some individuals survive despite severe injuries, human activities may adversely affect turtle populations through boat accidents. Burger and Garber (1995) observed a major increase in shell injuries and death from boat motors in female diamondback terrapins between the 1970s (1%–2%) and the 1990s (12%–17%), concurrent with an increase in boating activity during the same period. A relatively high prevalence of boat injuries was observed on this same species with concerns on the impact at population level (Gibbons et al. 2001). It is now established that the loss of even a few adult females every year in addition to natural mortality may jeopardize the survival of a turtle population, sometimes in only a few years (Brooks et al. 1991; Congdon et al. 1993, 1994; Garber and Burger 1995). This is even more critical in northern populations where age at maturity is often delayed (Galbraith et al. 1989; St. Clair et al. 1994; Litzgus and Brooks 1998), increasing the risk of death before reproduction. Because of turtle longevity, delayed maturity, low recruitment, and absence of density-dependent adjustment, several studies recommend that conservation efforts should target subadult and adult female survival (Iverson 1991; Congdon et al. 1993, 1994; Cunningham and Brooks 1996).

Recreation-related accidents are of concern when added to habitat alteration and other negative impacts faced by the Lake Champlain eastern spiny softshell turtle population. Lake Champlain has experienced many alterations in the past, including shoreline modifications, an increase in human presence, cottages, campgrounds, private and public beaches, and an increase in boating, fishing, and other water-related recreational activities. A bridge construction project was initiated in the spring of 2004 over the main eastern spiny softshell turtle overwintering site in this area. Furthermore, intense cyanobacteria blooms were recurrent for the past several

summers in Missisquoi Bay, with unknown effects on turtle health.

In view of the threats to eastern spiny softshell turtles, new management recommendations should be considered. Boating regulations, including speed limits on rivers, may decrease the risk of collision with turtles. Such regulations already exist for manatees (*Trichechus manatus*) in Florida (Reynolds 1999) and beluga whales (*Delphinapterus leucas*) in Québec, but they need to be strictly enforced and publicized in order to be efficient (Aipanjiguly et al. 2003). Education of anglers about removal of the hook from a hooked turtle should coincide with the promotion of unleaded fishing sinkers.

In Québec, an eastern spiny softshell turtle observation network has been established to collect observations and educate people about these and other turtle species. As part of this project, an identification and information package has been distributed to anglers, boaters, and riverine landowners in the area. In particular, an econautical chart indicating sensitive water areas where soft nautical activities such as canoeing are recommended has been distributed and is available in local stores and public outlets. In order to support these volunteer-based approaches, managers should regulate boating and fishing in proximity to critical turtle habitat areas such as nesting and hibernating sites. Sanctuaries in which certain water-related human activities will be prohibited, at least during critical periods of the year, need to be established for the eastern spiny softshell turtle.

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Incidence of Aural Abscesses in Painted Turtle (*Chrysemys picta*) Populations in Minnesota

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ABSTRACT. – Aural abscess incidence in 22 painted turtle (*Chrysemys picta*) populations in Minnesota averaged 0.7% (range, 0.0%–9.1%) of more than 2700 captured turtles. Results indicate the need for more research regarding incidence and causes of aural infections in turtles and possible directions for future work are suggested.

Aural abscesses in turtles result from opportunistic bacterial infection of the middle ear and appear as large swellings on one or both sides of the head (Fig. 1). Most of the literature regarding aural abscesses in turtles involves box turtles (*Terrapene*), but the condition is known to affect many turtle species (Murray 1996). Several factors are thought to predispose turtles to such infections. In captivity, aural abscesses typically result from improper husbandry, poor nutrition, and keeping animals at suboptimal temperatures. The exact causes in wild turtles are unknown, although aural abscesses in box turtles have been associated with such factors as wet weather (Dodd and Griffey 2004), insect bites and trauma (Dodd 2001), and environmental contamination (Tangredi and Evans 1997; Holladay et al. 2001). This is the first report on the incidence of aural abscesses in wild painted turtle populations in Minnesota.

Methods. — Abscess data were collected from 22 painted turtle (*Chrysemys picta*) populations in central Minnesota. Turtles were captured from May through August 2001 and 2002, May 2003, and August 2004 using basking traps, baited hoop traps, and by hand. Front claw length and position of the cloaca relative to the rear edge of the carapace were used to classify each captured turtle as

male or female (Gibbons and Lovich 1990). Turtles with no discernable secondary sex characteristics and a carapace length (CL) < 9–10 cm were considered juveniles (Ernst et al. 1994). Turtles received a permanent, unique identification code drilled into the marginal carapace scutes so they could be identified if recaptured. Every captured turtle that possessed an aural abscess was noted. Contingency table analysis was used to determine if there was a nonrandom association between the presence of an abscess and the type of trap in which a turtle was captured.

Results. — Turtles with abscesses occurred in 9 of the 22 sampled populations. Nineteen out of 2703 painted turtles marked between 2001 and 2004 possessed aural abscesses (0.7%). The incidence of abscesses varied among the 9 populations that had abscessed turtles from 0.5% to 9.1% (Table 1). All abscessed turtles appeared otherwise healthy and none showed signs of lethargy or other illness. Nine turtles had an abscess on the right side of the head, 8 turtles had one on the left side, and in 2 animals the side was not recorded. All but one of the turtles captured with abscesses were adults. The smallest turtle, a juvenile, had a CL of 94 mm. The remaining turtles had CL ranging from 97 to 168 mm. Two individuals with abscesses were captured multiple times. The first was a male captured 3 times in 2002 in Lake Maria (Wright County). The second was an adult female first captured in 2002 in Beaver Lake (Stearns County) and subsequently recaptured in 2004 with no apparent change in the abscess. Turtles with abscesses were captured in every month trapping was conducted.

Turtles with abscesses were caught in basking traps at a slightly higher rate than in hoop traps, compared to turtles without abscesses. The basking trap/hoop trap catch ratio was 7.7:1 for turtles with abscesses and 4.7:1 for turtles without abscesses, although this difference was not statistically significant (Pearson chi-square contingency table analysis, $\chi^2 = 0.631$ $p = 0.4271$).

Discussion. — The incidence of aural abscesses in painted turtles was variable among populations in central Minnesota. The only other account of abscesses in painted



Figure 1. A male painted turtle with aural abscess on the right side of the head, captured in a basking trap in Lake Maria, Wright County, Minnesota in August 2001.

Table 1. Incidence of aural abscesses in painted turtles captured in central Minnesota lakes from 2001 to 2004.

Lake	County	No. of marked turtles in each lake	No. with abscesses	% with abscesses
Bjorkland	Wright	75	0	0.0
Gemini East	Stearns	43	1	2.3
Gemini West	Stearns	59	1	1.7
Half Moon	Hennepin	71	1	1.4
Henschein	Kandiyohi	112	1	0.9
Lake 21	Kandiyohi	198	0	0.0
Maria	Wright	914	5	0.5
Sagatagan	Stearns	107	0	0.0
Spurzum	Hennepin	143	0	0.0
Stumpf	Stearns	88	0	0.0
Beaver	Stearns	173	3	1.7
Black Oak	Stearns	134	0	0.0
Cedar South	Stearns	27	0	0.0
Cedar North	Todd	40	2	5.0
Guernsey	Todd	57	0	0.0
Goodners	Stearns	50	0	0.0
Little Sauk	Todd	50	0	0.0
Long South	Stearns	123	0	0.0
Long North	Todd	31	0	0.0
Mary	Todd	122	0	0.0
Pelican	Stearns	53	2	3.8
Sylvia	Stearns	33	3	9.1
Total		2703	19	0.7

turtles appears to be Christiansen et al. (2005) reporting 1 abscess in 212 captured turtles (0.47%) along the Mississippi River in Iowa. The prevalence of aural abscesses in other emydid turtle species is quite variable: 26 of 2477 (1.0%) in Florida box turtles (*Terrepenne c. bauri*) in Florida (Dodd and Griffey 2004); 5 of 19 (26.3%) in eastern box turtles (*Terrepenne c. carolina*) in Virginia (Holladay et al. 2001); 19 of 90 (21.1%) in eastern box turtles in New York (Tangredi and Evans 1997); and 16 of 460 (3.47%) in ornate box turtles (*Terrepenne ornata*) in Iowa (Christiansen et al. 2005). The prevalence of abscesses in Minnesotan painted turtle populations was within the range of published accounts, although some populations have much higher rates than others, such as Lake Sylvia in Stearns County, where 9.1% of 33 captured turtles possessed abscesses.

Turtles bioaccumulate several pollutants (Helwig and Hora 1983), and organochlorine compounds have been implicated in the occurrence of aural abscesses in box turtles (Tangredi and Evans 1997; Holladay et al. 2001). Organochlorine compounds are thought to interfere with vitamin A metabolism, a shortage of which can predispose turtles to aural abscesses (Murray 1996; Brown et al. 2004). Because the link between abscesses and organochlorine compounds is far from conclusive (Willer et al. 2003), it is important to identify average abscess rates in wild turtle populations so that findings on contaminants can be put into proper context. Knowledge of the average rate of aural abscesses in turtles will allow researchers to identify populations with unusually high abscess rates that may require further investigation. Populations like the one in Lake Sylvia in this study would be a candidate for such further investigation, which would involve submitting turtle liver biopsies and water samples for organochlorine analyses.

Painted turtles increase body temperature in response to bacterial infection (Monagas and Gatten 1983). Because basking is an important means of thermoregulation, one would expect more frequent or longer basking in turtles with abscesses compared with healthy turtles. Frequent basking would make turtles more likely to be captured in basking traps as compared to hoop traps. The failure to find significant differences in capture rates of turtles with abscesses in basking traps compared to turtles without abscesses is surprising given the different behaviors that influence the efficiency of each trap style. However, it is possible that turtles with abscesses bask for longer periods of time rather than more frequently, which would not be reflected in increased capture rates. Further work is needed to determine how painted turtles alter behavioral or basking patterns in response to bacterial infection.

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Northern Diamondback Terrapin Occurrence, Movement, and Nesting Activity Along a Salt Marsh Access Road

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ABSTRACT. – Northern diamondback terrapins, *Malaclemys terrapin terrapin*, were tagged with passive integrated transponder tags to mark them and monitor their activity along a road through salt marsh habitat in Tuckerton, New Jersey. A mark-recapture study was conducted to evaluate terrapin movements, nesting frequency, and nest site fidelity. During sampling periods throughout 2 nesting seasons (2004–2005), 300 adult females were tagged. Ninety-two recaptures were made of 54 individual terrapins, with most recaptures (81.5%) occurring within a season (range = 1–45 days, mean = 7.5 days). Some recaptures (18.5%) occurred the following year. Some females crossed the road multiple times during nesting, and nearly half searched for a site within 50 m of the area where they were initially tagged. Nest site selections of all multiple nesters (within and among seasons) varied greatly from approximately 4–1307 m (mean internesting distance = 202.75 m), yet 39% were recaptured within 50 m of their initial tagging location. One-third of yearly nesters showed an internesting distance within 25 m of their initial-year tagging location. These results indicate that some females travel variable distances between nest sites and may demonstrate evidence of nest site fidelity.

As aquatic and upland habitats are developed, modified, or fragmented by human activities (e.g., roads), reproduction of turtles may be increasingly affected as they need to make movements of variable distances overland to find suitable nesting habitat, which may be natural or altered by humans. Nesting females may be attracted to human disturbed sites where little vegetation is present and the ground is open to direct sunlight. These sites can be near houses and fences (Kolbe and Janzen 2002), human-made trails (Feinberg and Burke 2003), edges of power-line rights of way and forest clearcuts (Litzgus and Mousseau 2004), and mowed shoulders of roads (Aresco 2005). Turtles cross roads in agricultural (Reese and Welsh 1997) and residential (Steen and Gibbs 2004) areas and nest along roads near wetland and beach habitat (Seigel 1980a; Wood and Herlands 1997; Standing et al. 1999; Haxton 2000; Joyal et al. 2001; Hoden and Able 2003; Rowe et al. 2005; Szerlag and McRobert 2006). Some aquatic turtles travel great distances through terrestrial landscapes and across roads to nest in fragmented nesting habitat when suitable habitat is limited (Baldwin et al. 2004). Many aquatic turtles, including diamondback terrapins, prefer to nest in areas of sandier soils, little vegetation, and higher elevation (Burger and Montevecchi 1975; Butler et al. 2004). Because marsh roadsides may provide the habitat conditions that are suitable for nesting, substantial turtle mortality also results

from vehicular traffic (Wood and Herlands 1997; Hoden and Able 2003; Szerlag and McRobert 2006).

In the family Emydidae, distance traveled during nesting events has been documented for numerous species. Spotted turtles (*Clemmys guttata*) have been observed to travel an average of 247 m (range, 70–570 m) and Blanding's turtles (*Emydoidea blandingii*) an average of 633 m (range, 100–1620 m) to nest (Joyal et al. 2001). Standing et al. (1999) tracked one Blanding's turtle for approximately 3 km en route to her nesting site. Painted turtles (*Chrysemys picta marginata*) have been observed traveling up to 435 m to a nest site from water and up to 758 m between nest sites (Rowe et al. 2005). Western pond turtles (*Actinemys marmorata*) have been observed nesting up to 400 m from water (Holland 1991, 1994; Rathbun et al. 1992; Reese and Welsh 1997).

Diamondback terrapins appear to exhibit site fidelity and travel short distances to their nest sites. Terrapins have been recaptured numerous times over several years within a 100-m section of the same creek (Gibbons et al. 2001). Roosenburg (1994) found that most nesting routes were < 10 m and that < 1% of terrapins moved great distances of approximately 200 m. Burger and Montevecchi (1975) also found short nesting routes of < 100 m. Cook (1989) suggested females may nest within 200 yards of water, while Feinberg and Burke (2003) found nesting areas of terrapins a maximum of 250 m from water.

Long-distance movements by terrapins have been reported as limited (Gibbons et al. 2001), but they observed 1 female that completed a round-trip distance of 5.5 km after leaving her home range, nesting on a dune, and then returning. Butler (2002) found some tagged terrapins returned to specific creek areas ~ 5–10 km from their nesting sites, and Hurd et al. (1979) observed 1 female that traveled approximately 8 km to nest.

Despite nesting movements that have already been documented for terrapins, little attention has been directed to the extent of habitat females may utilize along roadsides and how distances may vary between nests. Therefore, this study focused on habitat use, movement, nesting activity, and mortality along a salt marsh road.

Methods. — Fieldwork was conducted along Great Bay Boulevard in Tuckerton, New Jersey. The site is a relatively pristine salt marsh of the 2168-ha peninsula of Great Bay Wildlife Management Area. Great Bay Boulevard is an 8.1-km paved along the centerline of the marsh (Fig. 1). Five bridges cross over subtidal creeks.

Surveys of Great Bay Boulevard were conducted during the terrapin nesting seasons of 2004 and 2005. Roadside sampling began when terrapins were first sighted (late May–early June) and lasted until the last terrapin was encountered (end of July). Adults were generally absent from the road all other times of the year (Hoden and Able 2003). Eight to 10 daily surveys were completed 5–6 days per week by car or bicycle. Surveys were typically conducted between 0800 and 1700 hours. An additional 12 surveys were conducted after dark between 2100 and 2400

hours each season. Parameters recorded for each encounter included date, location found (GPS coordinate), and whether the individual was alive, dead, or tagged for each encounter.

In this study, if a recapture was recorded after 17+ days during the same nesting season or during the following year, it was considered a “long-term” recapture and a multiple nester. Multiple nesters within a nesting season were based on previous studies finding an approximate 17-day internesting interval for terrapins (Klemens 1993; Feinberg and Burke 2003).

Three hundred adult female terrapins (100 in 2004 and 200 in 2005) were tagged during the first week(s) of nesting using passive integrated transponder (PIT) tags (12 × 2.1 mm, Biomark Inc., Boise, ID). Tagging methods followed Buhmann and Tuberville (1998) and adhered to field standards developed by the American Society of Ichthyologists and Herpetologists (2004).

Tags were inserted under the skin in soft tissue just caudal and medial to the bridge, pointed in the direction of the head, anterior to the right hind limb. The skin was cleansed with 70% isopropyl alcohol and the tip of the injector swabbed with an antibiotic ointment with an analgesic, praxomine hydrochloride (Johnson & Johnson Consumer Companies Inc., New Brunswick, NJ). Liquid bandage tissue adhesive (Prestige Brands, Inc., Irvington, NY) was applied after injection. The animal was checked for adverse reactions or discharges from the injection site and then scanned with a PIT-tag pocket reader (Biomark) to verify the tag number. Terrapins were released back in the marsh in the same direction they were traveling when captured.

Straight-line internesting distances and distance between road crossings were determined using the GPS positions obtained for each terrapin location using ArcView GIS (v. 3.3; ESRI, Redlands, CA). Data were projected using ArcView to Universal Transverse Mercator units in meters to allow calculation of these distances.

Results. — A total of 299 surveys were conducted from May to July 2004 and 272 surveys from May to July 2005. We tagged 300 adult female terrapins; 54 (18%) were recaptured a total of 92 times. We found no visible evidence of infection from the injected PIT tags.

During the 2004 nesting season, we documented 25 recaptures of 16 females, and in 2005 there were 50 recaptures of 38 individuals (Table 1). Additionally, 17 recaptures of 15 individuals from the 2004 tagged group were recorded in 2005 (Tables 1 and 2). We observed 2 tagged terrapin mortalities by automobiles, one in each year.

Time between recaptures varied, ranging from the same day of tagging to up to 45 days later within a season (mean = 7.5 days) (Fig. 2). Two modes were observed in the recapture intervals: one mode occurring within 0–9 days and another mode within 13–45 days. “Long-term” recaptures (probable multiple nesters 17+ days after initial

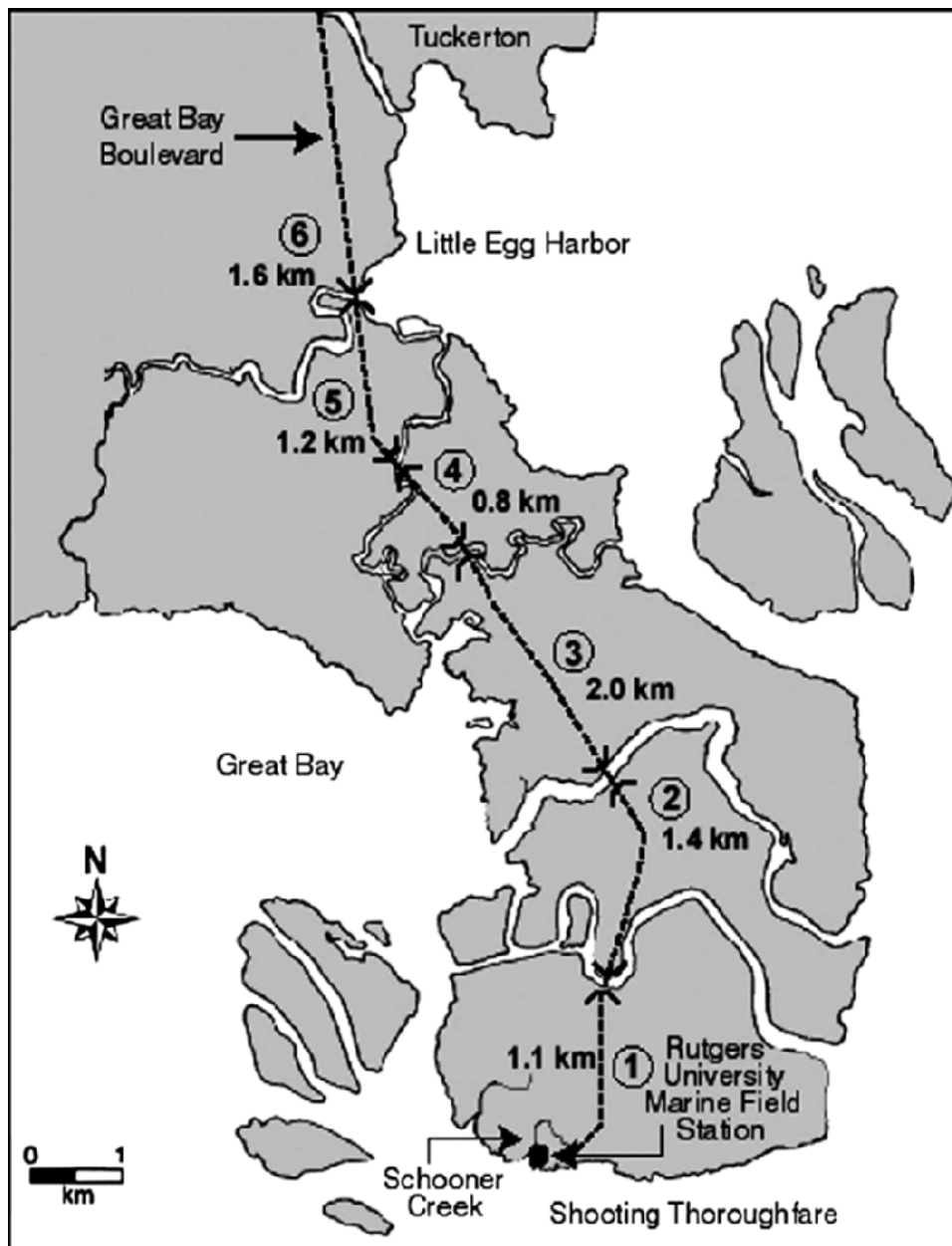


Figure 1. Map of the study site, Great Bay Boulevard within the Great Bay Wildlife Management Area of the Jacques Cousteau National Estuarine Research Reserve in Tuckerton, New Jersey.

tagging in a season or the following year) were observed within and among seasons (Tables 1 and 2).

Terrapins were recaptured crossing the road multiple times each season while searching for suitable nest sites. Distances between road crossings (excluding “long-term” seasonal recaptures) ranged from 4 to 934 m, with a mean of 140.2 m, but 47.3% of terrapins continued to search for a suitable nest site within 50 m of their initial tagging location.

Terrapins that probably nested more than once within a season (“long-term” recaptures, $n = 15$; 6 in 2004 and 9 in 2005) had a mean interesting distance of 171.8 m with a range of 4–916 m. Of these, 6 (40%) were recaptured nesting within 50 m of their original nesting site.

We found a mean interesting distance of 239.3 m (range = 6.8–1307.4 m) for 15 terrapins that were tagged in 2004 and recaptured nesting in 2005. Of these, 6 (40%) were recaptured within 50 m of their original nesting site, and of those, 5 (33%) were within 25 m of their original nesting site.

When combining all multiple nesting terrapins, we found similar results, a mean interesting distance of 202.8 m (range = 4.0–1307.4 m) (Fig. 3). These included 31 total recaptures (6 in 2004 and 9 in 2005 that nested more than once in their respective seasons, 15 [tagged in 2004] that were recaptured nesting once the following year [2005], and 1 [tagged in 2004] that was recaptured nesting at least twice the following year [2005]). Of these 31

Table 1. Summary results of PIT tagged terrapins within and among nesting seasons on Great Bay Boulevard.

Year	No. of tagged terrapins	No. of recaptures	No. of individuals recaptured	No. of "long-term" seasonal recaptures	Total no. of road crossings during single nesting events
2004	100	25	16	6	19
2004–2005	—	17	15	1	1
2005	200	50	38	9	41
Total	300	92	54 (18%)	16	61

recaptures, 12 (38.7%) were recaptured nesting within 50 m of their original nesting site (Fig. 3).

Discussion. — Collecting data from tagged animals can lead to a better understanding of general movement and migration patterns, reproductive strategies, population sizes, specific use of habitat, and individual behavior (Balazs 1999). Such information is critical to understanding life-history strategies and conserving terrapin populations. In this study, PIT tags proved to be a reliable method of tagging and identifying individual terrapins.

Our study revealed information on distances and time intervals between recaptures of terrapins crossing the road in search of initial nest sites and multiple nesting terrapins within a season and the following year. "Long-term" within-season recaptures were found 17 or more days after initial tagging and likely represented second nestings (Seigel 1980b; Butler 2002). Feinberg and Burke (2003) also tagged adult females and confirmed individuals nesting for a second time in a season.

Terrapins may search multiple areas before selecting a nest site, similar to Blanding's turtles that arrive at nesting beaches and adjacent roadways several days prior to nesting and make numerous attempts before effectively completing one (Standing et al. 1999). Western pond turtles also make multiple exploratory nesting excursions

on land ranging from 2 to 11 trips (Reese and Welsh 1997). Burger (1977) observed terrapins digging up to 10 different nests before selecting the final one. In our study, several individuals were also captured multiple times in relatively short periods of time. Terrapins were observed crossing the road during the same day, the following day, and up to 9 days after tagging, possibly still searching for a suitable nesting site. Nearly 50% of these terrapins searched within 50 m along the roadside for a nest site, while a few traveled well over 300 m.

Turtles returning to nesting sites may be displaying nest site fidelity nest or site philopatry (Roosenburg 1994; Gibbons et al. 2001; Rowe et al. 2005). In our study, terrapins used the same nesting area repeatedly (site fidelity) and are either faithful or restricted to certain nesting sites. Nest fidelity has previously been observed in terrapins, but distances between nest sites have not been reported. Burger (1977) found some terrapins returned to nest over several years on the same dune area (20 × 400-m transect) on Little Beach Island in southern New Jersey. Roosenburg (1991, 1994) documented females returning to the same nesting areas (~ 0.5 acres) each time they laid a new clutch, across one or more seasons in Maryland. Similar results were also observed in New York (Feinberg and Burke 2003).

Table 2. Summary results from terrapins tagged in 2004 and recaptured the following nesting season in 2005 on Great Bay Boulevard, illustrating variable recapture distances.

Terrapin no.	Date of tagging	Date of recapture	Distance (m) between initial tagging site and recapture site
4	5.25.04	6.8.05	12
		6.28.05	119
11	6.1.04	6.4.04	99
		6.7.04	60
		6.24.05	385
24	6.2.04	6.15.05	8
		6.7.04	103
28	6.2.04	6.13.05	8
		7.15.05	28
41	6.2.04	6.17.05	931
		6.9.04	355
46	6.3.04	6.23.05	7
		6.21.05	1307
54	6.3.04	6.15.05	142
		6.17.05	60
70	6.3.04	6.21.05	60
		6.21.05	148
71	6.3.04	6.23.05	114
		6.17.05	11
80	6.3.04	6.17.05	11
		6.17.05	406
87	6.4.04	6.17.05	406
		6.24.05	76
89	6.7.04	6.24.05	76

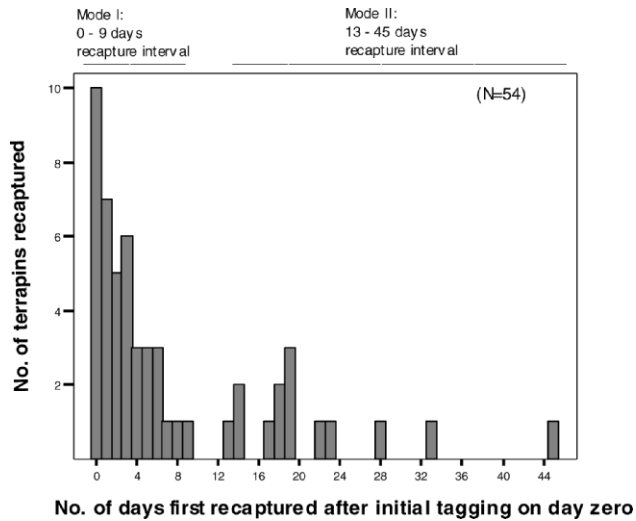


Figure 2. Number of terrapins recaptured after initial tagging (day 0) to next recapture day on Great Bay Boulevard.

In our study, interesting distances of all “long-term” recaptured terrapins along the roadside revealed a variable distance range up to 1307 m, but nearly all (28 of 31 individuals) nested within 450 m of their initial tagging site. Three females moved great distances (> 900 m) between nest sites. Interestingly, many females (nearly 40%) returned to nest in the same general area along the roadside within 50 m of their initial tagging location. Between years, approximately a third nested within 25 m of their initial tagging site. The data collected suggest there may be some evidence of successive nesting near initial

nesting sites (site fidelity) along roadsides for some individuals.

These results are similar to what has been observed in other Emydidae. Multiple nesting Blanding’s turtles have shown high site fidelity among years, with 73% returning to the same nesting areas (Standing et al. 1999). A painted turtle study reported an average internesting distance of 88.7 m ($n = 51$; range 5–310 m) among consecutive years and an average of 106.2 m ($n = 22$; range 6–500 m) within a season (Rowe et al. 2005). The same study considered an internesting distance within 50 m, as some evidence of nest site fidelity and many individuals (~ 30%) nested within 25 m of the previous year (Rowe et al. 2005). Further studies should be conducted from year to year to confirm if terrapins display nest site fidelity within a certain distance of previous nesting sites.

The results from our study provide some insight for management strategies in this and other areas where terrapins cross roadways. Terrapins making multiple road crossings and repeated nesting efforts are exposed to high risk from vehicular mortality, even though we recorded only 2 of 104 female terrapins killed over the 2 nesting seasons. Fencing along roads has been used to help reduce mortalities of some turtles (Aresco 2005). By identifying nesting sites and heavily used road crossing areas (nesting and road mortality “hot spots”), certain portions of wetlands that are intersected by roads may need more protection than others.

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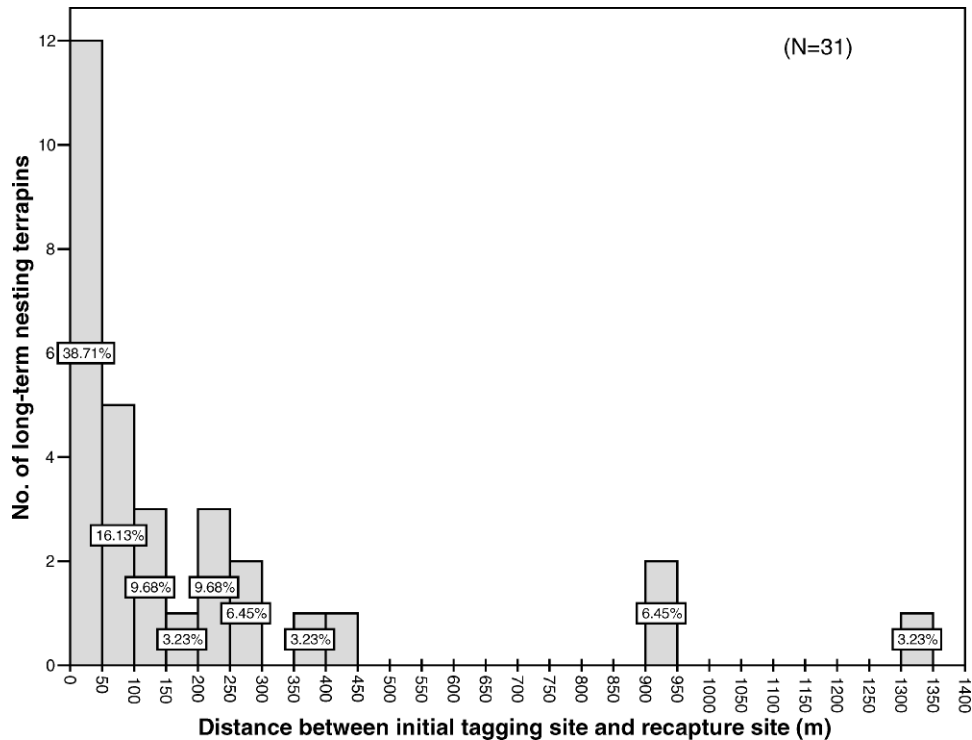


Figure 3. Internesting distances of all multiple nesting terrapins (within and among seasons) on Great Bay Boulevard.

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