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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

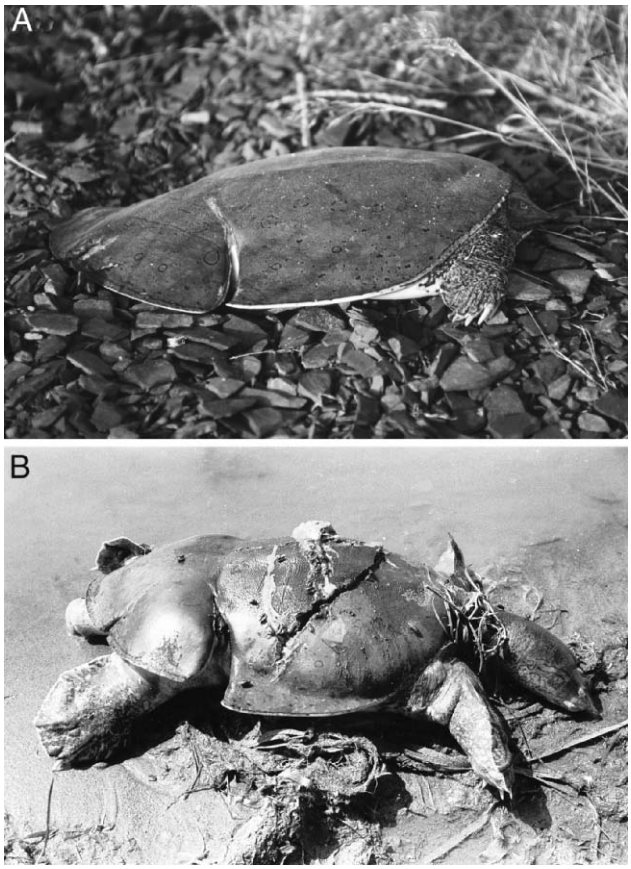

Figure 1. A: Adult female eastern spiny softshell turtle (*Apalone spinifera*) in June 1995 with a fresh traumatic laceration on the posterior right side of the shell. B: The same female found dead in August 1999 with new deep lacerations and fractures of the carapace in addition to the healed previous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